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

Informative Inventory Report 2025

Emissions of transboundary air pollutants in the Netherlands 1990-2023

RIVM report 2025-0007

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Synopsis

Informative Inventory Report 2025

Emissions of transboundary air pollutants in the Netherlands 1990–2023

This Informative Inventory Report (IIR) describes the emission of air pollutants in 2023 compared to 2022. The report also indicates the extent to which the Netherlands has met the European obligations to reduce emissions compared to 2005, the baseline year. It shows that all targets (as laid down in the EU NEC Directive) were met in 2023, as they were in 2020, 2021 and 2022.

In 2023, 116.4 kilotons of ammonia were emitted, which was 4.0 kilotons less than in 2022. It was also 25 per cent less than in the baseline year (compared to the NEC target of 13 per cent less ammonia). The decrease in 2023 was mainly caused by fewer animals (cattle, poultry and pigs) being kept on farms and more poultry manure being processed and exported.

The emission of PM2.5 particulate matter fell further to 13.8 kilotons in 2023, which was 51 per cent less than in the baseline year (compared to the NEC target of 37 per cent less).

The emission of nitrogen oxides fell by 7.7 kilotons in 2023 to 62 per cent less than in the baseline year (compared to the NEC target of 45 per cent less). The decrease in 2023 was due to industry and consumers using less gas due to the high natural gas prices and thus emitting fewer nitrogen oxides. In addition, modern cars emit less, and less electricity was generated using coal.

In 2023, the emission of sulphur oxides was 2.1 kilotons less than in 2022. This was mainly due to a lower sulphur content in refinery gas and because less coal was used to generate electricity. The emission of sulphur dioxides was 74 per cent less than in the baseline year (compared to the NEC target of 28 per cent less).

The emission of volatile organic compounds was 0.3 kilotons less in 2023 than in 2022. The total emission was 24 per cent less than in the baseline year (compared to the NEC target of 8 per cent less).

The Dutch government uses the analyses to make national policy and to report on emission developments at the international level. RIVM prepares this report for the Ministry of Infrastructure and Water Management each year. By submitting the report, the Netherlands meets the national reporting obligations for 2025 of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the National Emission Ceilings Directive (NECD).

Keywords: emissions, air pollutants, emission inventory

Publiekssamenvatting

Informative Inventory Report 2025

Emissies van grootschalige luchtverontreiniging 1990-2023

Deze Informative Inventory Report rapportage (IIR) beschrijft de uitstoot van luchtverontreinigende stoffen in 2023 ten opzichte van 2022. Verder geeft het aan in hoeverre Nederland de Europese verplichtingen heeft gehaald om de uitstoot te laten dalen ten opzichte van 2005, het zogeheten basisjaar. Uit deze inventarisatie blijkt dat in 2023, net als in 2020, 2021 en 2022, alle doelen (EU NEC-Directive) zijn gehaald.

In 2023 is 116,4 kiloton ammoniak uitgestoten, 4,0 kiloton minder dan in 2022. Daarmee is de uitstoot 25 procent minder dan in het basisjaar (het NEC-doel is 13 procent minder ammoniak). De afname in 2023 komt vooral doordat er in de landbouw minder dieren (rund- en pluimvee en varkens) zijn gehouden en er meer pluimveemest is verwerkt en geëxporteerd.

De uitstoot van fijnstof $PM_{2.5}$ is verder gedaald tot 13,8 kiloton in 2023, een daling van 51 procent ten opzichte van het basisjaar (het NEC-doel is 37 procent minder).

De uitstoot van stikstofoxiden is in 2023 met 7,7 kiloton afgenomen en is 62 procent minder dan in het basisjaar (het NEC-doel is 45 procent minder). De uitstoot daalde in 2023 omdat de industrie en consumenten minder gas gebruikten vanwege de hoge aardgasprijzen, en zo minder stikstofoxiden uitstootten. Ook stoten moderne auto’s minder uit en is er minder elektriciteit opgewekt met steenkool.

De uitstoot van zwaveloxiden is in 2023 2,1 kiloton lager dan in 2022. Dat komt vooral door een lager zwavelgehalte in raffinaderijgas en doordat minder steenkool is gebruikt om elektriciteit op te wekken. Ten opzichte van het basisjaar is de uitstoot van zwaveldioxiden met 74 procent gedaald (het NEC-doel is 28 procent minder).

De uitstoot van vluchtige organische stoffen is in 2023 0,3 kiloton lager dan in 2022. Ten opzichte van het basisjaar is de totale uitstoot met 24 procent gedaald (het NEC-doel is 8 procent minder).

De Nederlandse overheid gebruikt de analyses in haar nationale beleid en om internationaal over de ontwikkeling van de uitstoot te rapporteren. Het RIVM stelt dit rapport elk jaar op voor het ministerie van Infrastructuur en Waterstaat (IenW). Hiermee voldoet Nederland aan de nationale rapportageverplichtingen voor 2025 van de Convention on long-range transboundary air pollution (CLRTAP) en de nationale emissieplafondrichtlijnen (National Emission Ceilings Directive, NECD).

Kernwoorden: emissies, luchtverontreinigende stoffen, emissieregistratie

Contents

Executive summary

ES1 Summary of trends in national emissions

Total national emissions for all pollutants have decreased substantially since 1990 (see Table ES1). The major overall drivers for these trends are:

- for the agricultural sector, the introduction of a ban on surface spreading of manure, direct incorporation of manure into the soil and covering of outdoor slurry manure storage; and more recently, the introduction of low-emission animal housing and precision feeding aiming to reduce N excretion; also, livestock numbers are slowly decreasing (for cattle and swine);
- emission reductions in the industrial sectors due to the introduction of cleaner production technologies and flue gas treatment technologies;
- the use of cleaner fuels through desulphurisation of fuels and reduced use of coal and heavy oils;
- cleaner cars due to EU emission regulations for new road vehicles.

Table ES1 Total emissions of pollutants for the years 1990 and 2020–2023

National total emissions CLRTAP/EMEP						
Pollutant	**Unit**	**1990**	**2020**	**2021**	**2022**	**2023**
NO_x	Gg	682.2	209.0	204.0	191.6	183.8
NMVOC	Gg	600.8	252.9	239.6	240.1	238.4
SO_x	Gg	198.1	19.6	20.9	19.6	17.5
NH_3	Gg	346.6	124.6	122.9	120.4	116.4
$PM_{2.5}$	Gg	57.2	14.2	14.4	14.1	13.8
PM_{10}	Gg	80.5	26.6	26.6	26.5	26.2
TSP	Gg	102.2	31.1	31.3	30.9	30.7
BC	Gg	14.2	2.4	2.3	2.2	2.1
CO	Gg	1,177.1	426.8	418.4	401.4	386.0
Pb	Mg	335.6	5.8	4.9	4.6	4.0
Cd	Mg	4.1	2.0	0.88	0.80	0.47
Hg	Mg	3.7	0.47	0.45	0.48	0.43
As	Mg	1.5	0.29	0.27	0.31	0.24
Cr	Mg	12.0	3.2	3.5	3.5	3.5
Cu	Mg	92.5	103.9	100.5	106.6	111.0
Ni	Mg	75.7	1.8	1.7	1.7	1.9
Se	Mg	0.41	0.21	0.19	0.19	0.13
Zn	Mg	225.7	178.1	149.7	155.6	70.1
Dioxins/furans	g I-TEQ	744.9	30.0	30.2	30.3	42.9
benzo(a) pyrene	Mg	5.5	1.5	1.6	1.6	1.5
benzo(b) fluoranthene	Mg	8.1	1.3	1.5	1.5	1.5
benzo(k) fluoranthene	Mg	4.2	0.70	0.78	0.82	0.79
Indeno (1.2.3-cd) pyrene	Mg	21.4	4.9	5.4	5.4	5.1
HCB	Kg	66.4	3.4	3.4	3.3	3.2
PCBs	Kg	38.4	0.14	0.19	0.18	0.13

ES2 Compliance with the NECD and the Gothenburg Protocol
For both the Gothenburg Protocol and the NECD, the Netherlands has opted to calculate the compliance totals on the basis of fuel sold.

The emission reduction targets for both the NECD and the Gothenburg Protocol are the same percentage for each pollutant. However, for NO_x and NMVOC, there is a difference between the NECD and the Gothenburg Protocol regarding the calculation of the emission totals for compliance checking. In contrast to the Gothenburg Protocol, the emissions of NO_x and NMVOC from manure management and agricultural soils (NFR 3B and 3D – Agriculture Sector) are exempted from the compliance total under the NECD.

Under the NECD, the emissions of NO_x, NMVOC, NH_3, SO_x and $PM_{2.5}$ comply with the 2020–2029 reduction targets (Table ES2).

Table ES2 Compliance under the NECD

	Emission reductions and compliance under the NECD without adjustments									
Pollutant	**Compliance Total**					**Target 2020-2029**	**Achieved reduction**			
	2005	**2020**	**2021**	**2022**	**2023**		**2020**	**2021**	**2022**	**2023**
NO_x	396.6	175.0	170.8	159.5	151.7	**45%**	56%	57%	60%	62%
NMVOC	202.2	165.2	152.6	153.1	152.8	**8%**	18%	25%	24%	24%
SO_x	67.8	19.6	20.9	19.6	17.5	**28%**	71%	69%	71%	74%
NH_3	155.2	124.6	122.9	120.4	116.4	**13%**	20%	21%	22%	25%
$PM_{2.5}$	28.4	14.2	14.4	14.1	13.8	**37%**	50%	49%	50%	51%

Under the Gothenburg Protocol, the Netherlands is not in compliance with the NMVOC reduction target in 2020 (Table ES3) without an adjustment.

Table ES3 Compliance under the Gothenburg Protocol

	Emission reductions and compliance under the Gothenburg Protocol without adjustments									
Pollutant	**Compliance Total**					**Target 2020-2029**	**Achieved reduction**			
	2005	**2020**	**2021**	**2022**	**2023**		**2020**	**2021**	**2022**	**2023**
NO_x	432.3	209.0	204.0	191.6	183.8	**45%**	52%	53%	56%	57%
NMVOC	268.1	252.9	239.6	240.1	238.4	**8%**	6%	11%	10%	11%
SO_x	67.8	19.6	20.9	19.6	17.5	**28%**	71%	69%	71%	74%
NH_3	155.2	124.6	122.9	120.4	116.4	**13%**	20%	21%	22%	25%
$PM_{2.5}$	28.4	14.2	14.4	14.1	13.8	**37%**	50%	49%	50%	51%

ES3 Adjustment application

As becomes clear from Table ES3, the Netherlands is not in compliance with the reduction commitment for NMVOC under the Gothenburg

Protocol. However, Decision 2012/3 (UNECE, 2012) of the Executive Body states that adjustments may be made to the national emission inventories under specific circumstances for the purpose of comparing the inventories with emission reduction commitments.

The 2013 EMEP/EEA Guidebook implemented a default methodology and default EFs for NMVOC from animal husbandry and manure management. This resulted in the inclusion of the NMVOC emissions from agriculture in the emission inventory in 2017, as described in Chapter 6. Thus, the NMVOC emissions from these sources were not accounted for at the time when emission reduction commitments were set. Therefore, the Netherlands applied for an inventory adjustment for an NMVOC source in NFR category 3B, more specific 3B1a (Manure management – Dairy cattle) for 2020. When the inventory is adjusted for this source, the Netherlands will be in compliance, as presented in Table ES4.

Table ES4 Compliance under the Gothenburg Protocol with inventory adjustment

NMVOC Compliance under the Gothenburg Protocol based on the adjusted inventory						
Year	**Inventory total (Gg)**	**Reduction Target %**	**Unadjusted reduction %**	**Adjustment NFR-3B1a (Gg)**	**Adjusted Compliance total (Gg)**	**Reduction with adjustment %**
2005	268.1	-	-	24.2	243.8	-
2020	252.9	8%	6%	43.6	209.3	14%
2021	239.6	8%	11%	-	-	-
2022	240.1	8%	10%	-	-	-
2023	238.4	8%	11%	-	-	-

ES4 Other information

Completeness of the national inventory

The Netherlands NFR inventory includes all sources and is generally considered to be complete. For some NFR source categories, no methods are available or they are regarded as negligible (see Table A1.2).

Methodological changes, recalculations and improvements

Several recalculations were made in this inventory. Most are small and deal with changes in methodology, error corrections, new data sources or changes in allocation.
The most noticeable changes are:

Energy

- Improvement of heavy metal emissions in 2000, 2004, and 2005 in 1A1a and 1A1b. For several power plants and refineries, heavy metals were missing in their AERs. Additional estimates have been made, resulting in an increase of emissions for 2000 and 2005.
- Recalculation of the NO_x emission factor for natural gas combustion in 1A4 (2010–2022).
- Activity data correction for frying meat, for the full time series.

- Updated NMVOC emissions in 1B, due to updated CH_4 emissions from gas distribution, resulting from the Oil and Gas Methane partnership (OGMP).

Specifically for transport:
- Update of PAH profiles for jet engines.
- Recalculations following aircraft type corrections for Amsterdam Airport Schiphol for 1998–2001.
- Updated emission factors for road transport.
- Error correction of double-counting NMVOS for road transport.
- For heavy-duty vehicles, auxiliary functions have also been included.
- The NO_x emission factor for LPG engines has been lowered.
- Update of the NRMM machine fleet.

IPPU
- For 2B10a, for some companies, heavy metals were missing in their AERs. Additional estimates have now been made.
- Increase in emissions for NMVOC, PM_{10}, benzene, PAH and cadmium in 2A6, resulting from a Tier 1 method to calculate emissions from asphalt production, that were not estimated before.

Agriculture
- Recalculation of NO_x and NH_3 emissions for 2010-2022 from updates in manure storage and treatment, due to updates in the amount of treated manure and N content of the treated or exposed manure.
- Recalculations of NMVOC emissions from manure storage (3B) and manure application (3D), as they are affected by changes in NH_3 emissions from housing and storage. As described in the first point, these were recalculated.
- Recalculation of NMVOC emissions for 2022 resulting from updates of the number of calves born per dairy cow. This led to increases in VS intake and excretion of dairy cows.
- NH_3 and NO_x recalculations for 2000-2022, caused by updates of model inputs for manure distribution of soil types and amount of manure available for applications.
- Recalculation of NO_x and NH_3 emissions for 2006-2022 resulting from an error correction for the rate of grassland renewal.
- Recalculation of NO_x emissions for the entire time series, due to a recalculation for the area of organic soils in the Netherlands.

Waste
- Recalculations of particulate matter emissions from mineral waste handling (5A), due to a change in methodology.
- Increase of NH_3 emissions in 5B for the years 2018-2022, due to recalculation of the amount of digested manure.
  NMVOC emissions from industrial wastewater treatment are recalculated for the time series 2016-2022 on the basis of activity data volunteered by individual industrial companies in their AERs.

A complete list of methodological changes, recalculations and improvements is presented in each specific sector chapter.

ES5 Background information on the air pollutions inventory

This report documents the Netherlands' submission for 2024 of its air Pollutant Release and Transfer Register (PRTR), in line with the annual reporting requirements under the Convention on Long Range Transboundary Air Pollution (CLRTAP) and its implementation under the European Monitoring and Evaluation Programme (EMEP), directed by the United Nations Economic Commission for Europe (UNECE) and in line with the European National Emission Ceilings (NECD).

This report has been prepared in line with the reporting guidelines provided by the CLRTAP Executive Body's decisions ECE/EB.AIR/122/Add.1; 2013/3 and 2013/4 and ECE/EB.AIR.125 (2014 Reporting Guidelines).

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

The National Institute for Public Health and the Environment (RIVM) has been contracted by the Dutch Ministry of Infrastructure and Water Management (IenW) and the Ministry of Climate Policy and Green Growth (KGG) to maintain a high-quality PRTR that complies with the agreed international guidances on emission inventories, and to compile and coordinate the annual preparation of the IIR and the completion of the NFR tables.

Methodology reports
Emissions data are compiled from the PRTR in accordance with the 2023 EMEP/EEA air pollutant emission inventory guidebook (EEA, 2023). Methodologies are described in detail in four separate sectoral methodology reports that form an integral part of the IIR reporting:

- Methodology for the calculation of emissions to air from the sectors Energy, Industry and Waste (Honig et al., 2025);
- Methodology for the calculation of emissions from the transport sector (Witt et al., 2025a; Witt et al. 2025b);
- Methodology for the calculation of emissions from product usage by consumers, construction and services (Visschedijk et al., 2025);
- Methodology for the calculation of emissions from agriculture (Van der Zee et al., 2025).

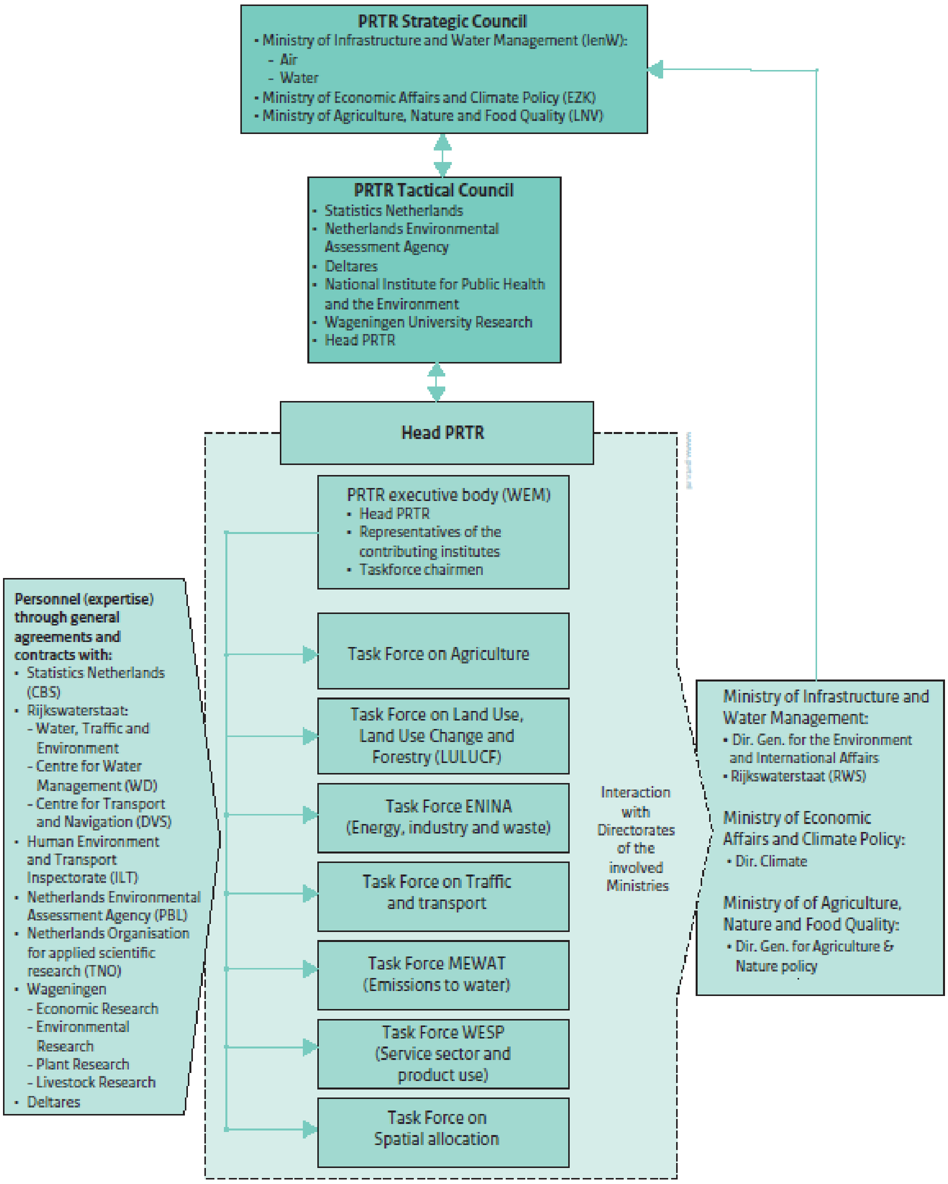


Figure ES.1 Main elements in the emissions inventory compilation process

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

Uncertainty estimates
The approach 2 uncertainty estimate method (Monte Carlo analysis) is used to calculate uncertainties that are updated annually as emission factors and activity data are updated. Most uncertainty estimates are based on the judgement of emission experts from the various task forces.

The expert elicitation was set up following the expert elicitation guidance in the 2006 IPCC Guidelines (motivation, structuring, conditioning, encoding and verification). The uncertainties of the individual source-specific activity data and the EFs were assessed separately using expert judgement. This approach is more detailed than the uncertainty assessment at the level of NFR categories. The Monte Carlo analysis takes correlations of the activity data and/or EFs into account. Table ES5 represents the Approach 2 method uncertainties at the level of NFR categories.

Table ES5 Uncertainty (95% confidence ranges) for NH3, NOx, SOx, NMVOC, PM10 and PM2.5 for each NFR category and for the national total, calculated with the Approach 2 method for emissions (%)

	Approach 2 uncertainties IIR 2025 submission					
NFR sector	**NH_3**	**NO_x**	**SO_x**	**NMVOC**	**PM_{10}**	**$PM_{2.5}$**
1 Energy	124	16	23	41	50	56
2 Industry	53	96	83	30	40	58
3 Agriculture	28	110	-	132	38	35
5 Waste	70	69	73	154	170	175
6 Other	277	-	-	-	-	-
Total	**27**	**19**	**22**	**48**	**29**	**42**

Key categories
Two key source analysis approaches are reported:

- Approach 1 consists of ranking the list of source category/gas combinations according to their contribution to national total annual emissions and to the national total trend. Key categories are those whose emissions add up to 80% of the national total (Appendix 2);
- The Approach 2 for the identification of key categories (Appendix 3) requires the incorporation of the uncertainty in each of the GNFR categories before ordering the list of shares. This has been carried out using the uncertainty estimates from the Approach 2 method as they are considered to be more up to date and available at PRTR sources level (approximately as detailed as SNAP (Selected Nomenclature for Air Pollution)).

Planning inventory improvements
With limited annual budget, there is a need to prioritise annual improvements. Several factors are taken into account in this prioritisation process; for instance (*not in order of importance*) the availability of new science and/or new data sources, review recommendations, current policy issues, et cetera. Additionally, a tool is used that used identifies the NFR categories that contribute >5% to the national total and have an Approach 2 uncertainty of >50% (Appendix 6).

1 Introduction

The United Nations Economic Commission for Europe's 1979 Geneva Convention on Long-Range Transboundary Air Pollution (CLRTAP) was accepted by the Netherlands in 1982, and the amendments on the text and annexes to the protocol were accepted in 2017. The European Community subsequently adopted the Revised National Emission Ceiling Directive (NECD) in 2016 to set national emission reduction commitments for EU Member States (EU, 2016).

Parties to the CLRTAP and European Member States are obligated to report their emission data annually. Under the CLRTAP, this data is reported to the Convention's Executive Body in accordance with the implementation of the Protocols to the Convention (accepted by the Netherlands), and for the NECD, they are reported to the European Commission. For both the CLRTAP and the NECD, reports must be prepared using the 2023 Guidelines for reporting emissions and projections data under the Convention (UNECE, 2023).

Additionally, the emission reduction commitments under both the Gothenburg Protocol (UNECE, 2012) and the NECD (EU, 2016) are reported using the Technical guidance (UNECE, 2015).

The Informative Inventory Report 2025 (IIR 2025) comprises the national emission reporting obligation for both the CLRTAP and the NECD with respect to the pollutants SO_x, NO_X, NMVOC, NH_3, $PM_{2.5}$, other particulate matter (PM_{10}, total suspended particulate (TSP) and black carbon (BC)), CO, priority heavy metals (Hg, Pb and Cd), heavy metals (As, Cr, Cu, Ni, Se and Zn) and several persistent organic pollutants (POPs).

The IIR contains information on the Netherlands' emission inventories for the years 1990 to 2023, including descriptions of methods, data sources and annual QA/QC activities (including the trend analysis workshop). The inventory covers all anthropogenic emissions covered by the Nomenclature For Reporting (NFR).

This report is structured as follows:

- Chapter 1 documents the compiling of the NFR and IIR from the PRTR database.
- 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, respectively:
  - Energy;
  - Transport.
  - Industrial Processes and Product Use;
  - Agriculture;
  - Waste;
  - Other.
- Chapter 9 documents the 2025 submission of the large point sources (LPS).

- Chapter 10 documents the response to the 2024 NECD inventory review.
- Chapter 11 documents recalculations and improvements since the previous report (IIR 2021).
- Chapter 12 documents the 2025 submission of emission projections.
- Chapter 13 documents the Compliance and the Adjustment application for the pollutant NMVOC under the Gothenburg Protocol.
- Chapter 14 documents the spatial distribution of the Netherlands' PRTR emission data.
- Appendices that provide information about key categories, uncertainty analysis and other detailed information. As from the IIR 2025, a first attempt to verify the inventory data by inverse modelling results (provided by the PARIS project) is also added as an appendix to the document (see Appendix 8).

Note that this report provides no specific information on government policies for reducing emissions. Such information can be found, for example, in the Netherlands Monitoring Report Target scope for the Clean Air Agreement. Second progress assessment (Ruyssenaars et al., 2024, in Dutch).

The Nomenclature For Reporting (NFR) contains the data on emissions, activity data that form the basis for this report.

1.1 National inventory background

Emission estimates in the Netherlands are registered in the PRTR, which is the national database for sectoral monitoring of pollutant and greenhouse gas emissions to air, water and soil. The database was set up to support national environmental policy, as well as to meet the requirements of the EU National Emission Ceilings Directive (NECD), CLRTAP, the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (national system). This policy covers the annual PRTR updates, the process of data collection, processing and registration, and the reporting of emission data for some 375 compounds. Emission data and documentation can be found at www.emissieregistratie.nl.

Instead of using the defaults from the EMEP/EEA air pollutant emission inventory guidebook 2023 (EEA, 2023), the Netherlands often applies country-specific methods, with associated activity data (AD) and emission factors (EFs). The emission estimates are based on the official statistics of the Netherlands (e.g. on energy, industry and agriculture) and on environmental reports issued by companies in the industrial sectors. Both nationally developed and internationally recommended EFs have been used.

1.2 Institutional arrangements for inventory preparation

The Dutch Ministry of Infrastructure and Water Management (IenW) bears overall responsibility for the emission inventory and submissions made to the CLRTAP and the NECD. The PRTR system has been in operation in the Netherlands since 1974. Since 2004, IenW has outsourced the full coordination of the PRTR to the Emission Registration team (ER team) at the National Institute for Public Health and the Environment (RIVM).

The main objective of the PRTR is to annually produce a set of unequivocal emission data that is up to date, complete, transparent, comparable, consistent and accurate. This forms the basis of all the Netherlands' international emission reporting obligations and is used for national policy purposes.

Emission data is produced in annual (project) cycles. In addition to RIVM, various external agencies/institutes contribute to the PRTR by performing calculations or submitting activity data:
- Netherlands Environmental Assessment Agency (PBL);
- Statistics Netherlands (CBS);
- Netherlands Organisation for applied scientific research (TNO);
- Rijkswaterstaat; Water, Traffic and Environment (RWS-WVL);
- Deltares;
- Wageningen University & Research (WUR), Statutory research tasks:
  - Wageningen Environmental Research (WEnR);
  - Wageningen UR Livestock Research (WLR);
  - Wageningen Economic Research (WEcR);
  - Wageningen Plant Research (WPR).

Each of the contributing institutes has its own responsibility and role in the data collection, emission calculations and quality control. These are laid down in general agreements with RIVM and in the annual project plan.

1.3 The process of inventory preparation

1.3.1 Data collection

Task forces are set up to collect and process the data (according to pre-determined methods) for the PRTR. The task forces consist of sector experts from the participating institutes. Methods are compiled on the basis of the best available scientific knowledge. Changes in scientific knowledge result in changes in methods and in the recalculation of historical emissions. The following task forces are recognised (see Figure 1.1):
- ENINA: Task Force on Energy, Industry and Waste Management;
- MEWAT: Task Force on Water;
- TgL: Task Force on Agriculture and Land Use;
- V&V: Task Force on Traffic and Transportation;
- WESP: Task Force on Service Sector and Product Use.

Once the emission data has been collected, several quality control checks are performed by the task forces during an annual 'trend analysis' workshop. When the Task Forces have approved the data (relevant sector data), the head of the PRTR endorses the complete dataset. The participating institutes are requested to agree to the dataset to establish a unique set of emission data. Subsequently, the emission data is released for publication (www.emissieregistratie.nl). Then, this data is disaggregated into regional emission data for national use (e.g. 1 x 1 km grid, municipality scale, provincial scale and water authority scale).

1.3.2 *Point source emissions*

As of 1 January 2010, the legally obligated companies can only submit their emission data electronically as a part of an Annual Environmental Report (AER). All these companies have emission monitoring and registration systems in place, with specifications that correspond to those of the competent authority. The licensing authorities (e.g. provinces, central government) validate and verify the reported emissions. Information from the AERs is stored in a separate database at RIVM and remains the property of the companies involved.

Data on point source emissions in the AER database is checked for consistency by the ENINA task force. The result is a set of validated data on point source emissions and activities (ER-I), which is then stored in the PRTR database (Honig et al., 2024).

As a result of the Dutch implementation of the EU Directive on the European Pollutant Release and Transfer Register (E-PRTR), about a thousand facilities have been legally obligated since 2011 to submit data on their emissions of air pollutants if these exceed the reporting threshold. To include emissions from facilities in a particular subsector that do not exceed the threshold (small and medium-sized enterprises – SMEs), supplementary estimates are added to the emissions inventory. For these supplementary estimates, known EFs from research and implied factors from the reported emissions and production are used. Also, statistical information, such as production indexes and sold fuels, is used. The methods for these supplementary estimates are explained in detail in Chapters 3 and 5.

To ensure that the supplementary estimates do not add to the uncertainty of the subsectors' total emissions, the Dutch implementation of the E-PRTR directive (List of thresholds PRTR reporting) has set lower thresholds for major pollutants, so that a minimum of approximately 80% of the subsectors' total emissions is covered by facility emission reports.

1.3.3 *Data storage*

In cooperation with the contributing research institutes, all emission data is collected and stored in the PRTR database managed by RIVM (Figure 1.1).

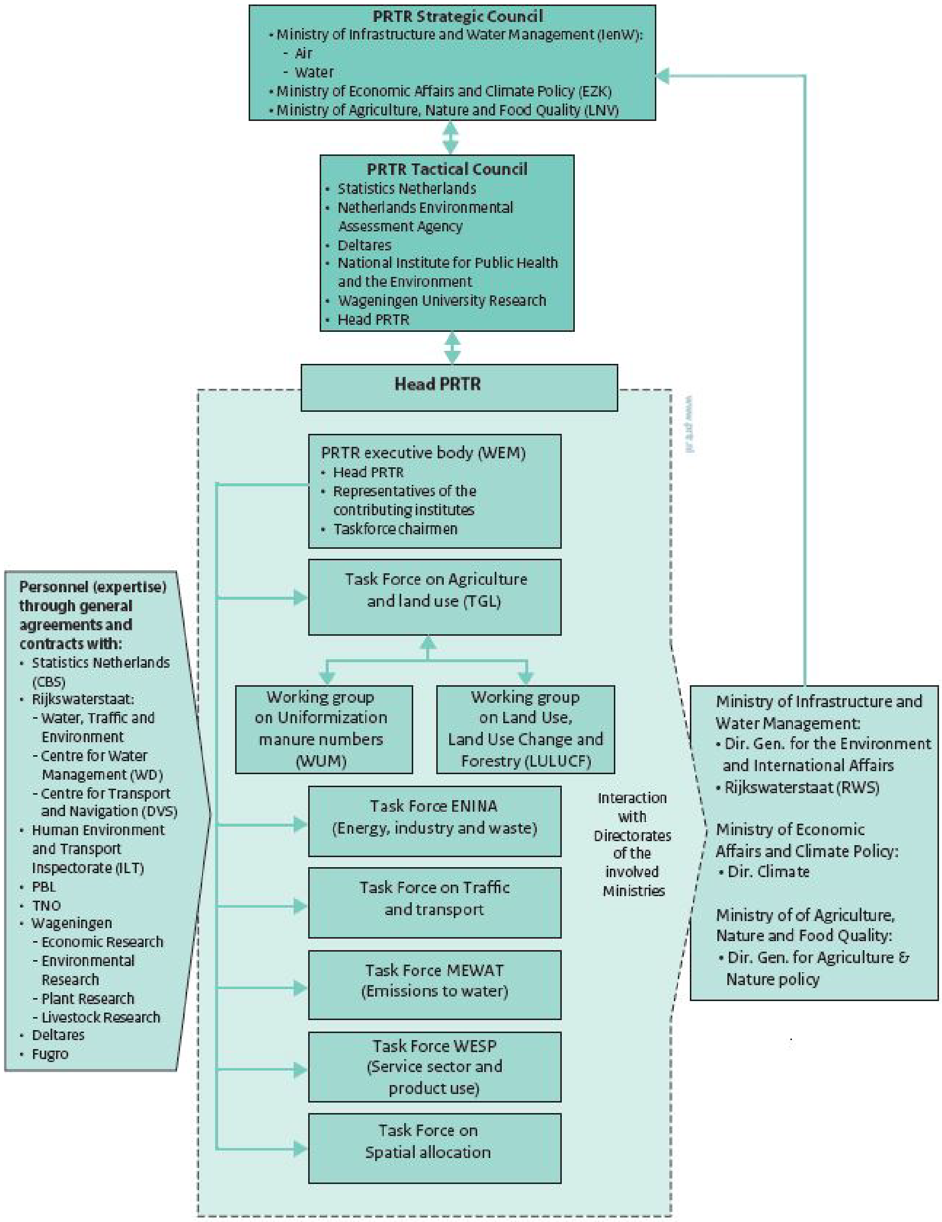


Figure 1.1 The organisational structure of the Netherlands Pollutant Release and Transfer Register (PRTR)

Emission data from the ER-I database and from collectively estimated industrial and non-industrial sources is stored in the PRTR database (see Figure 1.2). The PRTR database, consisting of a large number of geographically distributed emission sources (about 700), contains complete annual records of emissions in the Netherlands.
Each emission source includes information on the NACE code (*Nomenclature statistique des Activités économiques dans la Communauté Européenne*) and the industrial subsector includes separate information on process and combustion emissions, and the relevant environmental compartment and location. These emission

sources can be selectively aggregated per Nomenclature for Reporting (NFR) category.

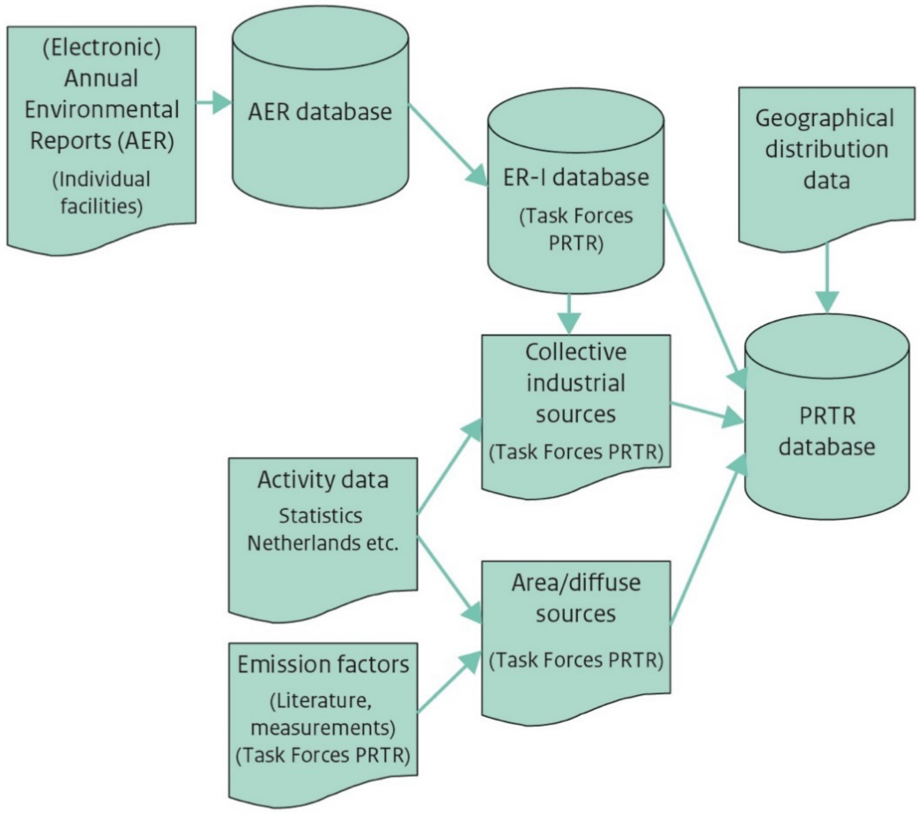


Figure 1.2 The data flow in the Netherlands Pollutant Release and Transfer Register (PRTR)

1.3.4 *Methods and data sources*

Methods used in the Netherlands are annually documented in several reports and are also available from www.emissieregistratie.nl. All methodology reports are in English. However, some background reports are only available in Dutch.
The methodology reports are considered to be an integral part of this Informative Inventory Report (see also Appendix 5).

In general, two data models are used in the Netherlands:

- A model for emissions from large point sources (e.g. large industrial and power plants), which are registered separately and supplemented by emission estimates for the remainder of the companies within a subsector (based mainly on IEFs from the individually registered companies). This is the so-called bottom-up method.
- Several sector-related models for emissions from 'diffuse sources' (e.g. road transport, agriculture), which are calculated from activity data and EFs from sectoral emission inventory studies in the Netherlands (e.g. SPIN documents produced by the 'Cooperation project on industrial emissions').

It should also be noted that:

- Condensable emissions are included in transport emissions and in emissions from domestic wood burning;
- Road transport emissions have been calculated using 'on-road' measured emission factors, so emission data is impervious to 'the diesel scandal'.

1.3.5 Key category analysis

A key category is defined as an emission source that significantly influences the national total emission for a given pollutant in terms of the absolute emission level, the emission trend or both. The key categories are the sources whose total emissions, when summed in descending order of magnitude, add up to 80% of the total level (EEA, 2023). The key source analysis follows the methodologies as explained in chapter 2 of the EMEP/EEA inventory guidebook 2023 (EEA, 2023) and includes both the Approach 1 and the Approach 2 method of identifying key categories.

The Approach 1 method consists of a level assessment that ranks the list of source categories according to their contribution to national total annual emissions. As the inventories of the latest year (2023) and the base year (1990) are available, the level assessment is performed for both years. This also enables the assessment of the contribution each category makes to the trend of the national inventory. A trend assessment aims to find the categories for which the trend (i.e. the change in emission over time) differs most from the trend of the overall inventory. See Appendix 2 for the analysis results.

The Approach 2 method requires uncertainty estimates for the source categories to identify the key categories. The uncertainty estimates are applied as weights to each of the source categories and incorporated in the level and trend assessment before ordering the list of shares.
As recommended by the IPCC guidelines, the uncertainty estimates are based on an Approach 2 (Monte Carlo) uncertainty analysis (see Section 1.5 for details). The outcomes of the Monte Carlo uncertainty analysis were aggregated on the gridded NFR (GNFR) level before the key source analysis was carried out. The results of the Approach 2 key category analysis are reported in Appendix 3.

As the uncertainty analysis produces results at the level of emission sources, which are more detailed than the NFR sector-based results, the Approach 2 analysis to find the key categories can also be applied at this level. This allows a more precise identification of inventory improvement actions. By not only ranking emission sources by their contribution to the national total, but also adding their uncertainty as a weight in that ranking, the key category analysis provides a more accurate listing and is used as an instrument to prioritise the next year's inventory improvements by the task forces (see Appendix 6).

1.3.6 Reporting

The IIR is prepared by the inventory compiling team at RIVM and includes contributions by experts from the PRTR task forces.

1.3.7 *QA/QC*

RIVM has an ISO 9001:2015 QA/QC system in place. PRTR quality management is fully in line with the RIVM QA/QC system. External agencies (other institutes) carry out part of the work for the PRTR. QA/QC arrangements and procedures for the contributing institutes are described in an annual project plan. The general QA/QC activities meet the international inventory QA/QC requirements described in part A, chapter 6 of the EMEP inventory guidebook (EEA, 2023).

There are no sector-specific QA/QC procedures in place within the PRTR. In general, the following QA/QC activities are performed:

Quality assurance (QA)
QA activities can be summarised as follows:

- For the Energy, Industry and Waste sectors, emission calculations in the PRTR are mainly based on AERs submitted by companies (facilities). The companies themselves are responsible for the data quality; the competent authorities (in the Netherlands, mainly provinces and local authorities) are responsible for checking and approving the reported data, as part of their annual quality assurance programmes.
- As part of the RIVM quality system, internal audits are performed at the Department for Pollutant Monitoring and Nitrogen research (SMO) of the RIVM Centre for Environmental Quality (MIL).
- Annual external QA checks are also conducted on selected areas of the PRTR system.

Quality control (QC)
A number of general QC checks have been introduced as part of the annual work plan of the PRTR (see Table 1.1). The QC checks built into the work plan focus on issues such as the consistency, completeness and accuracy of the emission data. Following an automated first check of the emission files by the Data Exchange Module (DEX) for internal and external consistency, the data was made available to the specific task force for the checking of consistency and trends (error checking, comparability, accuracy). The task forces have access to information on all emissions in the database by means of a web-based emission reporting system while the ER team provides them with comparable information on trends and time series. Several weeks before a final dataset is adopted, RIVM conducts a trend verification workshop (see Text Box 1.1) and documents its results, including any actions to be taken by the task forces to resolve the identified clarification issues. The task forces then make the requisite changes to the database.

Table 1.1 Key items of the verification actions on times series 1990–2023 data processing and NFR 2025

QC item/action	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	Upload event and 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
Centralised checks by data users	21-11-2024	RIVM	Input for trend analyses	Actiepunten Definitieve Emissiecijfers 1990-2023 on Microsoft teams ER Consortium channel
Desk data checks by the task forces	21-11-2024/ 28-11-2024	RIVM	Input for trend analyses	Actiepunten Definitieve Emissiecijfers 1990-2023 on Microsoft teams ER Consortium channel
Comparison sheets with concept data	22-11-2024/ 29-11-2024	RIVM	Input for data checks	Verschiltabel_LuchtActueel_29-11-2024 - verzonden.xlsx
Emission data for this inventory plus list of outstanding issues made available for trend analysis	3-12-2024	RIVM	Input for trend analyses	Actiepunten Definitieve cijfers 1990-2023 on Microsoft teams ER Consortium channel

QC item/action	Date	Who	Result	Documentation*
Trend analysis workshops	5-12-2024	Task Forces	Explanations of observed trends and actions to resolve before finalising the PRTR dataset	Actiepunten Definitieve cijfers 1990-2023 on Microsoft teams ER Consortium 1990-2023 on Microsoft teams ER Consortium channel Emissie landbouw 2024.pptx; Trendanalyse ENINA 2024.pptx; Presentatie taakgroep verkeer 2024.pptx; Trendanalyse WESP - 7-12-2024.pptx; Trendanalyse Grootschalige luchtverontreiniging 2024.pptx.
Resolving the final actions before finalising the PRTR dataset	5-12-2024/ 12-12-2024	Task forces	Updated action list	Actiepunten Definitieve cijfers 1990-2023 on Microsoft teams ER Consortium 1990-2023 on Microsoft teams ER Consortium channel
Request to the individual task force chairs to approve the data produced by the task force	16-12-2024	RIVM-PRTR	Updated action list	Email (16-12-2024 10:39) with the request to endorse the PRTR database
Formal adoption of the emission dataset	19-12-2024	Head PRTR	Fixed emission dataset 1990–2023	Email (19-12-2024 16:37) from the head of the PRTR endorsing the 1990–2023 emissions dataset;
Input for compiling the NEC report (in NFR format)	16-01-2025	RIVM-NIC	List of allocations of PRTR emission sources for compiling the NFR tables	NFR-Koppeltabel-2025-01-16_113302-dtt68 ACTUEEL

* All documentation (emails, data sheets and checklists) is stored electronically on a data server at RIVM

Text Box 1.1 Trend verification workshops

About a week before a trend analysis workshop, RIVM makes a snapshot of the database available in a web-based application (Emission Explorer, EmEx) for checks by the institutes involved, sectoral and other experts (PRTR task forces) and the RIVM PRTR team. Thus, the task forces can check for level errors and consistency in the algorithm/method used for calculations throughout the time series. The task forces perform checks on the relevant gases and sectors. The sectors are then compared to the previous year's dataset. Where significant differences are found, the task forces check the emission data in more detail. The results of these checks form the subject of discussion at the trend analysis workshop and are subsequently documented.

The PRTR team also provides the task forces with time series of emissions for each substance in each subsector. The task forces examine these time series. During the trend analysis for this inventory, the emission data was checked in two ways: (1) 2023 emissions from the new time series were compared to those of last year's inventory; and (2) the data for 2023 was compared to the trend development for each gas since 1990. The checks of outliers are performed on a more detailed level of the sub sources in all sector background tables:

- annual changes in emissions;
- annual changes in activity data;
- annual changes in implied emission factors (IEFs); and
- level values of IEFs.

Exceptional trend changes and observed outliers are noted and discussed at the trend analysis workshop and included in the action list. Items on this list have to be processed before the formal adoption of the dataset, or dealt with in next year's inventory.

1.4 Archiving and documentation

Internal procedures are agreed on (e.g. in the PRTR work plan) for general data collection and the storage of fixed datasets in the PRTR database, including the documentation/archiving of QC checks. As of 2010, sector experts can store related documents (i.e. interim results, model runs, etcetera) on a central server at RIVM. These documents then become available through a limited-access website. Updating monitoring protocols for substances under CLRTAP is one of the priorities within the PRTR system. Emphasis is placed on the documentation of methodologies for calculating SO_x, NO_x, NMVOC, NH_3, PM_{10} and $PM_{2.5}$. Methodologies, protocols and emission data (including emissions from large point sources on the basis of AERs, as well as emission reports, such as the National Inventory Report and the IIR, are made available on the website of the PRTR: www.emissieregistratie.nl.

1.5 Quantitative uncertainty

Approach 2 method

Uncertainty estimates of total national emissions are calculated using an Approach 2 method (Monte Carlo analysis). Most uncertainty estimates are based on the judgement of emission experts from the ENINA, TgL, V&V and WESP task forces. For agriculture, the judgement of experts is combined with an Approach 1 uncertainty calculation. In the Approach 1 uncertainty calculation for agriculture, it is assumed that emissions from manure management and manure application correlated.

The expert elicitation was set up in accordance with the expert elicitation guidance in the 2006 IPCC Guidelines (motivation, structuring, conditioning, encoding and verification). The uncertainties of the individual source-specific activity data and the EFs were assessed separately using expert judgement. This approach is more detailed than the uncertainty assessment at the level of the NFR categories. The Monte Carlo analysis takes correlations of the activity data and/or EFs into account. The following correlations are included:

- Activity data:
  The energy statistics0F[1] are more accurately registered on an aggregated level (e.g. for Industry) than on a detailed level (e.g. for the separate Industrial sectors). Therefore, uncertainties are assigned to the aggregated categories, for which good estimates are available, rather than trying to estimate uncertainties for the subcategories. This type of correlation is also used for several Transport source categories (such as Shipping and Aviation).
  The number of animals in one emission source is equal and therefore, positively correlated to the number of animals of the same type in another emission source. This type of dependency is taken into account where the identifier of the activity (number of animals or inhabitants) is equal in different emission sources.
- Emission factors:
  Within the stationary combustion sector, the estimated uncertainty of an EF for a specific fuel is assumed to be equal for all of the emission sources that use this type of fuel. This type of positive correlation is also used for several Transport categories (such as shipping and aviation).
  The EFs for the various categories of cows (meat or dairy cows) are positively correlated, as the input data is the same (e.g. chickens, pigs), or because the EFs are derived from another animal category (e.g. ducks and chickens, horses and asses).

The results of the Monte Carlo analysis (Approach 2 method) are presented in Table 1.2.

Table 1.2 Uncertainty (95% confidence ranges) for NH_3, NO_x, SO_x, NMVOC, PM_{10} and $PM_{2.5}$ for each NFR sector and for the national total, calculated with the Approach 2 method for emissions in the IIR 2025 submission

	Approach 2 uncertainties IIR 2025 submission					
NFR sector	**NH_3**	**NO_x**	**SO_x**	**NMVOC**	**PM_{10}**	**$PM_{2.5}$**
1 Energy	124	16	23	41	50	56
2 Industry	53	96	83	30	40	58
3 Agriculture	28	110	-	132	38	35
5 Waste	70	69	73	154	170	175
6 Other	277	-	-	-	-	-
Total	**27**	**19**	**22**	**48**	**29**	**42**

[1] The energy statistics are available on the website of Statistics Netherlands. The following link relates to the energy statistics for 2018: https://opendata.cbs.nl/ By means of the 'Change selection' button on the website, it is possible to select the data for another year.

The uncertainty estimates from the Approach 2 method (see Table 1.3) differ from the uncertainty estimates from this method as presented in the IIR 2024 (see Table 1.3).

Table 1.3 Uncertainty (95% confidence ranges) for NH_3, NO_x, SO_x, NMVOC, PM_{10} and $PM_{2.5}$ for each NFR sector and for the national total, calculated with the Approach 2 method for emissions in the IIR 2024 submission

	Approach 2 uncertainties IIR 2024 submission					
NFR sector	**NH_3**	**NO_x**	**SO_x**	**NMVOC**	**PM_{10}**	**$PM_{2.5}$**
1 Energy	110	15	22	37	49	55
2 Industry	53	88	86	32	44	66
3 Agriculture	28	110	-	130	36	34
5 Waste	71	84	89	158	178	177
6 Other	261	-	-	-	-	-
Total	**27**	**18**	**21**	**48**	**28**	**41**

At NFR category level, this comparison shows some changes in uncertainty for all shown pollutants. Generally, changes in the total uncertainty of a sector/pollutant can result from changes in absolute emissions, reallocations or updated uncertainty estimates of activity data or emission factors.

Approach 1 method
Uncertainty estimates from earlier studies (Van Gijlswijk et al., 2004; RIVM, 2001) are presented in Table 1.4. In 2025, the uncertainties for NH_3, Nox and SO_x are higher than those obtained in the studies by Van Gijlswijk et al. (2004) and RIVM (2001). For SO_x, this can be explained by the fact that the uncertainty of the SO_x emission factor from chemical waste gas, coal and cokes is assumed to be more uncertain.

Table 1.4 Uncertainty (95% confidence ranges) in earlier studies for NH_3, NO_x and SO_x emissions in 1999 (RIVM, 2001) and 2000 (Van Gijlswijk et al., 2004)

Component	**Tier 1 for 1999**	**Tier 1 for 2000**	**Tier 2 for 2000**
NH_3	± 17%	± 12%	± 17%
NO_x	± 11%	± 14%	± 15%
SO_x	± 8%	± 6%	± 6%

1.6 Explanation of the use of notation keys

The Dutch emission inventory covers all sources specified in CLRTAP that are relevant to emissions to air in the Netherlands. Because of the long history of the inventory, it is not always possible to specify all subsectors in detail. This is why notation keys are used in the NFR emission tables. The use of the notation keys is explained in Tables A1.1 and A1.2 in Appendix 1. The notation key 'IE' (Included Elsewhere) is generally used when activity data cannot be split or is confidential. For most cases where 'NE' (Not Estimated) was used as a notation key, the respective source is assumed to be negligible, or there is no method available for estimating this source.

1.7 Explanation of 'Other' emission sources

Several source categories in the NFR format are used for allocating emission sources that are related to an NFR category, but that cannot be allocated to a specific source category in the relevant source sector. In the NFR format, these source categories are named starting with 'Other'. Table 1.5 represents which source sectors for the Netherlands are allocated to the various 'Other' NFR source categories. These emission sources and their emissions are explained in the relevant chapters for each source sector.

Table 1.5 Sub-sources accounted for in reporting of NFR 'Other' codes

NFR code	Substance(s) reported	Sub-source description
1A2gviii	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	Stationary combustion from production industries in: construction; textiles and clothing; leather and fur preparation; rubber and plastic products; metal products; machine construction; electronic and electric equipment production; computers, electronics and optical equipment production; cars industry; other transport production; furniture production; rug and carpet production; wood products; concrete, gypsum and cement production; construction materials and glass production; synthetic fibre production; ceramics, bricks and roofing tile production; waste preparation for recycling; mineral extraction; shipbuilding.
1A5b	NO_x, NMVOC, SO_x, NH_3, CO, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs, HCBs and PCBs	Recreational navigation and ground machinery at airports.
2A6	NO_x, NMVOC, SO_x, NH_3, CO, $PM_{2.5}$, PM_{10}, TSP, Hg and PAHs	Process emissions by product industries, excl. combustion, in building activities and production of building materials.
2B10a	NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins and PAHs	Process emissions from production of chemicals, fertilisers, paint, pesticides, pharmaceuticals, soap, detergents, glues and other chemical products.

NFR code	Substance(s) reported	Sub-source description
2D3i	NMVOC, NH_3, Dioxins and PAHs	Air conditioning, fumigation of ship holds, use of pesticides and cosmetics, fireworks, preservation and cleaning of wood and other materials.
2G	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, CO, Pb, Cd, Cu, Ni, Zn and PAHs	Smoking of tobacco products, burning of candles, cooling and refrigerating in industry and fireworks.
2H3	NO_x, SO_x, NH_3, $PM_{2.5}$, PM_{10}, Pb, Cd, Hg, Cr, Cu, Ni and Zn	Process emissions from: services sector; textiles and clothing; leather and fur preparation; rubber and plastic products; metal products; machine construction; electronic and electric equipment production; computers, electronics and optical equipment production; car industry; other transport production; furniture production; rug and carpet production; mineral extraction; transhipping, storage and handling; ship building and painting.
3B4giv	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	Ducks
3B4h	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	Rabbits and furbearing animals.
3Da2c	NO_x, NH_3	Use of compost.
5E	NO_x, NMVOC, SO_x, NH_3, CO, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs, HCBs and PCBs	Process emissions from: accidental building and car fires, waste preparation for recycling, scrapping of fridges and freezers.
6A	NH_3	Human transpiration and respiration; domestic animals (pets).

2 Trends in Emissions

2.1 National emissions of the main pollutants and particulate matter

Total national emissions for all pollutants have decreased substantially since 1990. Tables 2.1, 2.2 and 2.3 provide an overview of the emissions with respect to the time series. The major overall drivers for this trend are:

- for the agricultural sector, introducing a ban on surface spreading of manure, direct incorporation of manure in the soil, covering of outdoor slurry storage and lately, the introduction of low-emission animal housing, introduction of precision feeding aiming to reduce N excretion and slowly decreasing livestock numbers (mainly cattle and swine);
- emission reductions in the industrial sectors due to the introduction of cleaner production technologies and flue gas treatment technologies;
- use of cleaner fuels through the desulphurisation of fuels and reduced use of coal and heavy oils;
- increasingly cleaner cars due to EU emission regulations for new road vehicles.

Table 2.1 Total national emissions of main pollutants and PM10, 1990–2023

Year	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC
	Tg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**682.2**	**600.8**	**198.1**	**346.6**	**57.2**	**80.5**	**102.2**	**14.2**
1995	579.7	432.6	136.9	219.9	45.2	62.7	79.5	12.2
2000	491.3	334.6	78.5	174.9	34.7	50.0	57.0	10.6
2005	432.3	268.1	67.8	155.2	28.4	42.2	50.8	8.3
2010	345.9	271.9	36.1	134.4	22.0	35.6	43.0	4.9
2015	271.0	255.8	31.0	129.4	17.6	31.5	37.0	3.3
2020	209.0	252.9	19.6	124.6	14.2	26.6	31.1	2.4
2021	204.0	239.6	20.9	122.9	14.4	26.6	31.3	2.3
2022	191.6	240.1	19.6	120.4	14.1	26.5	30.9	2.2
2023	**183.8**	**238.4**	**17.5**	**116.4**	**13.8**	**26.2**	**30.7**	**2.1**
1990-2023 period[1)]	-498.5	-362.3	-180.6	-230.2	-43.5	-54.3	-71.5	-12.1
1990-2023 period[2)]	-73%	-60%	-91%	-66%	-76%	-67%	-70%	-85%

1. Absolute difference in Gg
2. Relative difference from 1990 in %

As a result of following the 'best science', several sources of NMVOC were added to the inventory after setting the targets in 2013. As a result of this, the Netherlands' 2022 submission was not in compliance with the reduction target for NMVOC in the year 2020. For the purpose of demonstrating compliance with the 2013 targets, the Netherlands applied for an inventory adjustment in its 2022 submission. After being reviewed, this adjustment was approved by the EMEP-EB (EMEP-Executive Body).

In the current IIR-submission for 2025, non-compliance continues for the 2020 unadjusted NMVOC emissions. For the purpose of demonstrating compliance, this will be adjusted in line with the adjustment already approved in 2022.

A complete discussion and justification for this adjustment can be found in Chapter 13 (Adjustments).

2.1.1 *Trends in nitrogen oxides (NO_x)*

The Netherlands' NO_x emissions decreased by 499 Gg in the 1990–2023 period to 184 Gg, a 73% decline compared to the national total in 1990 (Figure 2.1). Although all sectors show a decrease over this period, the main contributors to this decrease were the Road transport, Industry and Energy sectors. In the Road transport source category, emissions per vehicle decreased significantly over this period due to increasingly cleaner vehicles. However, this reduction was partially negated by an increase in the number of vehicles and total mileage. In 2023, the Transport sector still is the main contributor to NO_x emissions, with a 57% share of the national total. Especially in Road transport and Civil aviation, the effects of the COVID-19 pandemic are visible in both the 2020 and the 2021 emissions. For Road transport, this is the result of the fact that fewer kilometres were driven as most people worked from home. For Civil aviation, there was a strong decrease in landing and take-off cycles (LTO), due to flight cancellations and travel restrictions. The individual relative shares in the national total of the Energy, Industry (combustion) and Transport sectors show a decrease over the 1990–2023 period, while the relative share of Agriculture increased from 7% to 17%.

Total NO_x emissions in 2023 decreased by 7.8 Gg compared to 2022. This is the result of high gas prices, increasingly modern road transport vehicles and reduced coal use for electricity production.

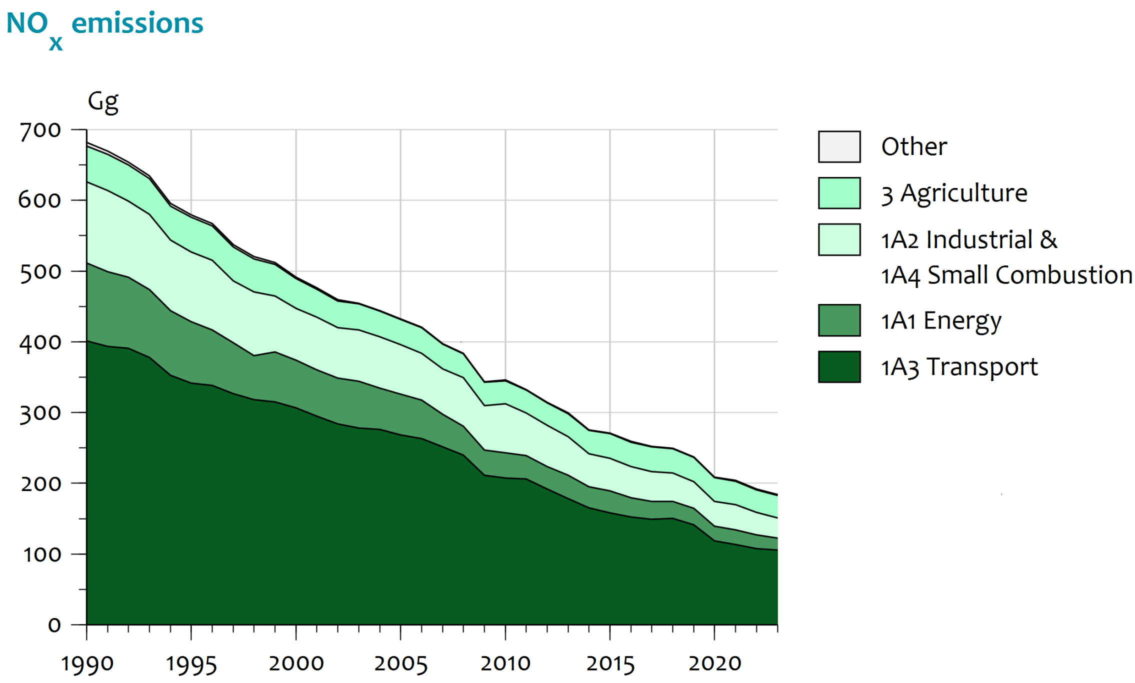


Figure 2.1 NOx emission trends, 1990–2023

2.1.2 *Trends in sulphur oxides (SO_x)*

Dutch SO_x emissions (reported as SO_2) decreased by 181 Gg in the 1990–2023 period to 18 Gg, a 91% decline compared to the national total in 1990 (Figure 2.2). The main contributors to this decrease were the Energy, Industry, and Transport sectors. The use of coal decreased, and major coal-fired electricity producers installed flue-gas desulphurisation plants. In addition, the sulphur content in fuels for the (chemical) industry and traffic was reduced. Over the 1990–2018 period, oil refining was the main contributor to total SO_x emissions, with shares of 34% and 39% in 1990 and 2018, respectively. During the 2019–2021 period, Industry became the main contributor to the national SO_x emissions. In 2022 and 2023, Oil refineries were the main source again, as a result of the high oil and gas prices due to the war in Ukraine.

In 2023, the combined Industry, Energy and Refining source sectors are responsible for 90% of national SO_x emissions. Compared to 2022, SO_x emissions decreased by 2.1 Gg as a result of a lower sulphur content in the refinery gas used, and reduced coal use for electricity production.

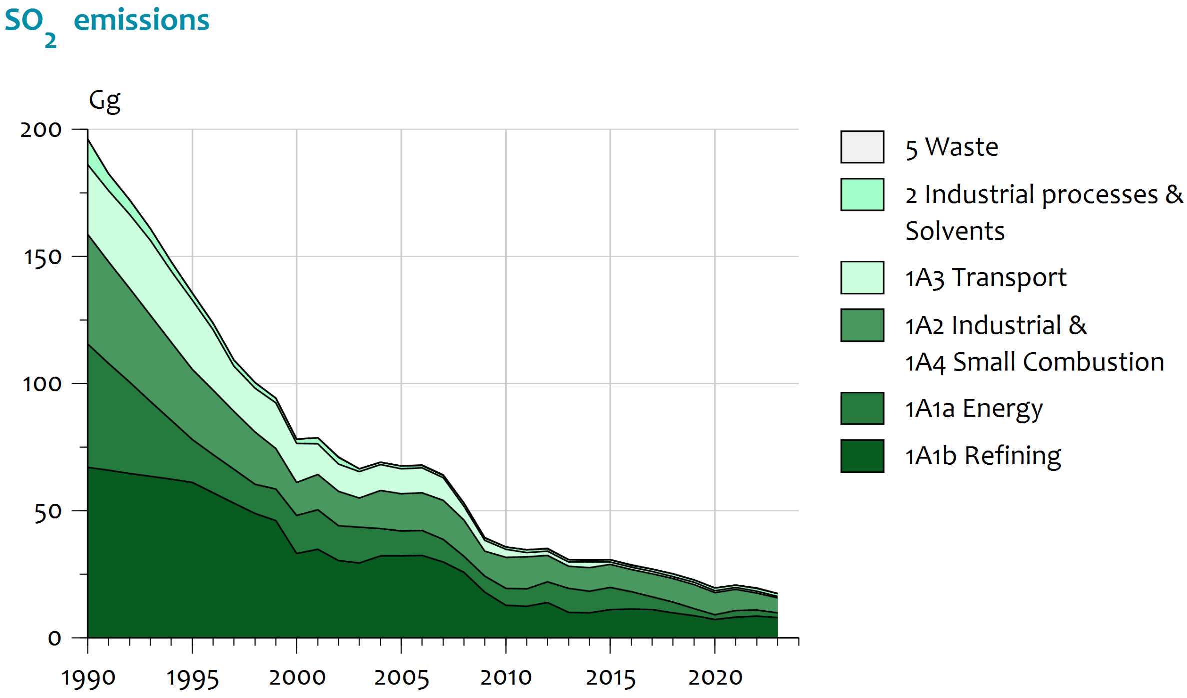


Figure 2.2 SOx emission trends, 1990–2023

2.1.3 *Trends in ammonia (NH_3)*

The NH_3 emissions decreased by 66% between 1990 and 2023, from 346.6 Gg to 116.4 Gg. Most of the NH_3 emissions (90% in 2023) originate from agricultural sources (Figure 2.3). During the 1990–2013 period, the decrease in NH_3 emissions was due to a decrease in livestock numbers, low-protein feed, covering manure storage, low-emission fertilisation, and low-emission stables. Between 2014 and 2017, after years of decline, NH_3 emissions increased again. This was mainly caused by a rise in animal numbers due to the abolition of the milk quota and the changed composition of feed for livestock. The increase in emissions was partially mitigated by cleaner stable systems for pigs and poultry. From 2018 onwards, NH_3 emissions have decreased again. This was due to declining animal numbers resulting from the introduction of the policy to limit phosphate production, a further increase in the use of low-emission pig stables, and the mandatory dilution of manure when applying it to clay and peat grasslands.

In 2023, the remaining 10% of the NH_3 emissions came from the sectors Transport (3.4 %), Other (2.9%), Industry (2.3%) and Energy and Waste (1.3% combined).

In 2023, NH_3 emissions decreased by 4 Gg compared to 2022. This reduction mainly occurred in the Agriculture sector and is caused by a decrease in livestock numbers, reduced TAN excretion by pigs and increased processing and export of poultry manure. In the Transport sector, NH_3 emissions increased slightly compared to 2022, by 0.3 Gg, due to modern diesel cars with SCR catalysts having higher NH_3 emissions.

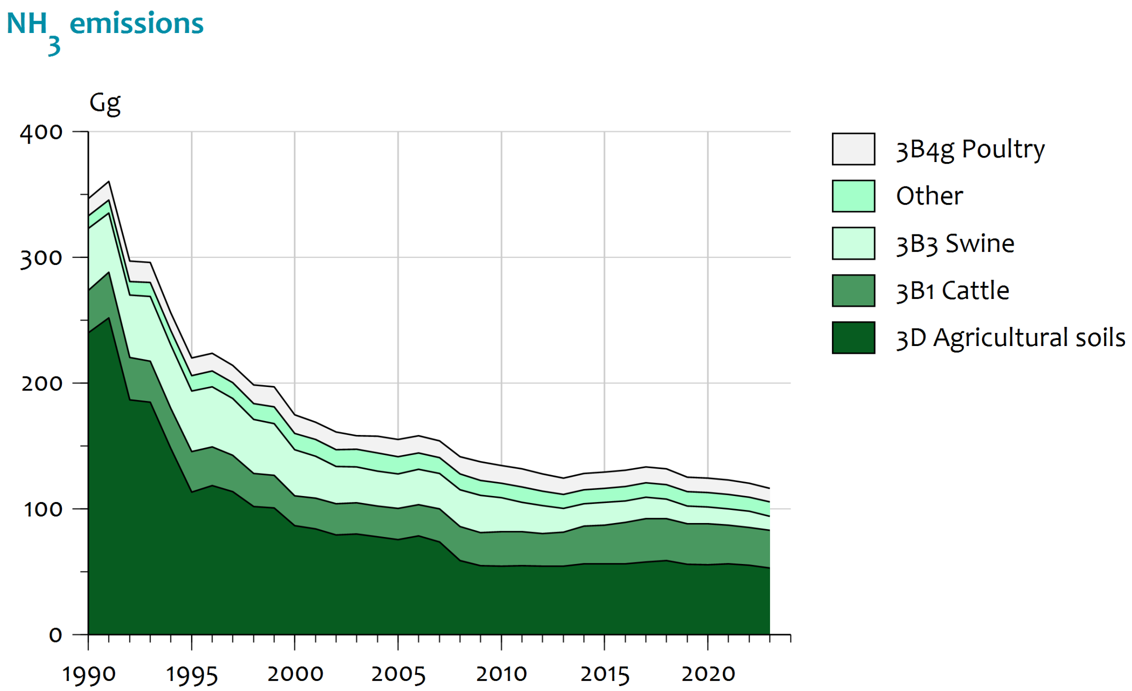


Figure 2.3 NH_3 emission trends agriculture 1990–2023

2.1.4 *Trends in non-methane volatile organic compounds (NMVOC)*

In the 1990–2023 period, NMVOC emissions decreased from 601 to 239 Gg, a decline by 60% (Figure 2.4). Emissions decreased mainly in Transport (due to the introduction of catalysts and cleaner engines), product use (thanks to an intensive programme to reduce the NMVOC content in consumer products and paints) and Industry (as a result of the introduction of emission abatement techniques specifically for NMVOC). In Agriculture NMVOC emissions from soils initially decreased in the 1990–1995 period because of changes in the method of manure application. However, emissions from agricultural soils remained constant over the 1996–2022 period while the NMVOC emissions from live stock in the 1990–2022 period increased, mainly as result of the increased use of silage.

In 2020, there was a peak in total NMVOC emissions due to the increased use of hand sanitisers during the COVID-19 pandemic. Subsequently, total NMVOC emissions decreased again. However, emissions specifically from hand sanitisers have shown an upward trend since 2021.

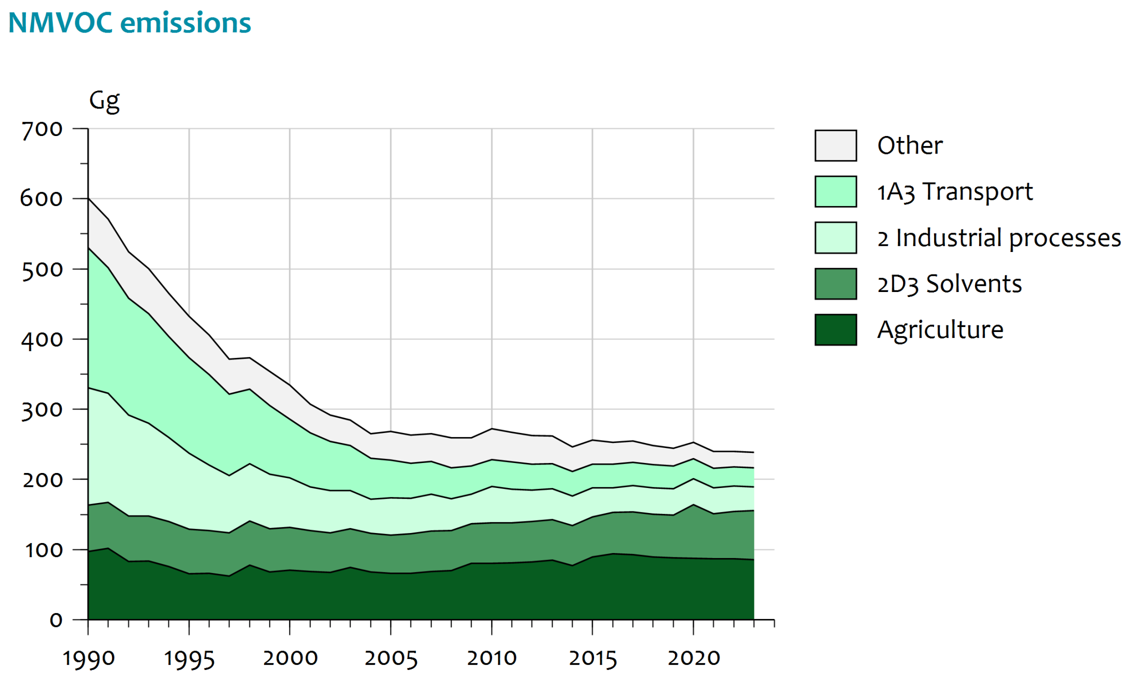


Figure 2.4 NMVOC emission trends, 1990–2023

2.1.5 *Trends in $PM_{2.5}$*

Most $PM_{2.5}$ emissions are calculated as a specific fraction of PM_{10} by sector (based on Visschedijk et al. (2007)). In the 1990–2023 period, $PM_{2.5}$ emissions decreased by 43.5 Gg to 13.8 Gg, a decline by 76% (Figure 2.5). The three major source categories contributing to this decrease were the Industry, Energy and Transport sectors. In the Industry sector, the refineries use increasingly cleaner fuels, and in both the Industry and the Energy sectors, abatement technology has been installed. Emission reduction in the Transport sector (road transport) is the result of increasingly stringent EU emissions standards that led to better engine management and particulate filters.

Compared to 2022, $PM_{2.5}$ emissions in 2023 decreased by 0.3 Gg. This reduction mainly occurred in the Industry sector, due to declining demand caused by high energy prices, and in the Energy sector, due to reduced use of coal.

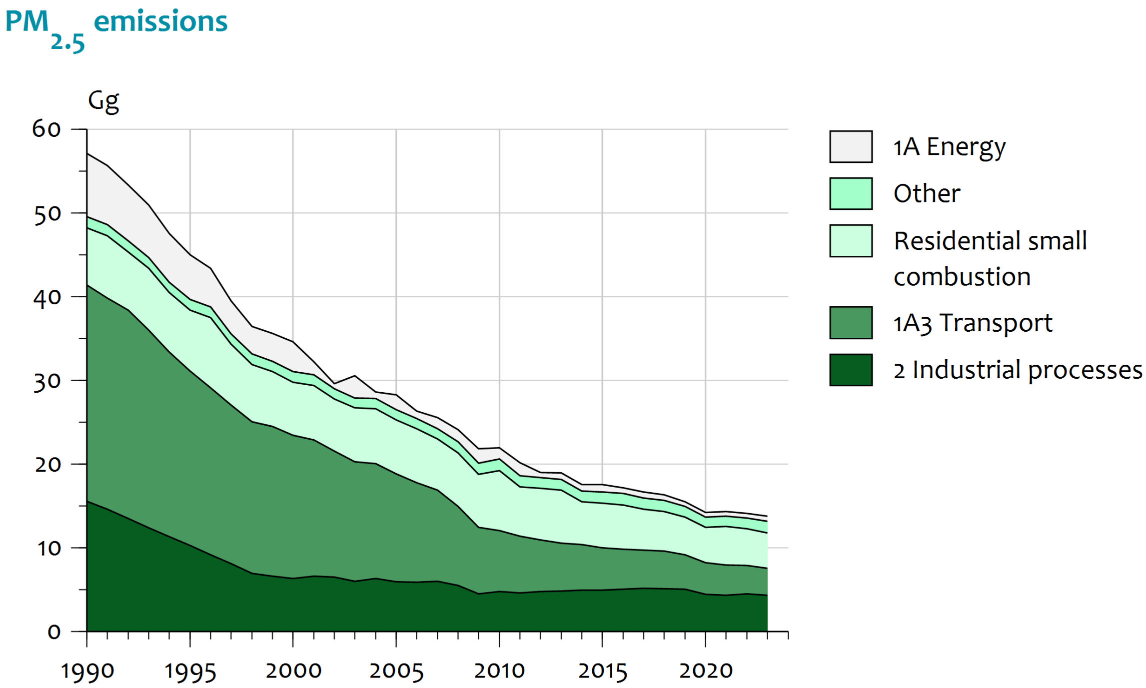


Figure 2.5 $PM_{2.5}$ emission trends, 1990–2023

2.1.6 *Trends in PM_{10}*

Over the 1990–2023 period, PM_{10} emissions decreased from 80.5 to 26.2 Gg, a decline by 67% (Figure 2.6). The three major source categories contributing to this decrease were the Industry, Energy and Transport sectors. In the Industry sector, the refineries increasingly use cleaner fuels, and in both the Industry and the Energy sectors, abatement technology has been installed. Emission reductions in the Transport sector (road transport) are the result of increasingly stringent EU emissions standards that led to better engine management and particulate filters.

From 1990 to 2011, PM_{10} emissions from agriculture gradually increased. This was mainly caused by a change in housing systems (a shift from liquid manure to solid manure systems), especially for laying hens.

In 2023, total PM_{10} emissions decreased by 0.3 Gg compared to 2022.

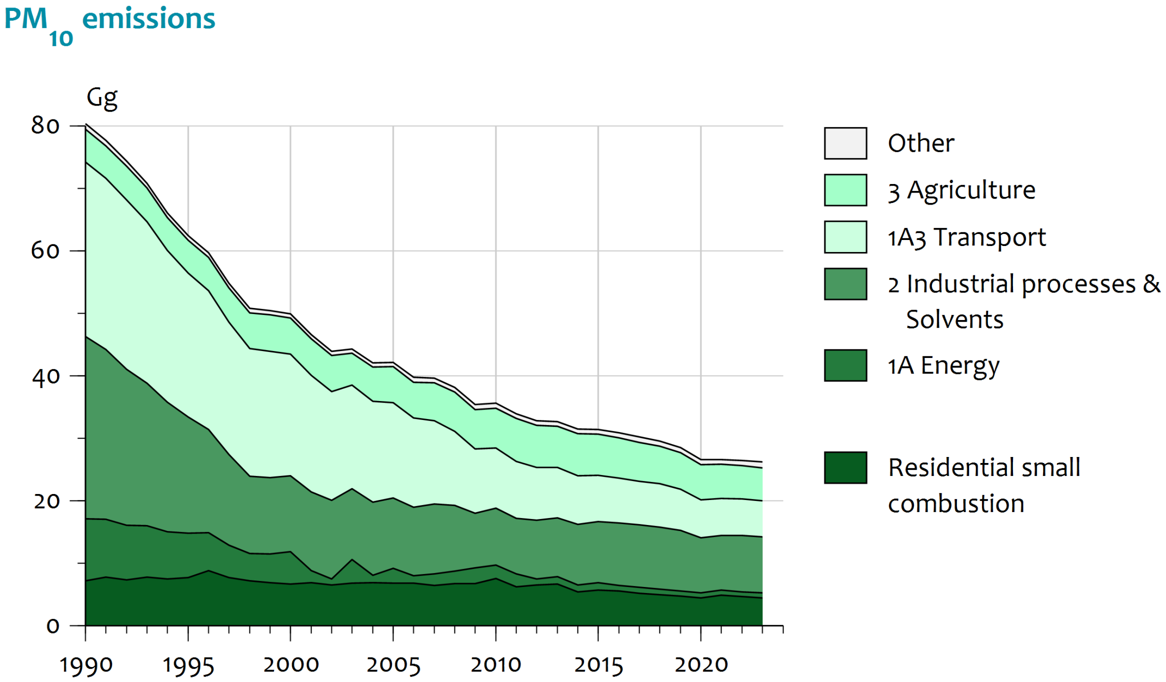


Figure 2.6 PM_{10} emission trends, 1990–2023

2.2 National emissions of priority heavy metals

Under the Protocol to the Convention on Long-range Transboundary Air Pollution on Heavy Metals and the Gothenburg Protocols, the Netherlands is committed to reducing its total annual emissions of priority heavy metals (lead, cadmium and mercury). The base year for this commitment is 1990. In 2023, all priority heavy metal emissions comply.

Table 2.2 Total national emissions of priority heavy metals, 1990–2023

	Priority Heavy Metals		
	Pb	Cd	Hg
Year	Mg	Mg	Mg
1990	**336**	**4.1**	**3.7**
1995	155	3.1	1.6
2000	29	3.1	1.2
2005	30	3.8	1.0
2010	38	4.7	0.77
2015	8.7	2.9	0.69
2020	5.8	2.0	0.47
2021	4.9	0.88	0.45
2022	4.6	0.80	0.48
2023	**4.0**	**0.47**	**0.43**
1990-2023 period[1)]	-332	-3.6	-3.2
1990-2023 period[2)]	-99%	-88%	-88%

1. Absolute difference
2. Relative difference from 1990 in %

2.2.1 *Trends in lead (Pb)*

Over the 1990–2022 period, lead (Pb) emissions in the Netherlands decreased from 336 Mg to 4.0 Mg, a 99% decline (Figure 2.7). This decrease is primarily attributable to the Transport sector, where, due to the removal of Pb from gasoline, Pb emissions collapsed. Other sources contributing to this decrease are industrial process emissions, particularly from the iron and steel industry (due to the replacement of electrostatic filters and the optimisation of various other reduction technologies at Tata Steel).

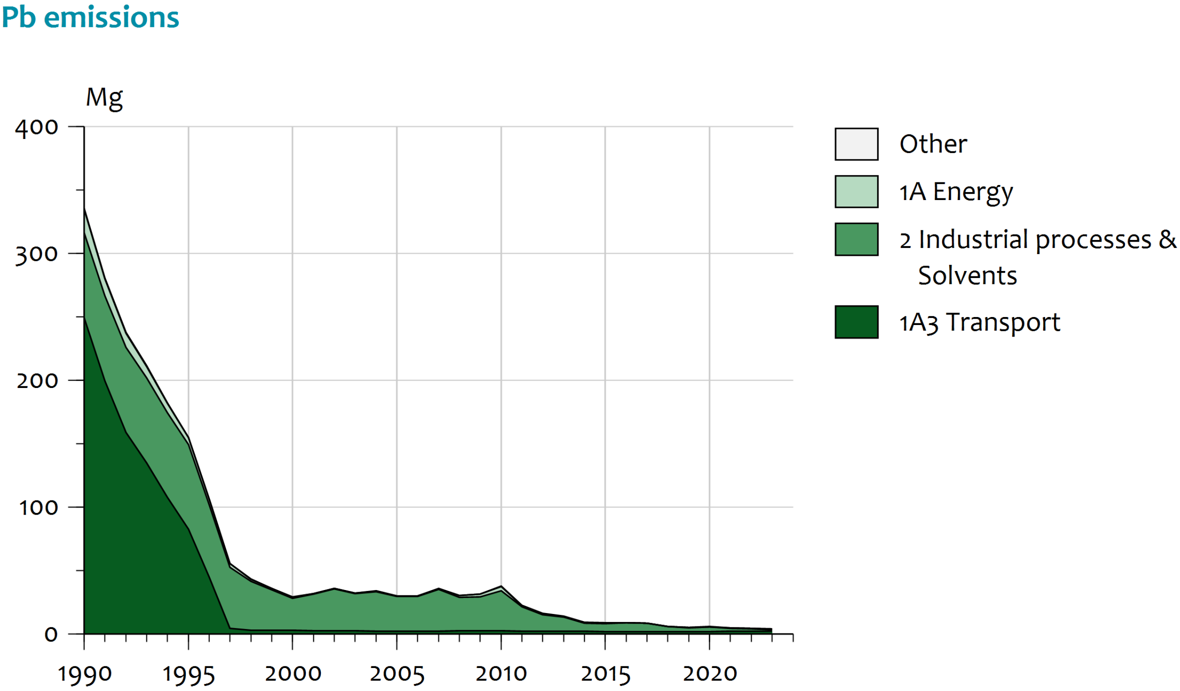


Figure 2.7 Pb emission trends, 1990–2023

2.2.2 *Trends in Cadmium (Cd)*

Over the 1990–2023 period, cadmium (Cd) emissions in the Netherlands decreased from 4.1 Mg to 0.47 Mg, an 88% decline (Figure 2.8). This decrease is primarily attributable to the Energy sector and Other sources, where cadmium emissions from the only zinc production plant (Nystar) were the main source. The emissions from zinc production gradually increased until 2019. After 2019 the Cd emissions from zinc production decreased sharply. The reason reported by the zinc production plant was that the gases coming from a venturi scrubber sometimes contain aerosols with high concentrations of zinc. This affects the measurements of zinc concentration in the emitted gas as the aerosol is not always captured in the sampling. New measurements in 2021 resulted in significantly lower emission factors.

The increased Cd emissions over the 2000–2011 period in Other sources result from the activities of one operator in the Chemical industry (ThermPhos). This operator ended production in 2011.

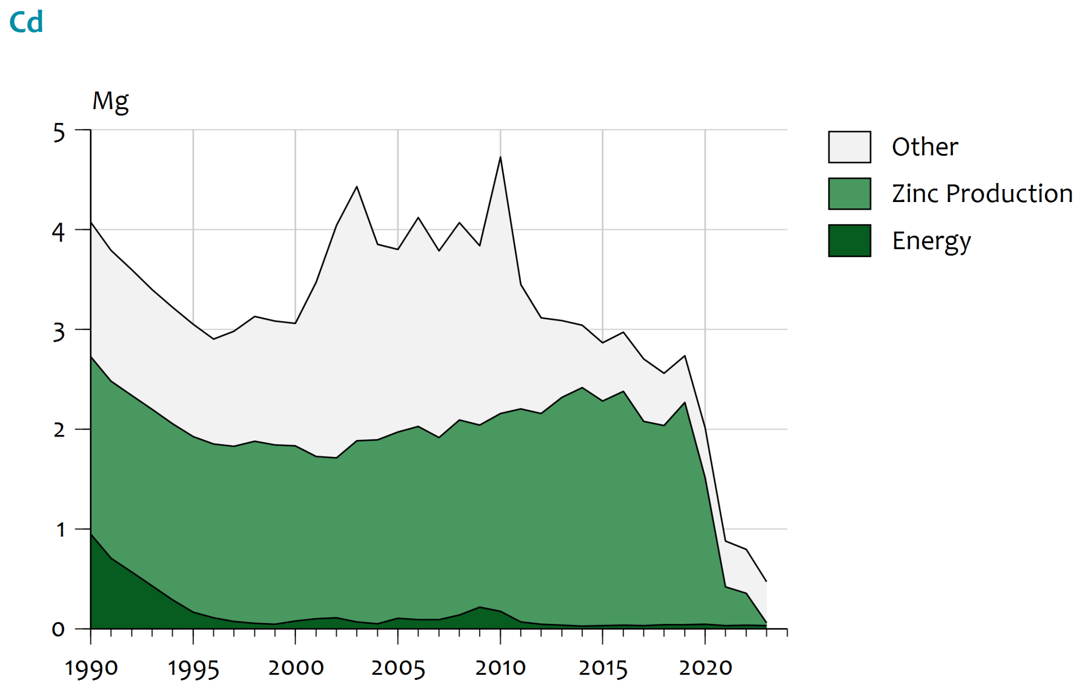


Figure 2.8 Cd emission trends, 1990–2023

2.2.3 Trends in Mercury (Hg)

Over the 1990–2023 period, mercury (Hg) emissions in the Netherlands decreased from 3.7 Mg to 0.43 Mg, an 88% decline (Figure 2.9). In 1990, the Energy and Industry (industrial processes) sectors were the main source of Hg emissions with 1.9 Mg and 1.2 Mg, respectively, and had a combined total Hg emission of 86% of the national total. In 2023, these sectors reduced their combined Hg emissions to 0.24 Mg (56% of the 2022 national total).

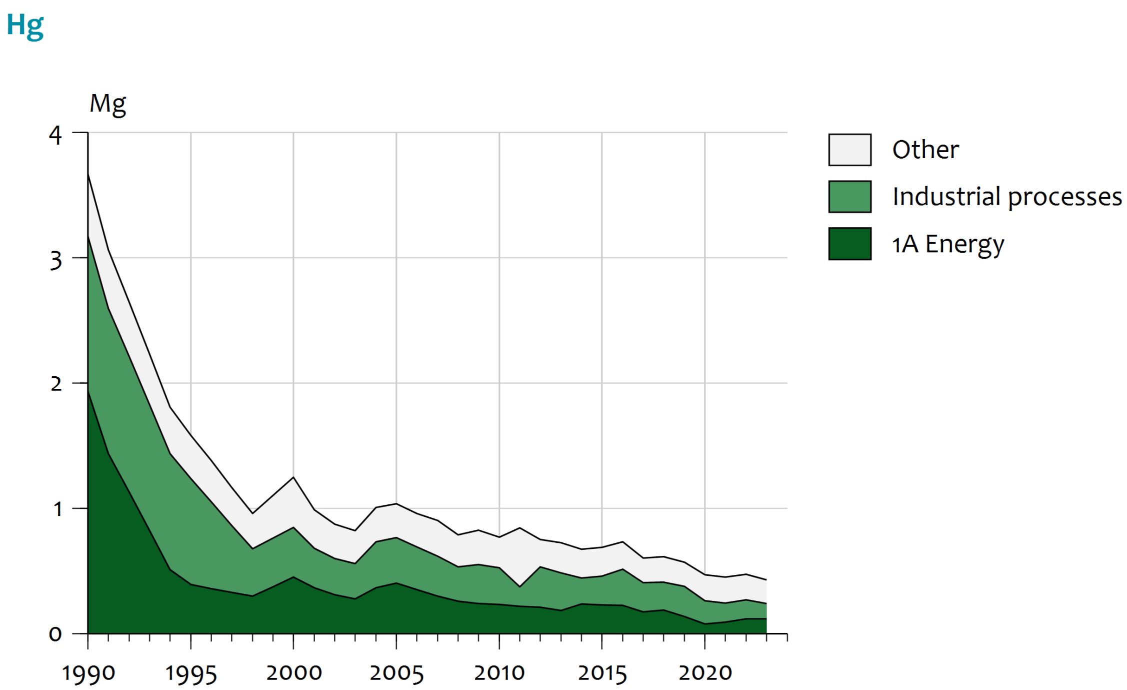


Figure 2.9 Hg emission trends, 1990–2023

2.3 National emissions of persistent organic pollutants

On the basis of the Protocol on Persistent Organic Pollutants (POPs), the Netherlands is committed to reducing its total annual emissions of Polycyclic Aromatic Hydrocarbons (PAHs), Dioxins/furans (PCDDs/PCDFs), Hexachlorobenzene (HCB) and Polychlorinated biphenyls (PCBs). The base year for the POP commitment is 1990 for PAHs, PCDDs/PCDFs and HCB and 2005 for PCBs. In 2023, all POP emissions comply.

Table 2.3 Total national emissions of POPs, 1990–2023

	POPs			
	DIOX	PAH	HCB	PCB
Year	g I-Teq	Mg	kg	kg
1990	745	21	66	38
1995	70	12	40	22
2000	38	6.6	17	0.26
2005	35	6.6	3.4	0.27
2010	40	7.5	3.5	0.27
2015	32	6.1	4.1	0.33
2020	30	4.9	3.4	0.14
2021	30	5.4	3.4	0.19
2022	30	5.4	3.3	0.18
2023	43	5.1	3.2	0.13
1990-2023 period[1)]	-702	-16	-63	-38
1990-2023 period[2)]	-94%	-76%	-95%	-100%

1. Absolute difference
2. Relative difference from 1990 in %

2.3.1 Trends in dioxins/furans (PCCD/PCDF)

In the Netherlands, emissions of dioxins/furans mainly result from waste combustion in the Energy sector, residential wood combustion and accidental car and building fires. Over the 1990–2023 period, emissions of dioxins/furans in the Netherlands decreased from 745 g I-TEQ to 43 g I-TEQ, a 94% decline (Figure 2.10). This decrease is primarily attributable to reduced emissions from waste incineration in the Energy sector. The rapid decrease of dioxins/furans emissions in this sector is due to both better incinerator management (temperature) and the introduction of abatement technology at waste incinerators.

In 2023, the emissions of dioxins/furans increased by 13 g I-TEQ compared to 2022. This is caused by one waste incineration plant reporting higher emissions of dioxins.

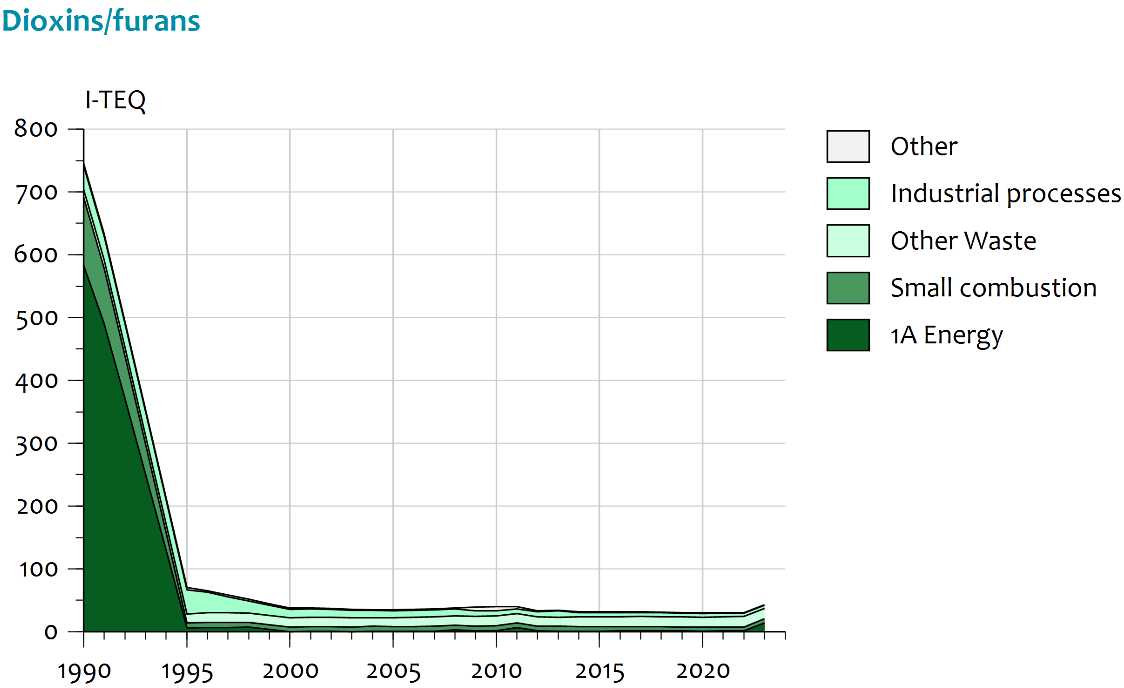


Figure 2.10 Dioxins/furans emission trends, 1990–2023

2.3.2 *Hexachlorobenzene*

Over the 1990–2023 period, emissions of hexachlorobenzene (HCB) in the Netherlands decreased from 66 kg to 3.2 kg, a 95% decline (Figure 2.11). This decrease is primarily attributable to the Energy sector (waste incineration for energy) and the Agricultural sector (use of pesticides). The decrease in the Agricultural sector is due to the reduction in the number of applied pesticides containing HCB as well as to a reduction in the maximum amount of HCB allowed as a contaminant in pesticides. HCB from agriculture is calculated from the annual sales of HCB-containing pesticides. The increased HCB emissions from agriculture between 1996 and 2000 were the result of increased sales of the chlorothalonil fungicide that contained HCB as an impurity.

HCB

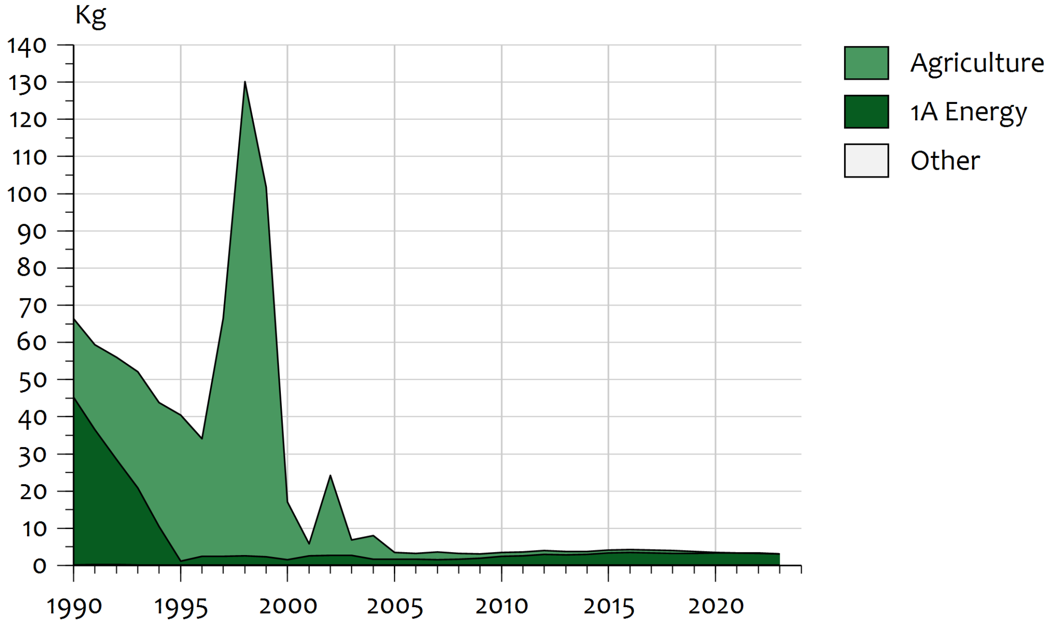


Figure 2.11 HCB emission trends, 1990–2023

2.3.3 *Polychlorinated biphenyl*

Over the 1990–2023 period, polychlorinated biphenyl (PCB) emissions in the Netherlands collapsed from 38 kg to 0.13 kg, a 100% decline (Figure 2.12). This decrease is attributable to all sectors and is due to the ban on the production and use of PCBs. This ban resulted in a relatively fast decrease of PCB use in (electronic) products and oil in electrical transformers.

PCB

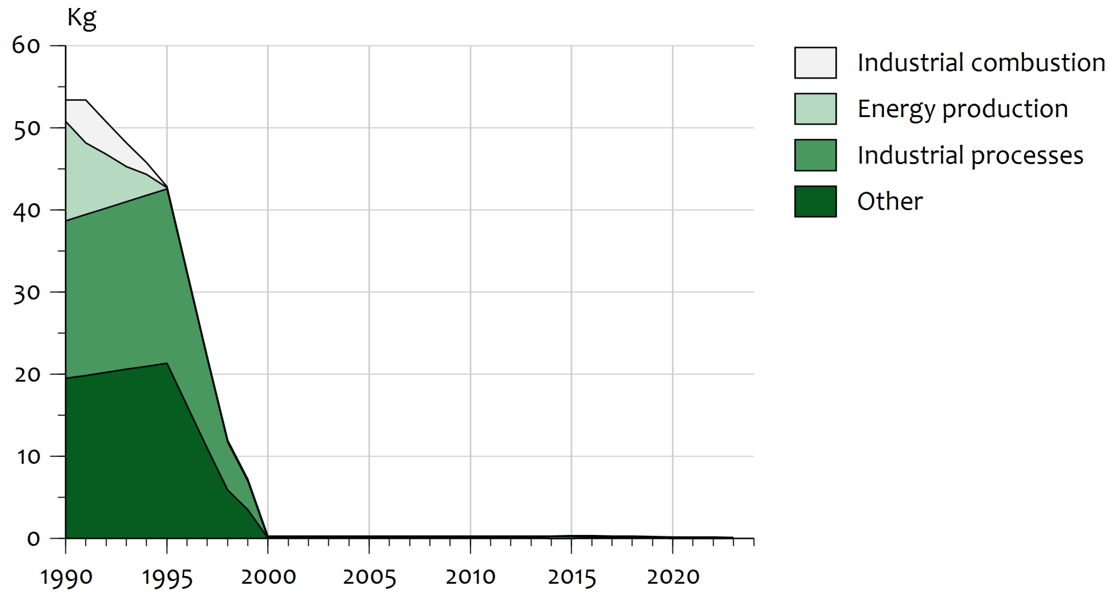


Figure 2.12 PCB emission trends, 1990–2023

3 Energy

3.1 Overview of the sector

Emissions from the Energy sector include all energy-related emissions from stationary combustion, as well as fugitive emissions from the Energy sector.

The majority of the emissions from stationary combustion for electricity production and industry (NFR categories 1A1 and 1A2) are reported in the AERs (Annual Environmental Reports) submitted by large industrial companies. For SO_x in 2023, in the categories 1A1 and 1A2 (excluding 1A2gvii), 98% of the emissions were based on company data (AERs and other company data), while for other pollutants, the proportions were 93% (NH_3), 80% (NMVOC), 90% (NO_x) and 85% (PM_{10}). The emission data from individual companies comes from direct emission measurements or from calculations using fuel input and EFs. Most of the emission data from 'other' stationary combustion (categories 1A4 and 1A5) was calculated using energy statistics and default EFs.

As in most other developed countries, the energy system in the Netherlands is largely driven by the combustion of fossil fuels. In 2023, the total of primary fuels used in the Netherlands consisted of natural gas (36%), liquid fuels (42%), biogenic fuels (14%), solid fuels (6%) and waste (3%). Figures 3.1 and 3.2 represent the energy supply and energy demand in the Netherlands. The energy consumption is directly related to the temperature during the winter. The natural gas consumption is higher in cold winters (e.g. 1996 and 2010) and lower in warm winters (e.g. 2014). The decrease in natural gas consumption in 2022 is due to the high natural gas prices in 2022.

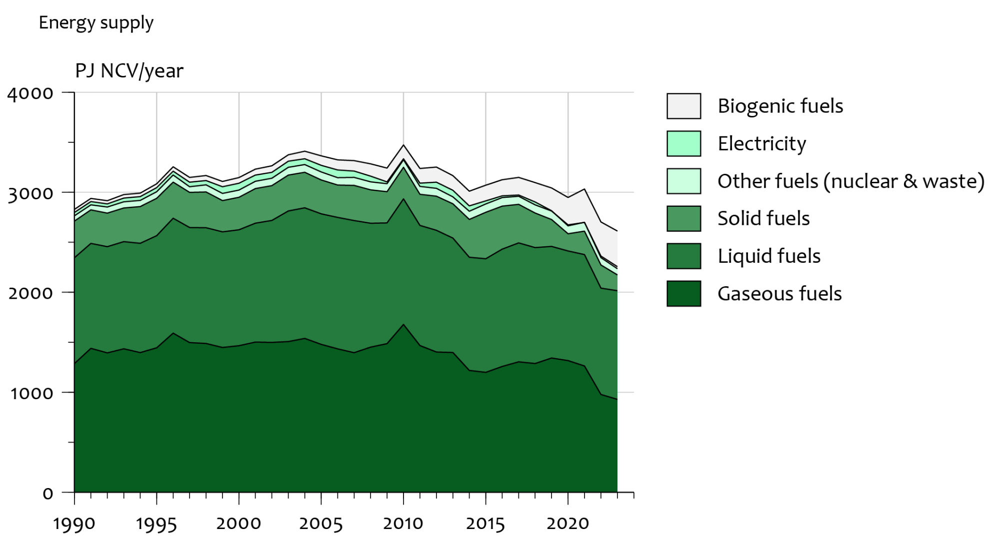


Figure 3.1 Energy supply by fuel in the Netherlands, 1990–2023 ('Electricity' refers to imported electricity only)

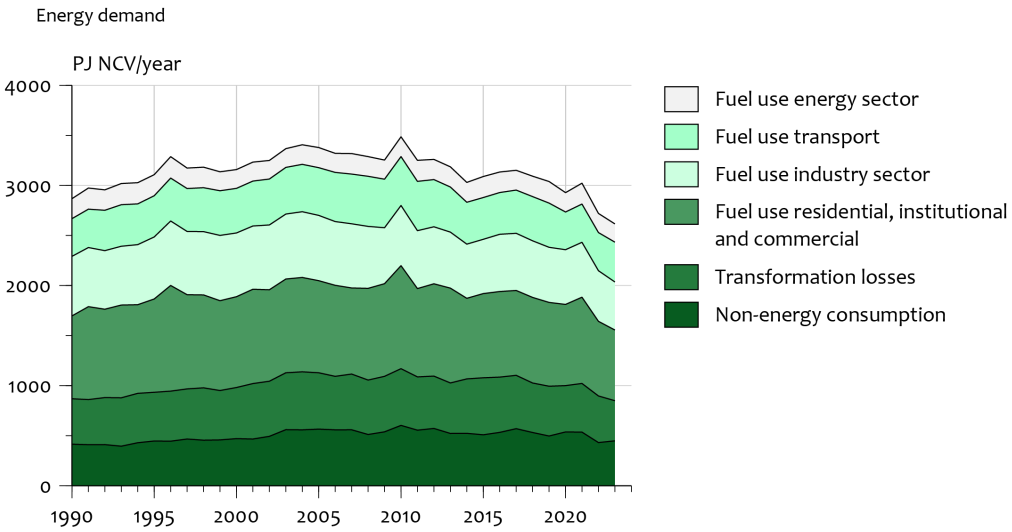


Figure 3.2 Energy demand in the Netherlands, 1990–2023

The full energy statistics are available on the website of Statistics Netherlands. The following link refers to the energy statistics for 2023: https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B37C0. On this website, it is also possible to access data for other years.

3.2 Public electricity and heat production (1A1a)

3.2.1 Source category description

In this section, one source category is included: Public electricity and heat production (1A1a). This source category consists mainly of gas-fired cogeneration plants and coal-fired power stations. Waste incineration plants with energy recovery generate a relatively small share (~2%) of electricity in the Netherlands. All waste incineration plants recover energy and are included in source category 1A1a. Renewable energy (biomass, solar and wind) used to make a small contribution to the total primary energy supply in the Netherlands, but is increasing to 14%.

3.2.2 Key sources

In 2023, the source category 1A1a is a key source of the pollutants listed in Table 3.1.

Table 3.1 Pollutants for which the Public electricity and heat production sector (NFR 1A1a) is a key source

Category / Subcategory	Pollutant	Contribution to national total of 2023 (%)
1A1a Public electricity and heat production	SO_x	10.4
	NO_x	5.7
	Hg	27.7
	Cd	7.2
	Pb	4.6
	Dioxins	33.2
	HCB	94.2
	PCB	40.1

3.2.3 *Overview of shares and trends in emissions*

An overview of the trends in emissions is provided in Table 3.2. For nearly all pollutants, emissions decreased between 1990 and 2023. Over the same period, total fuel consumption increased in source category 1A1a.

Table 3.2 Overview of trends in emissions in sector 1A1a Public electricity and heat production

Year	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**82.9**	**0.89**	**48**	**0.00**	**1.8**	**2.2**	**2.5**	**0.03**	**8.3**
1995	62.1	1.7	17	0.04	0.39	0.63	0.99	0.01	7.6
2000	51.5	2.1	15	0.04	0.25	0.33	0.33	0.01	15.4
2005	43.4	0.91	9.9	0.26	0.40	0.54	0.82	0.01	8.3
2010	25.6	0.67	6.7	0.07	0.22	0.29	0.60	0.01	4.8
2015	20.5	0.70	8.6	0.09	0.30	0.40	0.78	0.01	4.6
2020	13.5	0.68	1.8	0.11	0.09	0.12	0.20	0.00	3.5
2022	12.8	0.63	2.4	0.11	0.13	0.16	0.25	0.00	4.4
2023	**10.5**	**0.65**	**1.8**	**0.10**	**0.11**	**0.13**	**0.21**	**0.00**	**3.6**
1990-2023 period[1)]	-72	-0.24	-47	0.10	-1.7	-2.1	-2.3	-0.03	-4.7
1990-2023 period[2)]	-87%	-27%	-96%		-94%	-94%	-91%	-88%	-57%

Table 3.2 Overview of trends in emissions in sector 1A1a Public electricity and heat production (continued)

Year	Priority Heavy Metals			POPs		Other Heavy Metals					
	Pb	Cd	Hg	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	**16.3**	**0.95**	**1.9**	**583**	**0.18**	**0.53**	**0.68**	**2.1**	**2.5**	**0.02**	**41**
1995	1.6	0.16	0.39	6.1	0.06	0.23	0.37	0.47	1.4	0.06	3.34
2000	0.34	0.08	0.45	0.13	0.01	0.24	0.24	0.24	0.31	0.72	0.56
2005	0.35	0.11	0.40	0.79	0.01	0.26	0.35	0.34	2.0	1.9	0.75
2010	0.34	0.18	0.23	1.2	0.02	0.17	0.14	0.19	0.16	1.3	3.9
2015	0.16	0.03	0.23	1.1	0.03	0.09	0.16	0.20	0.17	0.91	4.1
2020	0.13	0.05	0.08	1.1	0.04	0.08	0.10	0.15	0.08	0.10	0.82
2022	0.08	0.04	0.12	1.3	0.04	0.06	0.09	0.10	0.19	0.07	1.18
2023	**0.18**	**0.03**	**0.12**	**14.3**	**0.03**	**0.06**	**0.12**	**0.14**	**0.24**	**0.02**	**0.41**
1990-2023 period[1)]	-16.2	-0.91	-1.8	-568	-0.14	-0.47	-0.56	-1.9	-2.3	-0.01	-40
1990-2023 period[2)]	-99%	-96%	-94%	-98%	-81%	-88%	-83%	-93%	-90%	-30%	-99%

1. Absolute difference
2. Relative difference compared to 1990 in %

Between 1990 and 2023, NO_x and SO_x emissions decreased by 87% and 96%, respectively. Other pollutant emissions decreased by at least 75%, except for CO (-57%), NMVOC (-27%), Se (-30%) and NH_3. The overall decrease in emissions was caused by a shift in fuel type, and by technological improvements (especially the large decrease in dioxin emissions). The increases in NH_3 and Se were due to a possible underestimation of emissions in 1990, which improved once individual companies started submitting annual environmental reports (AERs) from 2000 onwards.

3.2.4 *Activity data and (implied) emission factors*

Emission data is based on emissions reported in AERs and on calculated emissions for the companies that did not report their emissions in an AER. For this source category, a large part of the 2023 emission figures is based on AERs: NO_x (96%). NMVOC (84%), SO_x (98%), NH_3 (96%) and $PM_{2.5}$ (76%). To estimate emissions from other emission sources in this sector (for which no emissions were reported in AERs), national energy statistics (from Statistics Netherlands) are combined with IEFs from the AERs or with default EFs (see Table 3.3).

The activity data in the NFR tables is based on the reported activity data in the AERs of the individual companies, and the energy statistics data that is used for the emission calculation of the non-reporting companies. Please note that activity data reported in the AERs could be incomplete (especially in earlier years). Therefore, the activity data in the NFR could also be incomplete, but this does not affect the reported emissions.

Table 3.3 Default EFs for electricity production (g/GJ), used only for fuel consumption and emissions that were not reported by individual companies

Substance name	Natural gas	Biogas	Wood
NMVOC	2.6[1]	2.6[4]	1.33[5]
Sulphur dioxide	0.281[1]	0.281[4]	10.8[6]
Nitrogen oxides as NO_2	19.1[2]	89[4]	70[5]
Ammonia			1.2[7]
Carbon monoxide	15.0[2]	39[4]	150[5]
PM_{10}	0.2[3]	0.89[4]	10[5]

1. EMEP/EEA Guidebook (2019), 1A1, table 4.6, default value
2. Specific EFs derived from reported emissions in e-AERs
3. EMEP/EEA Guidebook (2019), 1A1, table 3.17, default value
4. EMEP/EEA Guidebook (2019), 1A1, table 3.4, default value
5. Koppejan and De Bree. (2018)
6. EMEP/EEA Guidebook (2019), 1A1, table 3.7, default value
7. EMEP/EEA Guidebook (2019), 1A2, table 3.5, default value

Emission data in AERs is calculated by companies on the basis of stack measurements or (default or technology-specific) emission factors combined with fuel consumption data. When emissions in AERs are calculated on the basis of stack measurements, they are calculated using uncorrected measurement data (i.e. no correction for the confidence interval). To calculate industrial emissions, Dutch companies are obligated to follow the guidance given in the Netherlands' PRTR regulations. The relevant documents are to be found on the government website https://iplo.nl/thema/lucht/stookinstallaties/ (in Dutch only).

These documents explicitly state that emissions shall be calculated by the companies using uncorrected measurement data, and that the confidence interval may not be subtracted. Additionally, the calculations shall include emissions during stops, starting-up and incidents. The competent authorities confirmed that they check whether companies use uncorrected measurement data for calculating emissions.

The AERs might be incomplete when a company does not report emissions that are below the reporting threshold. Additional estimates are made for these missing emissions:

- Since PCB emissions are not reported by individual companies, they are calculated for the entire sector. The activity data has been derived from the energy statistics and can be accessed here: https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B54BA. The PCB EF for solid biomass has been derived from the EMEP/EEA Guidebook (2019), chapter 1A2, table 3.5. The PCB EF for waste is from the EMEP/EEA Guidebook (2019), chapter 5C1a, table 3.1. The PCB EF of bituminous coal in 1A1 and 1A2 is based on the correlation between the dioxin and PCB EFs in the Guidebook and the reported dioxin emissions in the Dutch emission inventory. This results in an EF of 52.4 µg/GJ in 1990 and 0.67 µg/GJ from 1995 onwards (see Table 3.4). See Honig et al. (2025) for further details regarding the PCB EF.
- Since heavy metal emissions from the use of natural gas are not reported by individual companies either, they are calculated for the entire sector. The activity data has been derived from the energy statistics and can be accessed here: https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B54BA. The mercury EF is based on a study by the Dutch gas company Gasunie, while Tier 1 emission factors from the EMEP/EEA Guidebook 2019 (1A1, table 3.4) are used for the other metals. The resulting emission factors are presented in Table 3.5.
- PAH, dioxin and HCB emissions are not always reported by individual companies. Individual estimates of these emissions have been made for all industrial stationary combustion sectors and for solid fuels, liquid fuels (except diesel and LPG), gaseous fuels (except natural gas) and biomass (except biogas). The emissions have been calculated as a fraction of the reported hydrocarbon emission. The fraction is based on the ratio between the Tier 1 emission factors of PAH/dioxin/HCB/PCB with NMVOC from chapters 1A1 and 1A2 of the EMEP/EEA Guidebook (2023) and an assumed abatement efficiency of 90%. If the individual emission is higher than the reporting threshold, it is assumed that the emission is equal to the reporting threshold (assuming that a company would have reported these emissions if they exceeded the reporting threshold). If a company has already reported a certain emission, the individual emission estimate for that company is discarded, and only the reported emission is used.
- Since HCB emissions from incineration plants are not reported by individual companies, they are calculated with an EF of 0.2

mg/Mg waste (lower value of the EF from the EMEP/EEA Guidebook 2019, chapter 5.C.1.a, table 3.2).

- $PM_{2.5}$ emissions are either reported by individual companies or calculated using default $PM_{2.5}/PM_{10}$ ratios. These ratios are based on PM_{10} and $PM_{2.5}$ emissions reported by individual companies (differing per sector, activity and fuel) or literature (e.g. Visschedijk et al. (2004) and Ehrlich et al. (2007)). A complete list of the $PM_{2.5}/PM_{10}$ ratios, including references, is presented in Honig et al. (2025) and in Visschedijk & Dröge (2019). The latter report can be downloaded via: Visschedijk & Dröge (2019).

Table 3.4 List of PCB emission factors of solid fuels (microgram/GJ)

Year	Solid fuels	Waste	Biomass
1990	52.4	0.0034	0.06
1991	42.1	0.0034	0.06
1992	31.7	0.0034	0.06
1993	21.4	0.0034	0.06
1994	11.0	0.0034	0.06
from 1995	0.67	0.0034	0.06

Table 3.5 List of heavy metal EFs of natural gas (mg/GJ)

Pollutant	1990-2009	2010-2016	from 2017
Hg	0.039	0.023	0.01
Pb		0.0015	
Cd		0.00025	
As		0.12	
Cr		0.00076	
Cu		0.076	
Ni		0.00051	
Se		0.0112	
Zn		0.0015	

3.2.5 *Methodological issues*

Emissions are based on data in the AERs relating to individual facilities (Tier 3 methodology). A company needs to submit an environmental report if one or more of the activities of the company is included in annex 1 of the E-PRTR regulation. These companies need to report emissions that exceed the reporting threshold. For some pollutants, the Dutch reporting thresholds are lower than the European reporting thresholds (see the list of thresholds (in Dutch): https://www.e-mjv.nl/sites/default/files/2018-07/stoffenlijst_integraal_prtr-verslag.pdf). Emissions and fuel consumption data in the AERs are systematically examined for inaccuracies by checking the resulting IEFs. If the AERs provide data of sufficient quality, the information is used to calculate an IEF for a cluster of reporting companies (aggregated by NACE code). These IEFs are fuel- and sector-specific and are used to calculate emissions by companies that are not individually assessed.

$$\mathbf{IEF}_{\mathbf{ER\text{-}I}}\ \mathbf{(NACE.\ fuel)} = \frac{\mathbf{Emissions}_{\mathbf{ER\text{-}I}\ \mathbf{(NACE.\ fuel)}}}{\mathbf{Energy\ use}_{\mathbf{ER\text{-}I}\ \mathbf{(NACE.\ fuel)}}}$$

where:
IEF = Implied emission factor from individual companies
ER-I = Emission Registration database for individual companies

Next, combustion emissions by companies that are not individually assessed in this NACE category are calculated from their energy use according to the energy statistics (from Statistics Netherlands), multiplied by the IEF. If the data from the individual companies is insufficient to calculate an IEF, a default EF is used (see Table 3.3).

ER-C_emission (NACE. fuel) = IEF ER-I (NACE. fuel) * energy statistics (NACE. fuel)

where:
ER-C = Emission Registration database for emission data that is not based on emissions reported in an AER

Total combustion emissions are the sum of emissions by the individual companies (ER-I) plus emissions by the companies that are not individually assessed (ER-C).

3.2.6 *Uncertainties and time series consistency*
Uncertainties are explained in Section 1.7.

3.2.7 *Source-specific QA/QC and verification*
Emissions and fuel consumption data in the AERs are systematically examined for inaccuracies by checking the resulting IEFs, the emission trends and the IEF trends. If the AERs provide data of high enough quality (see Section 1.6 on QA/QC), the information is used. Section 3.1 of the ENINA methodology report (Honig et al., 2025) provides a more detailed description of the AER quality checks.

3.2.8 *Source-specific recalculations*
The following recalculations were performed:

Recalculation of reported emissions from individual companies
For several power plants, the heavy metal emissions have been corrected for the years 2000 and 2005, when individual companies sometimes submitted incomplete reports on heavy metal emissions. As a result, additional emission estimates were added for these companies. For one waste plant, the copper and nickel emissions were corrected for 2004, as further study of heavy metal emissions in this year indicated that these emissions were overestimated. Table 3.6 shows the resulting changes in emissions.

Table 3.6 Overview of change in heavy metal emissions in 2000, 2004 and 2005 (kg)

Pollutant	Unit	2000	2004	2005
As	kg	118.07		57.35
Cd	kg	2.04		10.92
Cr	kg	49.30	-16.00	15.14
Cu	kg	49.73	-8.00	24,07

Pollutant	Unit	2000	2004	2005
Hg	kg	39.58		8.30
Pb	kg	164.13		104.17
Ni	kg	232.18	-1247.00	100.95
Se	kg	268.83		181.78
Zn	kg	300.89		229.15

Recalculation of emissions in 2022 due to improved activity data
Activity data for the non-reporting companies (i.e. energy statistics) in 2022 has been updated. Table 3.7 shows the resulting changes in emissions.

Table 3.7 Overview of change in emissions in 2022 as a result of improved activity data (kg)

Pollutant	Unit	2022
NO_x	kg	-3,614.22
NMVOS	kg	-1,244.53
SO_x	kg	-88.44
CO	kg	-3,058.64
TSP	kg	-31.00
PM_{10}	kg	-31.00
$PM_{2.5}$	kg	-23.25

Correction of emissions reported by individual companies
For one company, an emission has been corrected in the reported CO emissions for 2022. This results in a decrease of CO emissions for 2022 by 107.24 ton.

3.2.9 *Source-specific planned improvements*
There are no planned source-specific improvements.

3.3 Industrial combustion (1A1b, 1A1c and 1A2)

3.3.1 *Source category description*
This section comprises the following source categories:
- 1A1b Petroleum refining;
- 1A1c Manufacture of solid fuels and other energy industries;
- 1A2a Iron and steel;
- 1A2b Non-ferrous metals;
- 1A2c Chemicals;
- 1A2d Pulp, paper and print;
- 1A2e Food processing, beverages and tobacco;
- 1A2f Non-metallic minerals;
- 1A2gviii Other.

The 1A2gviii sector includes industries for: mineral products (cement, bricks, other building materials, glass), textiles, wood and wood products and machinery.

3.3.2 *Key sources*
In 2023, the source categories 1A1b, 1A2a, 1A2b, 1A2c and 1A2gviii are key sources of the pollutants listed in Table 3.8.

Table 3.8 Pollutants for which the Industrial combustion sector (NFR 1A1b, 1A1c and 1A2) is a key source

Category / Subcategory		Pollutant	Contribution to total of 2023 (%)
1A1b	Petroleum refining	SO_x	45.5
		NO_x	2.6
1A1c	Manufacture of solid fuels and other energy industries	PCB	11.0
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	SO_x	16.9
		CO	12.6
		NO_x	2.3
		PCB	35.4
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	NO_x	4.1
		SO_x	5.9
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	SO_x	5.6
		Hg	8.3
		Pb	4.1

3.3.3 Overview of shares and trends in emissions

An overview of the trends in emissions is provided in Table 3.9. Since 1990, emissions have been reduced for most pollutants, except for dioxins. Reduction in the emissions of the main pollutants has been due to an improvement in the abatement techniques used. Fluctuations in dioxin emissions have been caused by differences in the fuels used and/or incidental emissions. The reduction in emissions of SO_x and PM_{10} is mainly due to a shift in fuel use by refineries, i.e. from oil to natural gas.

Table 3.9 Overview of trends in emissions in the Industrial combustion sectors 1A1b, 1A1c and 1A2

Year	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**100**	**6.2**	**110**	**0.57**	**5.7**	**7.7**	**8.1**	**0.58**	**266**
1995	78	6.6	89	0.32	5.0	6.5	6.7	0.56	215
2000	49	2.0	46	0.05	3.3	4.8	4.9	0.35	161
2005	49	2.0	46	0.11	1.4	1.8	2.0	0.14	156
2010	40	4.6	25	0.46	1.2	1.8	3.9	0.07	127
2015	35	2.9	20	0.41	0.57	0.82	1.1	0.05	99
2020	28	2.1	16	0.64	0.45	0.66	0.96	0.04	82
2022	26	2.1	15	0.41	0.40	0.57	0.68	0.03	80
2023	**23**	**1.7**	**13**	**0.26**	**0.49**	**0.65**	**0.77**	**0.04**	**67.7**
1990-2023 period[1)]	-77	-4.4	-97	-0.32	-5.2	-7.0	-7.3	-0.54	-198
1990-2023 period[2)]	-77%	-72%	-88%	-55%	-92%	-92%	-90%	-93%	-75%

Table 3.9 Overview of trends in emissions in the Industrial combustion sectors 1A1b, 1A1c and 1A2 (continued)

Year	Priority Heavy Metals			POPs		Other Heavy Metals					
	Pb	Cd	Hg	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	**2.0**	**0.14**	**0.20**	**0.01**	**1.0**	**0.23**	**2.58**	**1.5**	**67**	**0.05**	**3.2**
1995	4.0	0.17	0.10	1.0	0.37	0.22	3.19	2.23	81	0.06	3.7
2000	0.65	0.06	0.16	0.35	0.01	0.56	0.57	0.23	19	0.05	1.1
2005	0.04	0.01	0.03	0.85	0.01	0.81	0.10	0.14	6.6	0.10	0.61
2010	3.1	0.01	0.06	5.8	0.13	0.05	0.17	1.2	0.05	0.14	9.9
2015	0.11	0.01	0.09	0.12	0.03	0.03	0.04	0.04	0.05	0.02	1.3
2020	0.12	0.01	0.08	0.05	0.01	0.04	0.22	0.79	0.45	0.02	0.54
2022	0.16	0.01	0.07	0.03	0.01	0.04	0.11	0.04	0.20	0.02	1.29
2023	**0.17**	**0.02**	**0.05**	**0.03**	**0.01**	**0.03**	**0.21**	**0.16**	**0.35**	**0.03**	**0.40**
1990-2023 period[1)]	-1.8	-0.13	-0.15	0.02	-0.99	-0.20	-2.4	-1.3	-67	-0.02	-2.7
1990-2023 period[2)]	-91%	-89%	-74%	189%	-99%	-86%	-92%	-89%	-99%	-48%	-87%

1. Absolute difference
2. Relative difference compared to 1990 in %

3.3.4 *Activity data and (implied) emission factors*

Emission data is based on emissions reported in AERs (Annual Environmental Reports) and on calculated emissions for the companies that did not report their emissions in an AER.

The activity data in the NFR tables is based on the reported activity data in the AERs of the individual companies, and the energy statistics data that is used for the emission calculation of the non-reporting companies. Please note that activity data reported in the AERs could be incomplete (especially in earlier years). Therefore, the activity data in the NFR could also be incomplete, but this does not affect the reported emissions.

Petroleum refining (1A1b)
All emission data is based on emissions reported in AERs. Emissions from all refineries are included in 1A1b, with the exception of one industrial plant that refines and processes oil and that combusts refinery gas. On the basis of its main economic activity, this company is either included in 1A1b Petroleum Refining (from 2009 onwards) or in 1A1c Manufacture of Solid Fuels and Other Energy Industries (2005–2008).

Manufacture of solid fuels and other energy industries (1A1c)
Emission data is based on emissions reported in AERs and calculated emissions for the companies that did not report their emissions in an AER. Emissions from the combined coke plant / iron and steel plant are allocated in 1A2a and/or in 2C1. Therefore, 1A1c only includes the emissions from oil/gas production and from the stand-alone coke plant that closed in 1999.

Iron and steel (1A2a)
Emission data is mainly based on emissions reported in the AER of the combined coke plant / iron and steel plant. A small part consists of calculated emissions for the companies that did not report their emissions in an AER (7% of CO emissions and 1% of SO_x emissions in 2023).

The activity data in the NFR tables for 1A2a is based on the reported activity data in the AER of the combined coke plant / iron and steel plant, and the energy statistics data that is used for the emission calculation of the non-reporting companies. For 1A2a, the activity data in the NFR tables is incomplete. For transparency reasons, Figure 3.3 provides the final energy consumption of the iron and steel sector and the own use of fuels by coke plants, as reported in the energy statistics.

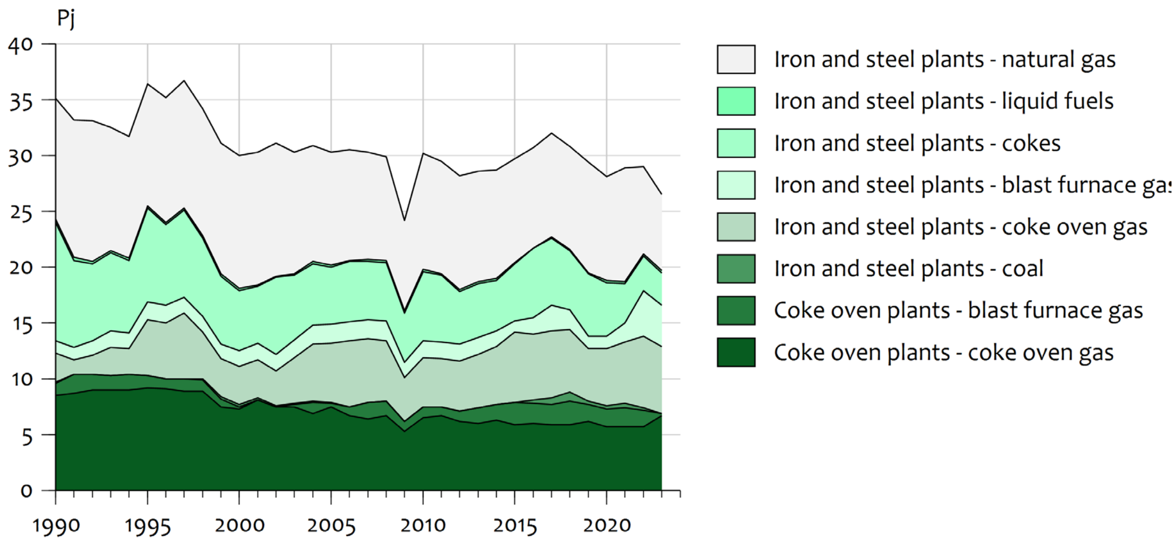


Figure 3.3 Final energy consumption in the iron and steel sector and own use of energy in coke oven plants (PJ)

Non-ferrous metals (1A2b)
Emission data is based on emissions reported in AERs and calculated emissions for the companies that did not report their emissions in an AER. Aluminium production stopped in the Netherlands in 2023, resulting in a decrease on emissions in 2023. For this source category, 6% of the NMVOC emissions, 11% of the NO_x emissions, 0.2% of the SO_x emissions, and 3% of $PM_{2.5}$ emissions were not reported in AERs (in 2023).

Chemicals (1A2c)
Emission data is based on emissions reported in AERs and calculated emissions for the companies that did not report their emissions in an AER. For this source category, 4% of the NMVOC emissions, 4% of the NO_x emissions, 4% of the SO_x emissions, and 1% of the $PM_{2.5}$ emissions were not reported in AERs (in 2023).

Pulp, paper and print (1A2d)
Emission data is based on emissions reported in AERs and calculated emissions for the companies that did not report their emissions in an AER. For this source category, 80% of the NMVOC emissions, 16% of the NO_x emissions, 3% of the SO_x emissions, and 100% of the $PM_{2.5}$ emissions were not reported in AERs (in 2023).

Food processing, beverages and tobacco (1A2e)
Emission data is based on emissions reported in AERs and calculated emissions for the companies that did not report their emissions in an AER. For this source category, 64% of the NMVOC emissions, 39% of the NO_x emissions, 44% of the SO_x emissions, and 29% of the $PM_{2.5}$ emissions were not reported in AERs (in 2023).

Non-metallic minerals (1A2f)
Emissions from non-metallic minerals are allocated to 1A2gviii.

Other (1A2gviii)
This sector includes all combustion emissions from the industrial sectors that do not belong to the categories 1A2a to 1A2e. Emission data is based on emissions reported in AERs and calculated emissions for the companies that did not report their emissions in an AER. For this source category, 32% of the NMVOC emissions, 25% of the NO_x emissions, 1% of the SO_x emissions, and 34% of the $PM_{2.5}$ emissions were not reported in AERs (in 2023).

For some of the above-mentioned categories, emissions were not entirely available from the AERs, as not all of the companies need to report their emissions. The remaining part of the emissions were calculated using national energy statistics and default EFs or IEFs from other companies that did report their emission in an AER (see Table 3.10).

Table 3.10 Emission factors for the Industrial sector (g/GJ)

Substance name	Natural gas	Biogas	Coal	Fuel oil	Wood (wood industries)	Wood (other industry)
NMVOC	[1]	2.6[11]	10[7]	50[8]	8.4[10]	1.33[10]
Sulphur dioxide	0.281[2]	0.281[11]	450[7]	47[9]	11[12]	11[12]
Nitrogen oxides as NO_2	[3]	89[11]	150[7]	64[6]	150[10]	75[10]
Ammonia					1.2[12]	1.2[12]
Carbon monoxide	[4]	39[11]	150[7]	66[9]	750[10]	16[10]
PM_{10}	0.297[5]	0.89[11]	60[7]	20[9]	27[10]	12[10]

1. For 1A2c, an EF from the Guidebook is used of 2.6 g/GJ (EMEP/EEA Guidebook (2019), 1A1, table 3.4, default value). For 1A2b, 1A2d, 1A2e and 1A2g, a specific EF is used of 5.2, 5.2, 3.8 and 5.2 g/GJ, respectively (derived from emissions reported in e-AERs).
2. EMEP/EEA Guidebook (2019), 1A1, table 4.6, average value.
3. For 1A2b, 1A2c, 1A2d, 1A2e and 1A2g, a specific EF is used of 40, 55, 43, 30 and 37 g/GJ, respectively (derived from emissions reported in AERs);
4. For 1A2b, 1A2c, 1A2d, 1A2e and 1A2g, a specific EF is used of 35, 40, 35, 40 and 35 g/GJ, respectively (derived from emissions reported in AERs).
5. EMEP/EEA Guidebook (2019), 1A1, table 4.6, minimum value.
6. Methodology report by Guis (2006).
7. EMEP/EEA Guidebook (2019), 1A2, table 3.2, minimum value.
8. EMEP/EEA Guidebook (2019), 1A4, table 3.31, default value
9. EMEP/EEA Guidebook (2019), 1A2, table 3.4, default value
10. Koppejan and De Bree (2018).
11. EMEP/EEA Guidebook (2019), 1A1, table 3.4, default value
12. EMEP/EEA Guidebook (2019), 1A2, table 3.5, default value

The AERs may be incomplete when a company does not report emissions that are below the reporting threshold. Additional estimates are made for these missing emissions:

- Since PCB emissions are not reported by individual companies, they are calculated for the entire sector. The activity data has been derived from the energy statistics and can be accessed here: https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B54BA. The PCB EF for solid biomass is from the EMEP/EEA Guidebook (2019), chapter 1A2, table 3.5. The PCB EF of bituminous coal in 1A1 and 1A2 is based on the correlation between the dioxin and PCB EFs in the Guidebook and in the Dutch emission inventory. This results in an EF of 52.4 µg/GJ in

1990 and 0.67 µg/GJ from 1995 onwards (see Table 3.11). See Honig et al. (2025) for further details regarding the PCB EF.

- Since heavy metal emissions from the use of natural gas are not reported by individual companies either, they are calculated for the entire sector. The activity data has been derived from the energy statistics and can be accessed here: https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B54BA. The mercury EF is based on a study by the Dutch gas company Gasunie, while Tier 1 emission factors from the EMEP/EEA Guidebook 2019 (1A1, table 3.4) are used for the other metals. The resulting emission factors are presented in Table 3.12.
- Heavy metal emissions from other fuels (other than natural gas) are not always reported by individual companies. Individual estimates of these metal emissions have been made for the refineries (1A1b), the non-ferro sector (1A2b), the chemical sector (1A2c) and the mineral products sector (1A2gviii). The EFs are from the EMEP/EEA Guidebook (2019), combined with an abatement of 50% for mercury, 90% for selenium and 95% for the other metals (from: EMEP/EEA Guidebook 2019, chapter 1A1, page 78). The emissions are calculated for the entire sector and then allocated to the relevant companies. If a company has already reported metal emissions, these reported emissions are used in the inventory (instead of the calculated emission). If the allocated emission exceeds the reporting threshold, it is assumed that the emission by that company is equal to the reporting threshold. Details of the emission calculation are available in chapter 3.1.2.2 of the ENINA methodology report (Honig et al., 2025). For 1A2a, no additional heavy metals are calculated. All emissions in this sector are reported by the iron and steel company in the Netherlands, and these emissions are reported in 1A2a and 2C1. Since it is not always possible to correctly allocate the heavy metal emissions between 1A2a and 2C1, the emissions are only reported in 2C1 for most years.
- PAH, dioxin and HCB emissions are not always reported by individual companies either. Individual estimates of these emissions have been made for all industrial stationary combustion sectors and for solid fuels, liquid fuels (except diesel and LPG), gaseous fuels (except natural gas) and biomass (except biogas). The emissions have been calculated as a fraction of the reported hydrocarbon emission. The fraction is based on the ratio between the Tier 1 emission factors of PAH/dioxin/HCB/PCB with NMVOC from chapters 1A1 and 1A2 of the EMEP/EEA Guidebook (2019) and an assumed abatement efficiency of 90%. If an individual emission exceeds the reporting threshold, it is assumed that the emission is equal to the reporting threshold (assuming that a company would have reported these emissions if they were above the reporting threshold). If a company has already reported a certain emission, the individual emission estimate for that company is discarded, and only the reported emission is used.
- $PM_{2.5}$ emissions are either reported by individual companies or calculated using default $PM_{2.5}/PM_{10}$ ratios. These ratios are based on PM_{10} and $PM_{2.5}$ emissions reported by individual companies

(differing per sector, activity and fuel) or on literature (e.g. Visschedijk, et al. (2004) and Ehrlich et al. (2007)). A complete list of the $PM_{2.5}/PM_{10}$ ratios, including references, is presented in Honig et al. (2025) and in Visschedijk & Dröge (2019). The latter report can be downloaded via: Visschedijk & Dröge. 2019.

Table 3.11 List of PCB emission factors of solid fuels (µg/GJ)

Year	Solid fuels µg/GJ	Biomass µg/GJ
1990	52.4	0.06
1991	42.1	0.06
1992	31.7	0.06
1993	21.4	0.06
1994	11.0	0.06
from 1995	0.67	0.06

Table 3.12 List of heavy metal EFs of natural gas (mg/GJ)

Pollutant	1990-2009	2010-2016	from 2017
Hg	0.039	0.023	0.01
Pb		0.0015	
Cd		0.00025	
As		0.12	
Cr		0.00076	
Cu		0.076	
Ni		0.00051	
Se		0.0112	
Zn		0.0015	

3.3.5 *Methodological issues*

Emissions are based on data in the AERs relating to individual facilities (Tier 3 methodology). A company needs to submit an environmental report if one or more of the activities of the company is included in annex 1 of the E-PRTR regulation. These companies need to report emissions that exceed the reporting threshold. For some pollutants, the Dutch reporting thresholds are lower than the European reporting thresholds (see the thresholds in Dutch: https://www.e-mjv.nl/sites/default/files/2018-07/stoffenlijst_integraal_prtr-verslag.pdf). The emission and fuel consumption data in the AERs is systematically examined for inaccuracies by checking the resulting IEFs. If environmental reports provide data of high enough quality, the information is used to calculate an IEF for a cluster of reporting companies (aggregated by NACE code). These IEFs are fuel- and sector-dependent and are used to calculate the emissions by companies that are not individually assessed.

$$\mathbf{IEF}_{\text{ER-I (NACE. fuel)}} = \frac{\mathbf{Emissions}_{\text{ER-I (NACE. fuel)}}}{\mathbf{Energy\ use}_{\text{ER-I (NACE. fuel)}}}$$

where:
EF = Implied emission factor from individual companies
ER-I = Emission Registration database for individual companies

Next, combustion emissions by the companies that are not individually assessed in this NACE category are calculated from the energy use according to the energy statistics (from Statistics Netherlands), multiplied by the IEF. If the data from the individual companies is insufficient to calculate an IEF, a default EF is used (see Table 3.10).

ER-C_emission (NACE. fuel) = IEF ER-I (NACE. fuel) * energy statistics (NACE. fuel)

where:
ER-C = Emission Registration database for emission data that is not based on emissions reported in an AER

The total combustion emissions are the sum of emissions by the individual companies (ER-I) plus emissions by the companies that are not individually assessed (ER-C).

The AERs contain emission data from individual plants at the level of individual installations (or sometimes a group of installations). The AER data is not always sufficiently detailed to indicate whether the emissions are resulting from combustion or from processes (for example when emissions are calculated from stack measurements that include concentrations from both combustion and processes). Therefore, the emissions are split into combustion emissions (allocated in NFR 1A2) and process emissions (allocated in NFR2), on the basis of the question whether the consumption of fuels is reported in an installation in the AER. Because of this split, emissions are sometimes only included in the energy sector, or only in the IPPU sector. The emissions in the energy sector should best be viewed together with the emissions in the corresponding IPPU sector.

The notation key 'IE' (Included Elsewhere) is used in the energy sector when the complete emission by a company is included in the industrial processes sector (as described in the section above). This is valid for the following subcategories:

- 1A1c: Emissions from the coke plant in the Netherlands are included in 1A2a and/or 2C1, as it is part of the combined coke / iron and steel plant.
- 1A2a: Emissions from the combined coke plant / iron and steel plant are allocated in 1A2a and/or in 2C1.
- 1A2b: Emissions from the non-ferrous metals industry are included in 1A2b, 2C3 and/or 2C6.
- 1A2f: Emissions from the non-metallic minerals industry are reported in 1A2gviii.

The notation key 'NE' (Not Estimated) is used for several subcategories for various reasons:

- Emissions are sometimes not estimated, because these emissions are not reported by the individual companies in their AERs (below the reporting threshold). The reporting thresholds are presented in Table 3.13, including a comparison to the 2023 national emission. For most pollutants, the reporting threshold is less than 0.1% of the national total. For heavy metals and PAH, the reporting threshold is often more than 0.1% of the national total; for that reason, an additional estimate for the not reported heavy metal and PAH emissions has been made (as described in Section 3.3.4).

- Emissions of NH_3 from gaseous, liquid and solid fuels and emissions of PCB and HCB from gaseous and liquid fuels are not estimated, because the EMEP/EEA Guidebook (2019) does not contain a methodology.

Table 3.13 Comparison between the reporting threshold in annual environmental reports (AERs) and the national emissions in 2023.

Pollutant	**Unit**	**National emission in 2023**	**Reporting threshold in AERs**	**Relative contribution (%)**
NO_x (as NO_2)	Gg	183.79	0.01	0.01%
NMVOC	Gg	238.45	0.01	0.00%
SO_x (as SO_2)	Gg	17.50	0.02	0.11%
NH_3	Gg	116.38	0.01	0.01%
PM_{10}	Gg	26.20	0.005	0.02%
CO	Gg	385.97	0.01	0.00%
Pb	Mg	4.00	0.05	1.25%
Cd	Mg	0.47	0.001	0.21%
Hg	Mg	0.43	0.001	0.23%
As	Mg	0.24	0.02	8.42%
Cr	Mg	3.48	0.1	2.88%
Cu	Mg	111.02	0.1	0.09%
Ni	Mg	1.88	0.05	2.66%
Zn	Mg	70.12	0.2	0.29%
PCDD/ PCDF (dioxins/ furans)	g I-TEQ	42.93	0.01	0.02%
benzo(a) pyrene	Mg	1.54	0.001	0.07%
benzo(b) fluoranthene	Mg	1.48	0.001	0.07%
benzo(k) fluoranthene	Mg	0.79	0.001	0.13%
Indeno (1.2.3-cd) pyrene	Mg	0.75	0.001	0.13%
Total 1-4	Mg	5.08	0.001	0.02%
HCB	kg	3.17	0.01	0.32%

The relative contribution indicates how the reporting threshold compares to the national emission

3.3.6 *Uncertainties and time series consistency*

Uncertainties are explained in Section 1.7.

Time series consistency

A large part of the emission inventory is built from emission data reported by individual companies. If a company does not report any emissions at all, the emissions are calculated on the basis of the energy statistics of these non-reporting companies.

The companies do not have to report their emissions when they are below a certain threshold. This is often the case for the emissions of heavy metals and PAHs. In order to ensure a consistent time series, metal emissions have also been calculated from the energy statistics combined with EFs from the EMEP/EEA Guidebook (2019), and PAH emissions have been calculated from the ratio between the reported hydrocarbon emissions and the PAH emissions. A more detailed description of the methodology is available in chapter 3.1.2.2 of the ENINA methodology report (Honig et al., 2025).

3.3.7 *Source-specific QA/QC and verification*

Emission and fuel consumption data in the AERs was systematically examined for inaccuracies by checking the resulting IEFs. If the environmental reports provided data of high enough quality (see Section 1.6 on QA/QC), the information was used.

3.3.8 *Source-specific recalculations*

The following recalculations were performed:

Recalculation of emissions reported by individual companies
For several refineries, the heavy metal emissions have been corrected for the year 2000. Since some companies submitted incomplete reports on heavy metal emissions in that year, additional emission estimates have been added for these companies. Table 3.14 shows the resulting changes in emissions.

Table 3.14 Overview of change in heavy metal emissions for 2000 in 1A1b (kg)

Pollutant	Unit	2000
As	kg	497.86
Cd	kg	54.44
Cr	kg	25.09
Cu	kg	5.06
Hg	kg	33.57
Pb	kg	533.40
Ni	kg	593.02
Se	kg	42.10
Zn	kg	28.96

Recalculation of emissions in 2022 due to improved activity data
Activity data for the non-reporting companies (i.e. energy statistics) in 2022 has been updated. Table 3.15 shows the resulting changes in emissions of the main pollutants. Please note that emissions of heavy metals and PAHs have also been recalculated (<1 kg differences).

Table 3.15 Overview of change in emissions in 2015–2022 as a result of improved activity data (kg)

NFR	Pollutant	2015	2016	2017	2018	2019	2020	2021	2022
1A2b	NO_x	-21,670	-19,910	7,920	7,425	-660	14,146	7,053	6,575
	NMVOC	-2,049	-1,882	749	702	-62	1,846	920	858
	SO_x	-111	-102	40	38	-3	100	50	46
	TSP	-117	-108	43	40	-4	105	53	49
	PM_{10}	-117	-108	43	40	-4	105	53	49
	$PM_{2.5}$	-117	-108	43	40	-4	105	53	49
	BC	-5	-4	2	2	0	4	2	2
	CO	-13,790	-12,670	5,040	4,725	-420	12,425	6,195	5,775

NFR	Pollutant	2015	2016	2017	2018	2019	2020	2021	2022
1A2c	NO_x	3,072	1,626	-497	-2,214	0	0	0	7,049
	NMVOC	354	187	-57	-255	0	0	0	642
	SO_x	38	20	-6	-28	0	0	0	69
	TSP	40	21	-7	-29	0	0	0	73
	PM_{10}	40	21	-7	-29	0	0	0	73
	$PM_{2.5}$	30	16	-5	-22	0	0	0	60
	BC	1	1	0	-1	0	0	0	2
	CO	5,440	2,880	-880	-3,920	0	0	0	9,880
1A2d	NO_x	-264	1,056	1,505	10,148	10,062	8,687	0	-346
	NMVOC	-31	125	182	1,227	1,217	1,175	0	-47
	SO_x	-2	7	10	66	66	64	0	-3
	TSP	-2	7	10	70	69	67	0	-3
	PM_{10}	-2	7	10	70	69	67	0	-3
	$PM_{2.5}$	-2	7	10	70	69	67	0	-3
	BC	0	0	0	3	3	3	0	0
	CO	-210	840	1,225	8,260	8,190	7,910	0	-315
1A2e	NO_x	9,240	8,890	6,780	13,110	0	9,717	6,960	6,990
	NMVOC	1,003	965	859	1,661	0	1,231	882	885
	SO_x	74	71	64	123	0	91	65	65
	TSP	78	75	67	130	0	96	69	69
	PM_{10}	78	75	67	130	0	96	69	69
	$PM_{2.5}$	12	11	10	19	0	14	10	10
	BC	0	0	0	1	0	1	0	0
	CO	10,560	10,160	9,040	17,480	0	12,956	9,280	9,320
1A2gviii	NO_x	8,177	7,622	9,102	-1,628	18,278	26,418	22,627	13,443
	NMVOC	1,149	1,071	1,279	-229	2,569	3,713	3,281	2,006
	SO_x	62	58	69	-12	139	201	177	117
	TSP	66	61	73	-13	147	212	187	130
	PM_{10}	66	61	73	-13	147	212	187	130
	$PM_{2.5}$	27	26	132	29	168	188	173	125
	BC	1	1	5	1	7	8	7	5
	CO	7,735	7,210	8,610	-1,540	17,290	24,990	22,085	13,652

Correction of emissions reported by individual companies
Several companies have updated the emissions they reported in their AERs for 2021 and 2022. This results in the changes as presented in table 3.16.

Table 3.16 Overview of change in emissions in 2021–2022 as a result of updated environmental reports from individual companies (kg)

NFR	Pollutant	2021	2022
1A1c	NO_x	-63	-49,404
1A2c	CO		-1,063,136
1A2d	CO		9,427
	NMVOC		-8,820
	NO_x		1,615
1A2e	CO	-1,960	
	NMVOC	-477	
	NO_x	-20,217	

3.3.9 *Source-specific planned improvements*
There are no planned source-specific improvements.

3.4 Other stationary combustion (1A4ai. 1A4bi. 1A4ci and 1A5a)

3.4.1 *Source category description*
This section describes the following source categories:
- 1A4ai Commercial/Institutional: Stationary. This source category comprises commercial and public services (banks, schools and hospitals, trade, retail, communication). It also includes the production of drinking water and miscellaneous combustion emissions from waste handling activities and from wastewater treatment plants.
- 1A4bi Residential: Stationary. This source category refers to domestic fuel consumption for space heating, water heating and cooking. About three-quarters of the sector’s consumption of natural gas is used for space heating.
- 1A4ci Agriculture/Forestry/Fisheries: Stationary. This source category comprises stationary combustion emissions from agriculture, horticulture, greenhouse horticulture, cattle breeding and forestry.
- 1A5a Other: Stationary. There are no emissions reported in this sector. Emissions from military are included in 1A4ai.

3.4.2 *Key sources*
The Small stationary combustion sector is a key source of the pollutants listed in Table 3.17.

Table 3.17 Pollutants for which the Small combustion sector (NFR 1A4 and 1A5) is a key source

Category / Subcategory	Pollutant	Contribution to total of 2023 (%)
1A4ai Commercial/institutional: Stationary	$PM_{2.5}$	2.1
1A4bi Residential: Stationary	NO_x	2.7
1A4bi Residential: Stationary	NMVOC	3.4
1A4bi Residential: Stationary	CO	15.3
1A4bi Residential: Stationary	PM_{10}	17.0
1A4bi Residential: Stationary	$PM_{2.5}$	30.6
1A4bi Residential: Stationary	BC	24.0
1A4bi Residential: Stationary	Dioxins	14.3
1A4bi Residential: Stationary	PAH	59.8
1A4bi Residential: Stationary	Hg	8.4
1A4bi Residential: Stationary	Cd	12.0

3.4.3 *Overview of shares and trends in emissions*

An overview of the trends in emissions is provided in Table 3.18. Emissions of all pollutants have decreased since 1990, while fuel use has increased slightly.

The decrease of Hg and Pb emissions between 1990 and 1991 in NFR 1A4ai was caused by the fact that from 1991 onwards, no hard coal has been used in the Services sector. The steady slow increase of HCB from 2007 onwards has been caused by the use of wood in the Services sector.

Table 3.18 Overview of trends in emissions in the Other stationary combustion sectors

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**41**	**13**	**2.2**	**0.35**	**7.1**	**7.6**	**8.2**	**0.91**	**78**
1995	45	15	1.2	0.38	7.4	7.8	8.4	0.98	88
2000	40	13	0.69	0.31	6.4	6.8	7.3	0.83	78
2005	35	15	0.55	0.29	6.6	7.0	7.5	0.84	85
2010	39	21	0.71	0.35	7.3	7.7	8.3	0.91	107
2015	22	15	0.51	0.31	5.5	5.8	6.2	0.67	81
2020	14	11	0.52	0.41	4.5	4.7	5.0	0.55	67
2022	12	11	0.50	0.38	4.7	4.9	5.2	0.59	70
2023	**11**	**11**	**0.47**	**0.35**	**4.6**	**4.8**	**5.1**	**0.60**	**66**
1990-2023 period[1)]	-30	-2.7	-1.7	0.00	-2.6	-2.7	-3.1	-0.32	-12.2
1990-2023 period[2)]	-73%	-21%	-78%	1%	-36%	-36%	-38%	-35%	-16%

Table 3.18 Overview of trends in emissions in the Other stationary combustion sectors (continued)

Year	Priority Heavy Metals			POPs		Other Heavy Metals					
	Pb	Cd	Hg	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	**0.92**	**0.07**	**0.14**	**108**	**3.5**	**0.19**	**3.5**	**0.83**	**2.1**	**0.01**	**2.4**
1995	0.15	0.05	0.07	8.2	4.0	0.12	0.05	0.41	0.39	0.01	0.86
2000	0.09	0.04	0.05	7.5	3.6	0.09	0.01	0.35	0.02	0.01	0.69
2005	0.09	0.05	0.05	7.7	4.0	0.08	0.00	0.39	0.01	0.01	0.75
2010	0.12	0.07	0.06	8.2	4.9	0.10	0.01	0.52	0.02	0.01	1.0
2015	0.09	0.05	0.05	7.0	3.7	0.07	0.00	0.42	0.00	0.01	0.81
2020	0.08	0.05	0.03	6.1	3.0	0.06	0.00	0.38	0.00	0.01	0.72
2022	0.09	0.06	0.04	6.3	3.3	0.05	0.00	0.43	0.00	0.00	0.84
2023	**0.08**	**0.06**	**0.04**	**6.2**	**3.1**	**0.05**	**0.00**	**0.42**	**0.00**	**0.00**	**0.82**
1990-2023 period[1)]	-0.84	-0.01	-0.10	-102	-0.45	-0.14	-3.5	-0.41	-2.1	-0.01	-1.6
1990-2023 period[2)]	-91%	-14%	-72%	-94%	-13%	-75%	-100%	-50%	-100%	-58%	-66%

1. Absolute difference
2. Relative difference compared to 1990 in %

3.4.4 *Activity data and (implied) emission factors*

Emission data is based on emissions reported in AERs (Annual Environmental Reports) and on calculated emissions for the companies that did not report their emissions in an AER. In this source category, the share of emissions reported in AERs is relatively small (compared to the industrial combustion sector):

- 1A4ai: 30% of the SO_x emissions, 8% of the NO_x emissions, 14% of the NMVOC emissions and 0.2% of the $PM_{2.5}$ emissions were reported in AERs (in 2023);
- 1A4bi: no emission data from AERs is used in the residential sector;
- 1A4ci: 1% of the NO_x and 1% of SO_x emissions were reported in AERs in 2023.

The following texts describe the calculation methods for the emissions that are not reported in an AER.

Commercial/institutional (1A4ai)
Combustion emission data from the commercial and institutional sectors is based on emissions reported by individual companies and an additional emission calculation from fuel consumption data (from Statistics Netherlands) and EFs (see Table 3.19).

Table 3.19 Emission factors for stationary combustion emissions from the Services sector (g/GJ)

Substance name	Natural gas	Biogas	Diesel	Coal	Wood
NMVOC	2.0[1]	23[9]	20[4]	10[3]	5[8]
Sulphur dioxide	0.2[2]	0.67[9]	94[4]	450[3]	8[8]
Nitrogen oxides as NO_2	19.7[6]	74[9]	60[5]	150[3]	91[7]
Ammonia					37[7]
Carbon monoxide	15[2]	29[9]	93[4]	150[3]	50[8]
PM_{10}	0.27[2]	0.78[9]	21[4]	60[3]	91[8]

1. EMEP/EEA Guidebook (2019), 1A4, table 3.27, default value
2. EMEP/EEA Guidebook (2019), 1A4, table 3.27, minimum value
3. EMEP/EEA Guidebook (2019), 1A4, table 3.7, minimum value
4. EMEP/EEA Guidebook (2019), 1A4, table 3.9, default value
5. Van Soest-Vercammen et al. (2002)
6. Visschedijk, Dröge & Hulskotte (2025). From 2005 onwards, the NOx-emission factor has decreased due to the further implementation of low-NOx technologies (EF2005: 42.5 to EF2023: 19.7)
7. EMEP/EEA Guidebook (2019), 1A4, table 3.10, default value
8. EMEP/EEA Guidebook (2019), 1A4, table 3.10, minimum value
9. EMEP/EEA Guidebook (2019), 1A4, table 3.8, default value

Residential (1A4bi)

Combustion emission data from central heating, hot water and cooking is based on fuel consumption data (from Statistics Netherlands) and EFs (see Table 3.20). The fuel used most in this category is natural gas. The use of wood in stoves and fireplaces for heating is very small compared to the amount of natural gas used.

Combustion emissions from (wood) stoves and fireplaces were calculated by multiplying the fuel consumption per appliance type and fuel type (Statistics Netherlands) by EFs (Jansen, 2016; Visschedijk & Dröge, 2020). Particulate matter emissions from wood combustion include the emission of condensables (see Table 3.21). EFs for charcoal combustion in barbecues are also included in this table. Wood consumption per appliance type is presented in Table 3.22.

Table 3.20 Emission factors for combustion emissions from households (g/GJ)

Substance name	Natural gas (heating)	Natural gas (cooking)	Diesel	LPG	Petroleum	Coal
NMVOC	1.8[1]	2.0[2]	0.69[3]	1.9[5]	0.69[3]	300[4]
Sulphur dioxide	0.3[1]	0.3[2]	70[3]	0.3[5]	70[3]	450[4]
Nitrogen oxides as NO_2	12.9[6]	57[6]	51[3]	40[5]	51[3]	150[4]
Carbon monoxide	22[1]	30[2]	57[3]	26[5]	57[3]	2,000[4]
PM_{10}	0.281	2.2[2]	1.9[3]	1.2[5]	1.9[3]	240[4]

1. EMEP/EEA Guidebook (2019), 1A4, table 3.16, default value
2. EMEP/EEA Guidebook (2019), 1A4, table 3.13, default value
3. EMEP/EEA Guidebook (2019), 1A4, table 3.5, default value
4. EMEP/EEA Guidebook (2019), 1A4, table 3.19, default value
5. EMEP/EEA Guidebook (2019), 1A4, table 3.4, default value
6. See Visschedijk, Dröge and Hulskotte (2025)

Table 3.21 Emission factors for wood combustion in households

Pollutant	Unit	Fire-place	Conven-tional stove	Im-proved stove	Eco-label stove	Eco-design stove	Pellet	Barbe-cues (char-coal)
NMVOC	g/GJ	1,290	774	387	252	250	10	250
SO_x	g/GJ	12.9	12.9	12.9	12.9	12.9	12.9	10
NO_x	g/GJ	77.4	129.0	129.0	129.0	95.0	80.0	50
NH_3	g/GJ	29.4	29.4	1.47	1.47	1.47	0.29	
CO	g/GJ	3,226	6,452	3,871	2,903	2,000	300	6,000
PM_{10}	g/GJ	670	534	233	97.0	97.0	30.0	150
$PM_{2.5}$	g/GJ	637	507	221	93.0	93.0	30.0	75
$EC_{2.5}$	g/GJ	76.4	73.3	27.5	10.3	25.9	9.0	
Pb	mg/GJ	4.71	4.71	4.71	4.71	4.71	4.71	
Cd	mg/GJ	3.23	3.23	3.23	3.23	3.23	3.23	
Hg	mg/GJ	1.94	1.94	1.94	1.94	1.94	1.94	
Dioxin	ng/GJ	1,613	174	174	174	174	100	150
PAH4	mg/GJ	193.5	343.9	221.3	172.3	35.0	35.0	143.4

Note: PM EFs include both the filterable and the condensable fraction
Source: Jansen (2016); Visschedijk & Dröge (2020); EF from charcoal use in barbecues from Visschedijk et al. (2025)

Table 3.22 Wood combustion per application type in NFR 1A4bi (TJ)

Appliance	1990	2005	2010	2015	2020	2023
Fireplace	3,834	2,972	2,700	2,322	1,917	1,715
Conventional stove	7,120	5,496	5,520	3,235	1,879	1,834
Improved stove	768	4,649	5,931	3,717	2,710	2,469
Eco-labelled stove	0	1,937	6,017	6,874	6,550	7,265
Eco-design stove	0	0	0	77	212	1,233
Pellet	0	0	0	166	1,218	2,036

Agriculture/forestry/fishing (1A4ci)
Stationary combustion emission data is based on default EFs (Table 3.23) combined with fuel consumption data obtained from Statistics Netherlands, whose figures are, in turn, based on data from Wageningen Economics Research.

Table 3.23 EF's for the Agriculture/Forestry/Fishing sectors (g/GJ)

Substance name	Natural gas (gas engines)	Natural gas (boilers)	Biogas	LPG	Wood
NMVOC	25.6[9]	2.0[1]	23[4]	1.3[5]	1.33[3]
Sulphur dioxide	0.2[2]	0.2[2]	0.67[4]	0.22[5]	11[1]
Nitrogen oxides as NO_2	35[9]	24.2[9]	74[4]	40[5]	80[3]
Ammonia					37[7]
Carbon monoxide	56[9]	15[2]	29[4]	10[5]	170[3]
PM_{10}	0.2[6]	0.27[2]	0.78[4]	2.0[5]	17[3]

1. EMEP/EEA Guidebook (2019), 1A4, table 3.27, default value
2. EMEP/EEA Guidebook (2019), 1A4, table 3.27, minimum value
3. From 'Kennisdocument Houtstook in Nederland' (Koppejan and De Bree, 2018)
4. EMEP/EEA Guidebook (2019), 1A4, table 3.8, default value
5. Methodology report Zonneveld (Guis. 2006)
6. EMEP/EEA Guidebook (2019), 1A4, table 3.28, default value
7. EMEP/EEA Guidebook (2019), 1A4, table 3.10, default value
9. Visschedijk, Dröge and Hulskotte (2025). For natural gas in gas engines, the NO_x EF decreases from 200 g/GJ in 2005 to 35 g/GJ in 2023. For natural gas in boilers, the NO_x EF decreases from 63 g/GJ in 2005 to 24.2 g/GJ in 2023

Since PCB emissions are not reported by individual companies, they are calculated for the entire sector. The activity data has been derived from the energy statistics and can be accessed here: https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B54BA.

The PCB EF of solid fuels in 1A4 is from the EMEP/EEA Guidebook (2019), chapter 1A4, table 3.7, while the PCB EF of solid biomass (non-residential) is from the EMEP/EEA Guidebook (2019), chapter 1A4, table 3.10. The PCB EF of residential solid biomass is from the EMEP/EEA Guidebook (2019), tables 3.39–3.43. The EF of the improved stove is an average of the conventional and the high-efficiency stove. See Table 3.24.

Table 3.24 List of PCB emission factors of solid fuels (Microgram/GJ)

Appliance		EF
Solid fuels		170
Biomass non-residential		0.06
Biomass residential	Fireplace	0.06
	Conventional stove	0.06
	Improved stove	0.045
	Eco-label stove	0.03
	Eco-design stove	0.007
	Pellet	0.01

Since emissions of heavy metals from the use of natural gas are not reported by individual companies either, they are calculated for the entire sector. The activity data has been derived from the energy statistics and can be accessed here: https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B54BA

The mercury EF is based on a study by the Dutch gas company Gasunie. while Tier 1 emission factors from the EMEP/EEA Guidebook 2019 (1A1, table 3.4) are used for the other metals. Table 3.25 lists the resulting emission factors.

Table 3.25 List of heavy metal EFs of natural gas (mg/GJ)

Pollutant	1990-2009	2010-2016	from 2017
Hg	0.039	0.023	0.01
Pb		0.0015	
Cd		0.00025	
As		0.12	
Cr		0.00076	
Cu		0.076	
Ni		0.00051	
Se		0.0112	
Zn		0.0015	

The $PM_{2.5}$ emissions are either reported by individual companies or calculated using default $PM_{2.5}/PM_{10}$ ratios, which are based on several data sources:

- PM_{10} and $PM_{2.5}$ emissions reported by individual companies (differing per sector, activity type and fuel);
- ratios from literature, e.g. Visschedijk et al. (2004) and Ehrlich et al. (2007).

See Honig et al. (2025) for the complete list of $PM_{2.5}/PM_{10}$ ratios. A complete list of the $PM_{2.5}/PM_{10}$ ratios, including references, is presented in Visschedijk & Dröge (2019). This report can be downloaded via: Visschedijk & Dröge. 2019.

3.4.5 *Methodological issues*

A Tier 2 methodology was used to calculate sectoral emissions by multiplying the activity data (fuel consumption) by the EFs (see previous section).

The notation key 'IE' (Included Elsewhere) is used for all pollutants in source category 1A5a. Emissions from military stationary combustion are included in 1A4ai.

3.4.6 *Uncertainties and time series consistency*

Uncertainties are explained in Section 1.7.

Time series consistency

The activity data in the NFR tables is based on data reported by individual companies and on energy statistics for the companies that did not submit AERs. Most of the emissions are likewise calculated from these activity data.

There are two exceptions: Both the emissions of PCB from solid fuels and solid biomass and the emissions of heavy metals from natural gas are calculated from the energy statistics. The energy statistics differ from the activity data in the NFR tables because the activity data from individual companies is allocated to their main economic activities, which can differ from the allocation of the energy statistics. The energy statistics can be accessed here: https://opendata.cbs.nl/statline/#/CBS/en/dataset/83140ENG/table?dl=B54BA

This also explains why activity data is included in the NFR for 1A4ai, while no PCB emissions have been reported in 1A4ai from 1995 onwards. These emissions have been allocated to other NFR categories (following the sectors in the energy statistics).

3.4.7 *Source-specific QA/QC and verification*

General QA/QC is explained in Section 1.3.

3.4.8 *Source-specific recalculations*

The following recalculations were performed:

Recalculation as a result of updated LPG statistics in 1990–2023 in 1A4ai
Energy statistics have been updated for LPG for the complete time series. The result of this recalculation is presented in Table 3.26.

Table 3.26 Increase in emissions (in kg) due to updated LPG statistics in 1A4ai for the complete time series

Pollutant	1990	2005	2010	2015	2020	2022
NO_x	48,000	48,000	48,000	63,173	66,097	74,589
NMVOC	2,280	2,280	2,280	3,001	3,140	3,543
SO_x	360	360	360	474	496	559
$PM_{2.5}$	1,440	1,440	1,440	1,895	1,983	2,238
CO	31,200	31,200	31,200	41,062	42,963	48,483

Recalculation as a result of updated energy statistics in 1A4ai, 1A4bi and 1A4ci
Energy statistics have been improved for 1A4ai. 1A4bi and 1A4ci:

- 1A4ai: Energy statistics have been updated for natural gas (2015–2022)
- 1A4bi: Energy statistics have been updated for natural gas (2020–2022), LPG (2015–2022), petroleum (2016 and 2021) and charcoal (2022)
- 1A4ci: Energy statistics have been updated for natural gas (2015–2022), biogas (2019, 2021 and 2022), wood (2021–2022) and LPG (2022)

Table 3.27 shows the change in emissions for the main pollutants. Also, emissions of heavy metals and PAHs have been recalculated (<1 kg difference).

Table 3.27 Overview of recalculations as a result of updated activity data for the additional emissions by non-reporting companies (in kg)

Pollutant	NFR	2015	2020	2022
NO_x	1A4ai	62	-4	-6,093
NO_x	1A4bi	60	-11	-54
NO_x	1A4ci	-7,482	4,218	-82,957
NMVOC	1A4ai	5	0	-590
NMVOC	1A4bi	3	-1	34
NMVOC	1A4ci	-6,180	-16,897	-21,430
SO_x	1A4ai	0	0	-59
SO_x	1A4bi	0	0	3
SO_x	1A4ci	0	0	-8,134
$PM_{2.5}$	1A4ai		1	0
$PM_{2.5}$	1A4bi		2	0
$PM_{2.5}$	1A4ci	10	50	-12,740
CO	1A4ai		35	-3
CO	1A4bi		39	-7
CO	1A4ci	-5,681	-29,377	-163,207

Recalculation of the NO_x emission factor for natural gas combustion in 1A4ai (2021–2022), 1A4bi (2020–2022) and 1A4ci (2010–2022)

- 1A4ai: The NO_x EF has been corrected from 20.6 g/GJ in 2021/2022 to 20.4 g/GJ in 2021 and 20.1 g/GJ in 2022.
- 1A4bi: The NO_x EF has been corrected from 14.4 g/GJ to 14.3 g/GJ in 2021 and from 14.4 g/GJ to 13.4 g/GJ in 2022. In 2020, there was only a small correction in the rounding of the EF.
- 1A4ci: NO_x emission factors of natural gas combustion in gas engines (2010–2017) and in boilers (2012–2022) have been updated. For gas engines, the EFs in the 2010–2017 period have been interpolated from 142 g/GJ in 2010 to 73.3 g/GJ in 2017. For boilers (and other appliances except gas engines), the EF proved to be too high in recent years and has been corrected to an EF of 24.4 g/GJ in 2022. The EF for boilers between 2012 and 2022 has been interpolated.

The results of these EF changes are presented in Table 3.28.

Table 3.28 Overview of recalculations as a result of updated EFs for the additional emissions by non-reporting companies (in kg)

Pollutant	NFR	2010	2015	2020	2022
NO_x	1A4ai				-54,718
NO_x	1A4bi			-6,581	-232,534
NO_x	1A4ci	4,359,657	-511,430	-569,637	-343,365

Correction of reported emission data in a company's AER
One company has corrected the emissions in the AER, resulting in a decrease of NO_x emissions in 1A4ai of 5251 kg in 2022.

Recalculation for baking of meat in 1A4bi in 1990–2023
The activity data for baking of meat has been updated. In the previous submission, this was based on the carcass weight. This was an

overestimation as a large part of the carcass is not baked. In this submission, the activity data has been corrected and emissions are now estimated on the basis of net weight (excluding bones, etcetera). The resulting change is presented in Table 3.29.

Table 3.29 Overview of recalculations as a result of updated activity data for baking of meat in 1A4bi (in kg)

Pollutant	1990	2005	2010	2015	2020	2022
NMVOC	-328,866	-359,131	-376,013	-372,241	-379,405	-378,344
$PM_{2.5}$	-95,693	-104,500	-109,412	-108,314	-103,700	-103,411

Activity data correction
In response to NECD recommendation NL-1A4bi-2024–0001, the activity data for 1A4bi has been corrected. In the previous submission, the activity data of some of the underlying emission sources had been included in the NFR 1A4bi category twice. Because of this error, the AD was almost doubled for gaseous fuels and a bit higher for solid fuels. In the current submission, the double counting in activity data has been removed. This correction only affects activity data, and does not influence emissions.

3.4.9 *Source-specific planned improvements*
No source-specific improvements are planned

3.5 Fugitive emissions (1B)

3.5.1 *Source category description*
This category includes fuel-related emissions from non-combustion activities in the energy production and transformation industries:

- 1B2aiv Fugitive emissions oil: refining / storage;
- 1B2av Fugitive emissions oil: products distribution;
- 1B2b Fugitive emissions from natural gas;
- 1B2c Venting and flaring;
- 1B2d Other fugitive emissions from energy production.

For the 1990–1999 period, source category 1B1b included fugitive emissions from an independent coke production facility. which closed in 1999. The emissions from coke production from the only combined iron and steel plant in the Netherlands have been included in category 1A2a because emissions reported by this company cannot be split into iron/steel and coke production. Therefore, from 2000 onwards, no emissions have been allocated to 1B1b, and the notation key ‘IE’ has been used.

3.5.2 *Key sources*
None of the sectors in 1B is a key category. Table 3.30 represents the main sources and pollutants in this sector.

Table 3.30 Main sources and pollutants in the Fugitive emissions sector category NFR 1B

Category / Subcategory	**Pollutant**	**Contribution to total of 2023 (%)**
1B2aiv Refining	NMVOC	0.6
1B2av Distribution of oil products	NMVOC	1.6
1B2b Fugitive emissions from natural gas	NMVOC	1.0

3.5.3 *Overview of shares and trends in emissions*

An overview of the trends in emissions is provided in Table 3.31. NMVOC emissions decreased between 1990 and 2023.

Table 3.31 Overview of trends in emissions in sector 1B Fugitive emissions

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	0.00	48	0.00	0.01	0.11	0.19	0.57	0.00	0.00
1995	0.00	34	0.02	0.01	0.14	0.21	0.38	0.00	0.00
2000	0.00	30	0.00	0.00	0.07	0.10	0.10	0.00	0.00
2005	0.00	21	0.00	0.00	0.07	0.10	0.11	0.00	0.00
2010	0.00	16	0.00	0.00	0.00	0.00	0.01	0.00	0.00
2015	0.00	15	0.00	0.00	0.05	0.05	0.05	0.00	0.00
2020	0.00	8.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2022	0.00	7.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2023	**0.00**	**7.5**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
1990-2023 period[1)]	0.00	-40	0.00	-0.01	-0.11	-0.18	-0.56	0.00	0.00
1990-2023 period[2)]		-84%		-96%	-99%	-99%	-100%		

Table 3.31 Overview of trends in emissions in sector 1B Fugitive emissions (continued)

	Priority Heavy Metals			POPs		Other Heavy Metals					
	Pb	Cd	Hg	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2015	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2020	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2022	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2023	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
1990-2023 period[1)]	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
1990-2023 period[2)]					-100%						

1. Absolute difference
2. Relative difference compared to 1990 in %

3.5.4 *Activity data and (implied) emission factors*

Emissions from source category 1B2aiv are available from environmental reports. Activity data for categories 1B2av and 1B2b is available from Statistics Netherlands.

3.5.5 *Methodological issues*

Fugitive NMVOC emissions from source category 1B2aiv comprise process emissions from oil refining and storage. The emissions are derived from the companies' e-AERs (electronic Annual Environmental Reports), in which the companies report their annual emissions (Tier 3 methodology). The reported emission data is based on both measurements and calculations and is checked by the competent authority. They include emissions from venting and flaring by refineries. The companies report emissions per fuel type (including the amount of fuel), and process emissions (without any activity data). Emissions reported with fuel are assumed to be combustion emissions and are included in 1A1b. while emissions reported without fuel are assumed to be fugitive emissions and are reported in 1B2aiv. When this results in zero emissions in source category 1B2aiv, the notation key 'IE' (Included Elsewhere) is used.

Flaring emissions are sometimes reported with fuel (and allocated to 1A1b), and sometimes without fuel (and allocated to 1B2aiv).

Fugitive NMVOC emissions from category 1B2av comprise dissipation losses from gasoline service stations, leakage losses during vehicle and aircraft refuelling and refinery process losses:

- Emissions from gasoline service stations are based on the amount of fuel used for road transportation combined with

country-specific EFs. A detailed description of the methodology is available in chapters 24 and 27 of the WESP methodology report (Visschedijk et al., 2025).
- Emissions from aircraft refuelling are based on the total quantity of jet fuel tanked, with an EF that is based on the environmental report by the company that handles all aircraft fuelling and fuel handling at Amsterdam Airport Schiphol. A detailed description of the methodology is available in the Transport methodology report (Witt et al., 2025a).
- Emissions from refinery processes are based on environmental reports from individual companies. The companies report emissions per fuel type (including the amount of fuel) and process emissions (without any activity data). The process emissions have been allocated to 1B2av. For the years when the company in question did not submit an environmental report, a supplemental emission estimate has been made.

Fugitive NMVOC emissions from category 1B2b comprise emissions from oil and gas extraction (exploration, production, processing, flaring and venting), gas transmission (all emissions including storage) and gas distribution networks (pipelines for local transport):
- Emissions from the extraction of oil and gas are reported by operators in their e-AER (Tier 3 methodology).
- NMVOC emissions from gas transmission were derived from data in the annual reports by the gas transmission company Gasunie (Tier 3 methodology).
- NMVOC emissions from gas distribution were calculated on the basis of an NMVOC profile with CH_4 emissions from annual reports by the distribution sector as input (Tier 2 methodology).

Detailed information on activity data and emissions can be found in Honig et al. (2025).

Emissions from venting and flaring are not included in 1B2c, because it is not possible to separate the venting and flaring emissions from the company emission data. Instead, the emissions are included in 1B2aiv (venting and flaring in refineries) and in 1B2b (venting and flaring from oil and gas extraction. The notation key ‘IE’ (Included Elsewhere) is used in source category 1B2c.

Oil and Gas extraction companies report the emission data in their e-AERs on the basis of a covenant (NOGEPA, 2012). Under the covenant, there are no reporting thresholds, and the operators report aggregated totals for all emissions except for greenhouse gas emissions, for which an obligation to report venting, flaring, combustion and process separately is agreed on. Emissions of $PM_{2.5}$, heavy metals and POPs are not estimated because the amount is expected to be a negligible part of the total NL emissions. Further information on operators’ reports on the emissions to air can be found in a guideline (NOGEPA, 2018).

Other fugitive emissions from category 1B2d are not estimated. Whilst the EMEP/EEA (2019) Guidebook provides Tier 1 EFs for geothermal power emissions, these are not applicable, because the geothermal power projects in the Netherlands are not combined with electricity production.

3.5.6 *Uncertainties and time series consistency*

Uncertainties are explained in Section 1.6.3.

3.5.7 *Source-specific QA/QC and verification*

General QA/QC is explained in Section 1.7.

3.5.8 *Source-specific recalculations*

As a result of the Oil and Gas Methane Partnership (OGMP) new data has become available for the methane emission from Gas distribution category 1.B.2.b. The methane emission from Gas distribution is combined with an NMVOC profile to calculate the NMVOC emission in this category. The resulting changes are presented in Table 3.32.

Table 3.32 Change in NMVOC emission for 1B2b (in kg)

Pollutant	1990	2005	2010	2015	2020	2022
NMVOC	402,437	432,637	420,071	393,480	392,900	307,942

3.5.9 *Source-specific planned improvements*

There are no source-specific planned improvements.

4 Transport

4.1 Overview of the sector

The Transport sector is a major contributor to emissions of NO_x, NMVOC, CO, TSP, PM_{10} and $PM_{2.5}$. Transport emissions of most substances have decreased throughout the time series, mainly due to the introduction of increasingly stringent European emission standards for new road vehicles.

The Transport sector (1A3) comprises the following subcategories:

- Civil aviation (1A3a);
- Road transport (1A3b);
- Railways (1A3c);
- Waterborne navigation (1A3d);
- Pipeline transport (1A3ei).

Table 4.1 provides an overview of the source categories within the Transport sector and the methodologies used for calculating emissions within the sector. For the first four source categories, national activity data and (mostly) country-specific EFs were used. Emissions from Civil aviation and Waterborne navigation were based on data about fuel consumption (fuel used), whereas emissions from Railways and Road transport were calculated using fuel sales data (fuel sold).

Table 4.1 Source categories and methods for 1A3 Transport and for other transport-related source categories

NFR code	Source category description	Method	AD	EF	Basis
1A3a	Civil aviation	Tier 3	NS	CS	Fuel-used
1A3b	Road transport	Tier 3	NS	CS	Fuel-sold
1A3c	Railways	Tier 2	NS	CS	Fuel-sold
1A3d	Waterborne navigation	Tier 3	NS	CS	Fuel-used
1A2gvii	Mobile combustion in manufacturing industries and construction	Tier 3	NS	CS	Fuel-used
1A4aii	Commercial/Institutional: Mobile	Tier 3	NS	CS	Fuel-used
1A4bii	Residential: Household and gardening (mobile)	Tier 3	NS	CS	Fuel-used
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	Tier 3	NS	CS	Fuel-used
1A4ciii	National fishing	Tier 3	NS	CS	Fuel-sold
1A5b	Other, mobile (including military, land-based and recreational boats)	Tier 3	NS	CS	Fuel-used

AD = Activity data; EF = Emission Factor; NS = National Statistics; CS = Country-specific

For the main pollutants, the Netherlands reports both fuel-sold and fuel-used emissions. The difference between fuel-used and fuel-sold emissions is described in Section 4.3.

This chapter also covers emissions from non-road mobile machinery (NRMM), recreational craft and national fishing. Emissions from NRMM are reported in several source categories within the inventory (i.e. 1A2gvii, 1A4aii, 1A4bii, 1A4cii), presented in Table 4.1. Emissions from NRMM were calculated using a Tier 3 methodology based on fuel used, comprising both national activity data and a combination of country-specific and default EFs. Emissions from recreational craft and vehicles operating at airports are reported under 1A5b (Other, mobile) and were calculated using Tier 3 and Tier 2 methodology, respectively. Emissions from fisheries are reported under 1A4ciii National fishing; they were calculated using a Tier 3 methodology. Notation key 'IE' is used for sector 1A3ei pipeline transport.

This chapter describes shares and trends in emissions for the various source categories within the Transport sector. The methodologies used for emission calculations are also described briefly. A detailed description of these methodologies is provided in Witt et al. (2025a), supplemented by tables with detailed emission and activity data, and the EFs used in the emission calculations (Witt et al., 2025b).

4.1.1 Key sources

The source categories within the Transport sector are key sources of various pollutants, as presented in Table 4.2. The percentages in Table 4.2 relate to the 2023 **level** assessment and the 1990–2023 **trend** assessment (in *<u>italics and underlined</u>*). The full results of the Approach 1 key source analysis are presented in Appendix 2.

The Approach 2 key source analysis (appendix 3) is only performed at the level of GNRFR sectors for the pollutants NO_x, NMVOC, SO_x, NH_3, PM_{10} and $PM_{2.5}$.

From this analysis:

- the GNFR sector Road Transport is a:
  - 2023 level key source of NO_x, NMVOC and PM_{10};
  - 1990–2023 trend key source of NH_3;
- the GNFR sector Aviation is a 1990–2023 trend key source of SO_x and NO_x;
- the GNFR sector Offroad is a 2023 level key source of $PM_{2.5}$ and a 1990–2023 trend key source of NO_x.

Key sources in the remaining part of this chapter refer to Approach 1.

Table 4.2 Key source analysis for the Transport sector

NFR code	Source category description	SO_x	NO_x	NH_3	NMVOC	CO	PM_{10}	$PM_{2.5}$	BC	Pb[3]
1A3aii(i)	Domestic aviation LTO (civil)		[1]							18.2%
1A3bi	Passenger cars	[1]	10.1% *24.3%*		3.9% *18.6%*	34.2% *54.8%*	*8.8%*	1.8% *12.0%*	4.2% *19.8%*	12.7% *69.2%*
1A3bii	Light duty vehicles		5.6%			*5.1%*	*6.0%*	*8.1%*	6.3% *15.6%*	
1A3biii	Heavy duty vehicles and buses	*5.3%*	12.6% *21.5%*		2.1% *2.6%*[2]		*12.5%*	2.0% *17.0%*	6.7% *30.7%*	
1A3biv	Mopeds and motorcycles					5.3%				
1A3bv	Gasoline evaporation				*7.0%*[2]					
1A3bvi	Automobile tyre and brake wear						6.0%	2.1%		8.3%
1A3bvii	Automobile road abrasion						4.9%			
1A3c	Railways									8.5%
1A3di(ii)	International inland waterways		5.7%					2.5%	7.3%	
1A3dii	National navigation (shipping)		3.8%					2.2%	6.4%	
1A2gvii	Mobile Combustion in manufacturing industries and construction		6.4%				1.9% *4.9%*	3.4% *6.3%*	11.0% *11.6%*[2]	
1A4aii	Commercial/institutional: mobile					2.9%				
1A4bii	Residential: household and gardening (mobile)									
1A4cii	Agriculture/forestry/fishing: off-road vehicles and other machinery		4.4%				*2.4%*[2]	2.0%	6.1% *5.5%*[2]	
1A4ciii	Agriculture/forestry/fishing: National fishing		2.7% *3.1%*[2]							
1A5b	Other, Mobile (including military, land based and recreational boats)					[1]		1.6%	4.3%[2]	

Percentages in italics and underlined are from the trend contribution calculation
1. No longer a key source; 2. New key source; 3. Emissions based on fuel used

4.2 Civil aviation

4.2.1 Source category description

The source category Civil aviation (1A3a) includes emissions from all landing and take-off (LTO) cycles of domestic and international civil flights in the Netherlands. This includes emissions from both scheduled and charter flights, passenger and freight transport, aircraft taxiing and general aviation (non-commercial). Emissions from helicopters are also included. Emissions from civil aviation result from the combustion of jet fuel (jet kerosene) and aviation gasoline (avgas) and from wear on tyres and brakes. They also include emissions from auxiliary power units (APU) on board of large aircraft. All Dutch airports are included in the calculations. Most civil aviation in the Netherlands is based on Amsterdam Airport Schiphol, which is by far the largest airport in the country. But some regional airports have grown quite considerably since 2005.

The source category Civil aviation does not include emissions from ground support equipment at airports. This equipment is classified as mobile machinery, and the resulting emissions are reported under source category Other, mobile (1A5b). Emissions from the storage and transfer of jet fuel are reported under source category Fugitive emissions oil: Refining/storage (1B2aiv).

Cruise emissions from domestic and international aviation (i.e. emissions occurring above 3000 feet) are calculated and reported as memo items as they are not part of the national emission totals.

Due to the small size of the country, there is hardly any commercial domestic aviation in the Netherlands. The split of LTO-related fuel consumption and the resulting emissions between domestic and international aviation was made using flight statistics per airport. This split has not been made for emissions from fuel storage, tyre and brake wear, or auxiliary power units, which are all reported under International aviation (1A3i) in the NFR. Condensables are included in PM_{10} and $PM_{2.5}$ emissions.

The notation key ‘NE’ is used for NH_3 and Hg. HCB and PCBs are indicated as ‘NA’, following the 2019 EMEP/EEA Guidebook. NH_3 emissions from Civil aviation are not estimated due to lack of EFs. Emissions are expected to be negligible.

4.2.2 Key sources

Civil aviation is a key source of Pb in the emissions inventory.

4.2.3 Overview of shares and trends in emissions

Fuel consumption in civil aviation, including fuel use for auxiliary power units, almost tripled between 1990 and 2019, increasing from 4.5 to 12.4 PJ. Amsterdam Airport Schiphol is responsible for over 90% of total fuel consumption in civil aviation in the Netherlands (specific activity data and IEFs for Amsterdam Airport Schiphol and for regional airports are provided in Witt et al. (2025a and 2025b)). Fuel consumption (LTO) at Amsterdam Airport Schiphol more than doubled between 1990 and 2008. After a 9% decrease in 2009 due to the financial crisis, fuel consumption increased again in 2010 and 2011 and was approximately at pre-crisis levels in 2011. Since 2012, fuel consumption of LTO in civil aviation has continued to increase by an average of 0.3 PJ per year. Due to the COVID-19 pandemic, fuel consumption halved to 6.2 PJ in 2020. It increased again to 7.0 PJ in 2021 and 10.0 PJ in 2022.

The trends in emissions from civil aviation in the Netherlands are presented in Table 4.3. The increase in air transport and related fuel consumption has resulted in an increase in the emissions of NO_x, NMVOC, SO_x, TSP, PM_{10} and $PM_{2.5}$ and CO. Fleet average NO_x EFs have not changed significantly throughout the time series; therefore, NO_x emissions more than tripled between 1990 and 2019, following the trend in fuel consumption. PM_{10} emissions from civil aviation have also increased throughout the period. This increase was due to the significant increase in tyre and brake wear emissions, which increased in line with the increase in the maximum permissible take-off weight (MTOW) of aircraft (which is used to estimate wear emissions). Fleet average PM_{10} exhaust EFs (per unit of fuel) have decreased since 1990. As a result, the share of wear emissions in total PM_{10} emissions from civil aviation has increased. Emissions in 2020–2022 were substantially lower due to the COVID-19 pandemic.

The $PM_{2.5}/PM_{10}$ ratio for brake and tyre wear emissions from civil aviation is assumed to be 0.2 and 0.15, respectively, whereas the ratio for exhaust emissions is assumed to be 1. Consequently, the share of wear emissions in $PM_{2.5}$ emissions is smaller than in PM_{10} emissions and the trend in total $PM_{2.5}$ emissions from civil aviation has been influenced more heavily by the negative trend in exhaust emissions. This explains why total $PM_{2.5}$ emissions remained more or less constant throughout the time series, while PM_{10} emissions showed a moderate increase.

Aviation petrol (avgas) still contains lead, whereas petrol for other transport purposes has been unleaded for quite some time. With lead emissions from other source categories decreasing substantially, the share that civil aviation contributed to lead emissions in the Netherlands has increased substantially.

4.2.4 *Activity data and (implied) emission factors*

The exhaust emissions of CO, NMVOC, NO_x, PM, SO_x and heavy metals from civil aviation LTO in the Netherlands were calculated using a flight-based Tier 3 methodology. Specific data was used for the number of aircraft movements per aircraft type and per airport, which were derived from the airports and from Statistics Netherlands. This data was used in the CLEO model (Dellaert & Hulskotte, 2017) to calculate LTO fuel consumption and resulting emissions. The CLEO model was derived from the method that the US Environmental Protection Agency (EPA) uses to calculate aircraft emissions. The EFs used in CLEO were taken from the ICAO Engine Emissions DataBank. A detailed description of the methodology can be found in chapter 8 of Witt et al. (2025a).

Table 4.3 Trends in emissions from 1A3a Civil aviation

	Main Pollutants				Particulate Matter				Other	Priority Heavy
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg
1990	**1.2**	**0.40**	**0.10**	**0.00**	**0.03**	**0.03**	**0.03**	**0.01**	**3.6**	**1.9**
1995	1.8	0.36	0.14	0.00	0.03	0.04	0.04	0.01	4.1	2.0
2000	2.3	0.30	0.18	0.00	0.03	0.04	0.04	0.02	3.9	1.7
2005	2.8	0.38	0.24	0.00	0.04	0.05	0.05	0.02	4.3	1.2
2010	2.8	0.36	0.23	0.00	0.04	0.05	0.05	0.02	4.3	1.3
2015	3.4	0.37	0.26	0.00	0.03	0.04	0.04	0.01	4.1	0.8
2020	2.2	0.20	0.14	0.00	0.02	0.02	0.02	0.01	2.5	0.7
2022	2.5	0.23	0.16	0.00	0.02	0.03	0.03	0.01	2.8	0.8
2023	**3.5**	**0.34**	**0.25**	**0.00**	**0.03**	**0.04**	**0.04**	**0.01**	**3.8**	**0.8**
1990-2023 period[1]	2.3	-0.06	0.14	0.00	0.00	0.01	0.01	0.00	0.27	-1.1
1990-2023 period[2]	184%	-16%	139%		12%	32%	32%	-20%	7%	-58%

1. Absolute difference
2. Relative difference from 1990 in %

4.2.5 *Methodological issues*

Due to the small size of the country, there is hardly any domestic aviation in the Netherlands, with the exception of general aviation (non-commercial air transport). Therefore, the split of fuel consumption and resulting emissions into domestic and international aviation was not made for the emissions from brake and tyre wear, APUs and fuel storage and fuelling. Given the minimal share of domestic aviation, fuel consumption and emissions from these sources are reported under International aviation (1A3i).

The Dutch PRTR does not currently have any data available to calculate aviation cruise emissions. For this reason, the emission data as provided annually by Eurocontrol is used. For domestic aviation, the data provided by Eurocontrol is not complete, as it does not include flights that failed to submit a flight plan (which is more common for domestic flights over the Netherlands). This is why domestic cruise emissions are estimated on the basis of the domestic LTO emissions (as calculated using the CLEO model). Year- and pollutant-specific LTO phase/cruise phase emission ratios are then derived from the Eurocontrol data and applied to the LTO emissions to estimate total emissions (LTO + cruise).

4.2.6 *Uncertainties and time series consistency*

Consistent methodologies have been used throughout the time series. In 2016, an experts' workshop was conducted to discuss and estimate the uncertainties in the activity data and EFs used for the emission calculations for the Transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for civil aviation are provided in Table 4.4.

Table 4.4 Uncertainty estimates for civil aviation (%)

			Emission factor						
Type	**Fuel**	**Activity data**	**NO_x**	**SO_x**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**	**$EC_{2.5}$**	**NMVOC**
LTO	Jet kerosene	10	35	50		200	200	200	200
LTO	Aviation gasoline	35	100	50		100	100	100	500
APU	Jet kerosene	50	50	50		100	100	100	200
Fuelling and fuel handling		20							100
GSE	Diesel	10	50	20	200	100	100	100	
Tyre wear		10					100		
Brake wear		10					100		

Source: Dellaert & Dröge (2017), updated in 2019 by PRTR

4.2.7 *Source-specific QA/QC and verification*

Every year, Eurocontrol performs a calculation of aviation emissions for each of their member countries, using the Eurocontrol FEIS (Fuel burn and emission inventory system) model (Eurocontrol, 2018). For CO_2 and NO_x, there is a fairly good agreement between the two models (see Table 4.5, a value above 100% means the Dutch national inventory is higher than the value calculated by Eurocontrol). For emissions of CO and NMVOC, the difference is largest for domestic aviation. This can be explained by the incomplete coverage of the Eurocontrol data (not including flights without a flight plan) and the larger contribution from smaller piston engine aircraft – involving more uncertainty and limited availability of engine-specific emission factors.

Table 4.5 Aviation emissions (LTO domestic + LTO international) compared to the Eurocontrol FEIS model

Pollutant	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
CO	197%	194%	250%	231%	216%	204%
CO_2	112%	112%	119%	113%	112%	110%
N_2O	115%	115%	123%	116%	116%	114%
NMVOC	151%	151%	191%	178%	174%	176%
NO_x	103%	103%	109%	106%	104%	104%
$PM_{2.5}$	102%	101%	116%	114%	107%	102%
SO_x	134%	134%	143%	135%	135%	132%

4.2.8 *Source-specific recalculations*

In the calculation of civil aviation LTO emissions, there have been recalculations following an aircraft type correction for Amsterdam Airport Schiphol for the 1998–2001 period, resulting in a small increase of emissions for these years.

Another change concerns the update of the PAH profiles used for jet engines. PAH profiles have been derived from measurements by Agrawal et al. (2008) and are relative to either the total VOC or total $EC_{2.5}$ emissions, depending on whether the PAH is expected to be gaseous or particle-bound when emitted. The update leads to a substantial increase of PAH emissions, up to several orders of magnitude (e.g. BaP emissions increased ~28 fold compared to the previous profiles).

4.2.9 *Source-specific planned improvements*

There are no source-specific planned improvements for civil aviation.

4.3 Road transport

4.3.1 *Source category description*

The source category Road transport (1A3b) comprises emissions from road transport in the Netherlands, including emissions from passenger cars (1A3bi), light-duty trucks (1A3bii), heavy-duty vehicles and buses (1A3biii), and mopeds and motorcycles (1A3biv). It also includes evaporative emissions from road vehicles (1A3bv), PM emissions from tyre and brake wear (1A3bvi), and emissions from road abrasion (1A3bvii). PM emissions caused by the resuspension of previously deposited material are not included. Condensables are included in PM_{10} and $PM_{2.5}$ emissions.

The notation key 'NA' is used for BC emissions from tyre and brake wear (1A3bvi). Although both brake and tyre wear emissions are optically dark and will show up in light absorption measurements (as used for Black Carbon), they contain little to no elemental carbon in the small particles. With Black Carbon set equal to Elemental Carbon in the inventory, the Netherlands uses the better defined Elemental Carbon standard (EUSAAR protocol). Consequently, non-exhaust emissions are no source of Black Carbon (i.e. Elemental Carbon).

The notation key 'NE' is used for HCB emissions. 'NA' is used for PCB emissions in the NFR tables. Although the EMEP/EEA Guidebook provides emission factors for these pollutants, they do not reflect development over time. The usage of PCBs in lubrication oil has been prohibited since 1985 and the usage of chlorine-containing scavengers in motor fuels has been discontinued, following the ban on leaded fuels, in 2000. For this reason, emissions of PCB are decreasing constantly and are considered negligible.

Historically, emissions from road transport in the Netherlands have been calculated and reported on the basis of the number of vehicle kilometres driven per vehicle type. The resulting emission totals are referred to as *fuel-used* (FU) emissions, since they correspond to the amount of fuel used by road transport on Dutch territory. Starting with the IIR 2017, reported emissions from road transport have been based on *fuel sold* (for the entire time series) in accordance with UNECE guidelines. Fuel-used emissions are still reported as a memo item in the NFR, per source category.

4.3.2 *Key sources*

The various source categories within Road transport are key sources of many substances in both the 1990–2023 trend assessment and the 1990 and 2023 level assessments, as presented in Table 4.6.

Table 4.6 Key source analysis for road transport sub-categories

Source category	Name	1990 level	2023 level	1990–2023 trend
1A3bi	Passenger cars	NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, BC, Pb[1], PAH	NO_x, NMVOC, CO, $PM_{2.5}$, BC, Pb[1], Cd[1], Hg[1]	NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, BC, Pb[1], PAH
1A3bii	Light-duty vehicles	NO_x, CO, PM_{10}, $PM_{2.5}$, BC	NO_x, BC	PM_{10}, $PM_{2.5}$, BC
1A3biii	Heavy-duty vehicles and buses	SO_x, NO_x, NMVOC, PM_{10}, $PM_{2.5}$, BC	NO_x, NMVOC, $PM_{2.5}$, BC	SO_x, NO_x, NMVOC, PM_{10}, $PM_{2.5}$, BC
1A3biv	Mopeds and motorcycles		CO	
1A3bv	Gasoline evaporation	NMVOC		NMVOC
1A3bvi	Tyre and brake wear		PM_{10}, $PM_{2.5}$, Pb[1]	Cu[1]
1A3bvii	Road abrasion		PM_{10}	

1. Based on fuel used

4.3.3 *Overview of shares and trends in emissions*

Road transport is a major contributor to air pollutant emissions in the Netherlands. Taken together, the various source categories within Road transport accounted for 29% of NO_x emissions (national totals), 14% of PM_{10}, 9% of $PM_{2.5}$, 19% of BC, 8% of NMVOC and 42% of CO emissions in 2022.

The trends in emissions from road transport are presented in Table 4.7. Emissions of the main pollutants and particulate matter decreased significantly throughout the time series with the exception of NH_3. This decrease in emissions can mainly be attributed to the introduction of increasingly stringent European emission standards for new road vehicles. Even though emission totals decreased throughout the time series, the share that Road transport contributed to the national emission totals for NO_x, PM_{10} and $PM_{2.5}$ decreased only slightly between 1990 and 2023, as emissions in other sectors decreased as well. Therefore, Road transport is still a major source of pollutant emissions in the Netherlands.

Table 4.7 Trends in emissions from 1A3b Road transport

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**295**	**176**	**16**	**0.94**	**18**	**19**	**19.4**	**8.5**	**694**
1995	234	114	15	2.4	13	15	15.0	6.8	512
2000	194	63	3.7	4.4	9.9	12	11.8	5.8	388
2005	173	37	0.25	5.0	7.0	9.1	9.07	4.4	367
2010	130	26	0.21	3.9	3.4	5.6	5.56	2.0	312
2015	87	23	0.18	3.5	2.0	4.1	4.12	0.9	235
2020	60	20	0.16	3.3	1.3	3.4	3.40	0.49	182
2022	57	20	0.17	3.4	1.3	3.5	3.47	0.45	171
2023	**53**	**19**	**0.17**	**3.8**	**1.2**	**3.6**	**3.60**	**0.37**	**162**
1990-2023 period[1]	-242	-156	-15.8	2.8	-16.5	-15.8	-15.8	-8.2	-532
1990-2023 period[2]	-82%	-89%	-99%	300%	-93%	-81%	-81%	-96%	-77%

1. Absolute difference
2. Relative difference from 1990 in %

Between 1990 and 2023, emissions of SO_x decreased by 99%, due to increasingly stringent EU fuel quality standards regulating the maximum allowable sulphur content of fuels used in (road) transport. Currently, all road transport fuels are 'sulphur free' (sulphur content <10 parts per million).

Emissions of NH_3 by road transport increased significantly between 1990 and 2005 due to the introduction and subsequent market penetration of the three-way catalyst for petrol-driven passenger cars. Since 2005, NH_3 emissions from road transport have decreased. Despite the increase in emissions since 1990, road transport is only a minor source of NH_3 emissions in the Netherlands, with a share of 3.2% in national emission totals in 2023.

Emissions of heavy metals have increased, except for Pb. Those emissions decreased significantly with the introduction of unleaded petrol.

Passenger cars (1A3bi)
The number of kilometres driven by passenger cars in the Netherlands steadily increased from approximately 82 billion km in 1990 to 109 billion km in 2018 (see Figure 4.1). Due to the COVID-19 pandemic it fell to 92 billion in 2020, in 2022 it increased again to over 102 billion and continued to increase to 107 billion in 2023, almost reaching the pre-pandemic level.

Since 1995, the share of diesel-powered passenger cars in the Dutch car fleet has grown significantly, resulting in an increase in diesel mileage by 95% between 1990 and 2012. Since 2017, the diesel mileage of passenger cars dropped significantly by over 50%.
Petrol mileage increased by 34% between 1990 and 2019. The share of LPG in the passenger car fleet decreased significantly, from 16% in 1990

to almost 1% in 2022. In 2020, the decrease in passenger vehicle kilometres due to the pandemic was relatively high for diesel cars (-28%) compared to petrol cars (-11%). Figure 4.1 makes clear that, even though the number of diesel kilometres increased significantly, petrol still dominates passenger car transport. Throughout the time series, petrol was responsible for approximately two-thirds of the total number of kilometres driven by passenger cars. The market share of diesel increased throughout the time series, mainly at the expense of LPG.

NO_x emissions from passenger cars decreased significantly throughout the time series, even though traffic volumes increased. This decrease can mainly be attributed to the introduction of the three-way catalyst (TWC), which led to a major decrease in NO_x emissions from petrol-powered passenger cars. Between 1995 and 2007, NO_x emissions from diesel-powered passenger cars increased by more than 60%. This increase resulted from the major increase in the kilometres driven by diesel cars combined with less stringent emission standards and the disappointing real-world NO_x emission performance of recent generations of diesel-powered passenger cars. Due to the decrease of NO_x emissions from petrol-powered passenger cars, NO_x has mostly become a diesel-related issue. Since 2007, NO_x emissions from diesel cars have decreased.

The introduction of the TWC for petrol-powered passenger cars also led to a major reduction in NMVOC and CO emissions. NMVOC exhaust emissions from petrol-powered passenger cars decreased by more than 80% throughout the time series, whereas CO emissions decreased by more than 60%. NMVOC and CO emissions from diesel- and LPG-powered passenger cars also decreased significantly, but both are minor sources of NMVOC and CO. In 2023, passenger cars were responsible for 3.9% of NMVOC emissions – not including evaporative NMVOC emissions (down from 16% in 1990) and 31% of CO emissions (down from 48% in 1990) in the Netherlands.

In 2023, Passenger cars (source category 1A3bi, including exhaust emissions only) were responsible for 1.5% of $PM_{2.5}$ emissions and 0.9% of PM_{10} emissions in the Netherlands. PM_{10} exhaust emissions from passenger cars decreased by more than 95% throughout the time series. Emissions from both petrol- and diesel-powered cars decreased significantly throughout the time series, due to increasingly stringent EU emission standards for new passenger cars. The continuing decrease of PM_{10} and $PM_{2.5}$ exhaust emissions in recent years is primarily due to the increasing market penetration of diesel-powered passenger cars equipped with *diesel particulate filters* (DPF). DPFs are required to comply with the Euro-V PM emission standard, which came into force by 2011. DPFs entered the Dutch fleet much earlier, though, helped by a subsidy that was introduced by the Dutch government in 2005. In 2007, more than 60% of all new diesel-powered passenger cars were equipped with a DPF. In 2008, the share of new diesel passenger cars with a DPF exceeded 90%. $PM_{2.5}$ exhaust emissions from passenger cars (and other road transport) are assumed to be equal to PM_{10} exhaust emissions.

Passenger cars are a key source of Cd emissions, as they are responsible for 23% of total national Cd emissions. Between 1990 and 2023, Cd emissions from passenger cars increased by 57%.
NH_3 emissions from passenger cars increased significantly from 1990 to 2006, as a result of the introduction of the TWC. From 2007 onwards, emissions have started to decrease, amounting to 2.9 Gg in 2023. The increase in vehicle kilometres driven since 2007 has been compensated by the introduction of newer generations of TWCs with lower NH_3 emissions per vehicle kilometre driven, resulting in a decrease of the fleet average NH_3 EF. Lead emissions from passenger cars decreased by more than 99% throughout the time series due to the phase-out of leaded petrol.

Light-duty trucks (1A3bii)
Between 1990 and 2005, the light-duty truck fleet in the Netherlands grew significantly, leading to a major increase in vehicle kilometres driven (see Figure 4.1). In 2005, private ownership of light-duty trucks became less attractive due to changes in the tax scheme. As a result, the size of the vehicle fleet has more or less stabilised since then. The number of vehicle kilometres driven varied between 17 and 18 billion between 2005 and 2011, decreasing somewhat in 2012 and 2013, and again increasing slightly after 2015. It is likely that the fluctuations in these years can mainly be attributed to the economic situation. The proportion of petrol-powered trucks in the fleet decreased steadily throughout the time series. In recent years, diesel engines have dominated the light-duty truck market and are now responsible for more than 98% of new-vehicle sales. Currently, over 95% of the fleet is diesel-powered. In 2022, following the corona pandemic, vehicle kilometres driven by light-duty trucks increased by 3% compared to 2021, and this increase continued in 2023.

In the1990–2016 period, NO_x emissions from light-duty trucks fluctuated between 17 and 22 Gg. Since 2016, the emissions have decreased to 10.3 Gg in 2023. in that year, they were 46% lower than in 1990, even though the number of vehicle kilometres driven more than doubled during this period. The EU emission standards for light-duty trucks and the subsequent market penetration of light-duty diesel engines with lower NO_x emissions caused a decrease in the fleet average NO_x emissions per vehicle kilometre. However, because of the poor NO_x emission performance of Euro-V light-duty trucks, the fleet average NO_x EF for diesel light-duty trucks has stabilised in recent years.

Light-duty trucks are a minor source of both CO and NMVOC emissions, accounting for approximately 1% and 0.4% of the national totals for both substances in 2023, respectively. Exhaust emissions of NMVOC and CO from light-duty trucks decreased significantly throughout the time series. Increasingly stringent EU emission standards for both substances have led to a major (85–87%) decrease in the fleet average EFs for both petrol and diesel trucks between 1990 and 2022. Petrol-powered trucks emit far more NMVOC and CO per kilometre than diesel-powered trucks. As a result, the decrease in the number of petrol-driven trucks has also contributed significantly to the decrease in NMVOC and CO emissions.

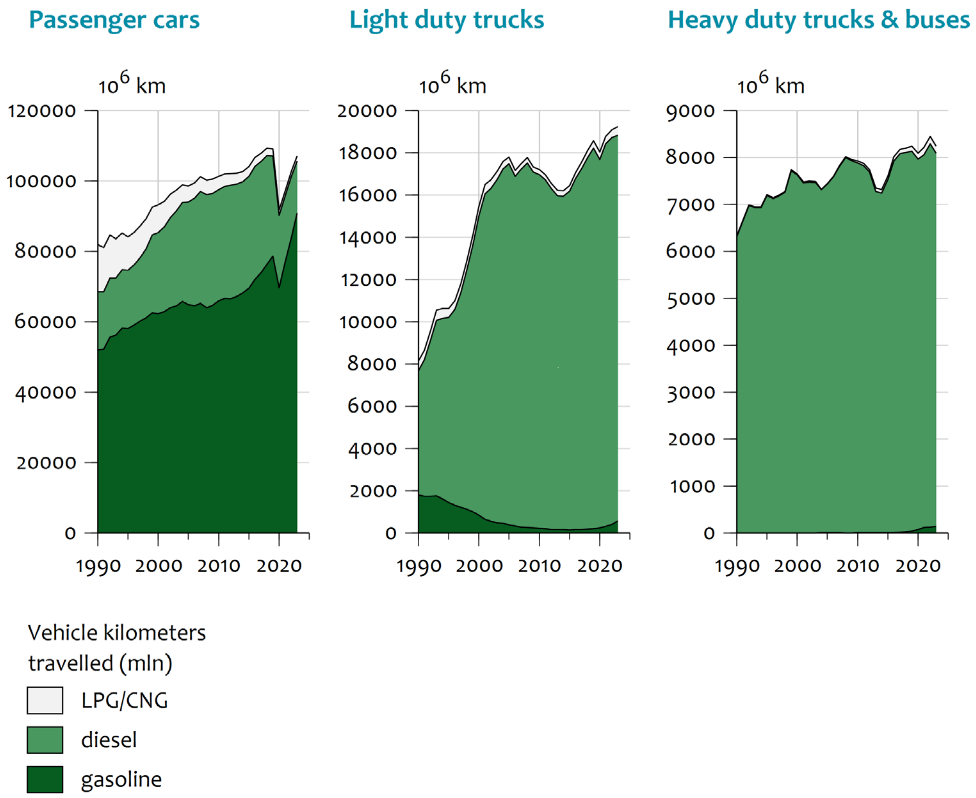


Figure 4.1 Kilometres driven per vehicle and fuel type in the Netherlands (source: Statistics Netherlands)

The exhaust emissions of PM_{10} and $PM_{2.5}$ from light-duty trucks decreased throughout the time series. The fleet average PM_{10} EF decreased consistently throughout the time series, but this decrease was initially offset by the increase in vehicle kilometres driven. Diesel-powered trucks are dominant in PM_{10} exhaust emissions, with a share of over 99%. The average PM_{10} exhaust EF for diesel-powered light-duty trucks has decreased significantly in recent years, due to the market penetration of diesel-powered light-duty trucks with DPFs. Even though the number of vehicle kilometres driven has stabilised since 2005, PM_{10} exhaust emissions decreased by 87% between 2005 and 2023.

Heavy-duty vehicles and buses (1A3biii)
Between 1990 and 2008, the number of vehicle kilometres driven by heavy-duty vehicles (rigid trucks, tractor-trailer combinations) and buses in the Netherlands increased by approximately 30% (see Figure 4.1). Following a decrease during the financial crisis, transport volumes increased again to pre-crisis levels. Diesel dominates the heavy-duty vehicle and bus fleet, with a share of 99%.

NO_x emissions from heavy-duty vehicles and buses decreased from 130 Gg in 1990 to 23 Gg in 2023. Emissions have decreased significantly in recent years, due to the decrease in vehicle kilometrages between 2008 and 2014 (Figure 4.1) and the decrease in the fleet average NO_x EF. The latter decreased significantly throughout the time series, mainly due to increasingly stringent EU emission standards for heavy-duty engines. With second-generation Euro-V trucks showing better NO_x emission performance during real-world driving, the fleet average NO_x EF for heavy-duty vehicles has decreased significantly since 2008. The current generation of Euro-VI trucks, which entered the market in 2013, is fitted with a combination of Exhaust Gas Recirculation (EGR) and a Selective Catalytic Reduction (SCR) system, resulting in very low real-world NO_x emission levels (Kadijk et al., 2015).

NMVOC exhaust emissions decreased by around 73% throughout the time series while PM_{10} and $PM_{2.5}$ exhaust emissions decreased by more than 95%. These decreases were also caused by changes to EU emission legislation. In the most recent year, heavy-duty vehicles and buses were only a minor source of NMVOC emissions.

Heavy-duty vehicles and buses are a minor source of NH_3 emissions in the Netherlands (0.5% of national totals). However, NH_3 emissions from heavy-duty vehicles and buses increased significantly between 2005 and 2023. This increase was caused by the rising use of SCR catalysts in heavy-duty trucks and buses. High SCR conversion rates may yield NH_3 slip, as described in detail by Stelwagen and Ligterink (2015). NH_3 EFs for Euro-V trucks and buses are approximately six times higher than EFs for previous Euro classes, as presented in table 3.11 of Witt et al. (2025b). Emission factors for Euro-VI trucks and buses are estimated to be 30 times higher than those for previous Euro classes. Therefore, NH_3 emissions from heavy-duty vehicles and buses have increased tremendously due to the market introduction of Euro-VI vehicles. In 2023, emissions amounted to 0.65 Gg, up from 0.19 Gg in 2012.

Motorcycles and mopeds (1A3biv)
Motorcycles and mopeds are a minor emission source in the Netherlands, being responsible for less than 1% of national totals for most substances. In 2023, motorcycles and mopeds were responsible for 1% of NMVOC emissions and 5% of CO emissions in the Netherlands. Even though the number of vehicle kilometres driven almost doubled between 1990 and 2023, exhaust emissions of NMVOC decreased significantly, due to increasingly stringent EU emission standards for two-wheelers. In 2023, the share of motorcycles and mopeds in NO_x emissions in the Netherlands was still small, amounting to 0.4%, as was the share in $PM_{2.5}$ emissions, amounting to approximately 0.3%.

Petrol evaporation (1A3bv)
Evaporative NMVOC emissions from road transport have decreased significantly, due to EU emission legislation for evaporative emissions and the subsequent introduction of carbon canisters for petrol-powered passenger cars. Total evaporative NMVOC emissions decreased by 95% throughout the time series. As a result, evaporative emissions are no longer a key source in the level assessment, accounting for <1% of total NMVOC emissions in the Netherlands in 2022 (down from 6% in 1990). Petrol-powered passenger cars are by far the largest source of evaporative NMVOC emissions from road transport in the Netherlands, although their share has decreased from more than 90% in 1990 to 61% in 2022. Motorcycles and mopeds were mainly responsible for the rest of evaporative NMVOC emissions; other road vehicles contributed below 3%.

PM emissions from tyre and brake wear and road abrasion (1A3bvi and 1A3bvii)
Vehicle tyre and brake wear (1A3bvi) and road abrasion (1A3bvii) were responsible for 6% and 5% of PM_{10} emissions in the Netherlands, respectively. PM_{10} emissions from brake wear, tyre wear and road abrasion increased throughout most of the time series, as presented in Figure 4.2, due to the increase in vehicle kilometres driven by light- and heavy-duty vehicles. PM_{10} EFs were constant throughout the time series.

$PM_{2.5}$ emissions were derived from PM_{10} emissions using $PM_{2.5}/PM_{10}$ ratios of 0.2 for tyre wear and 0.15 for both brake wear and road abrasion. Therefore, the trend in $PM_{2.5}$ wear emissions was similar to the trend in PM_{10} emissions. The shares of tyre and brake wear (2%) and road abrasion (1%) in total $PM_{2.5}$ emissions in the Netherlands was smaller than their shares in PM_{10}.

In response to the recommendation from the IIR 2023 review (NL-1A3bvi-2023-0001) regarding the ratio $PM_{10}/PM_{2.5}$, we have planned improvements on these ratios for the IIR 2025.

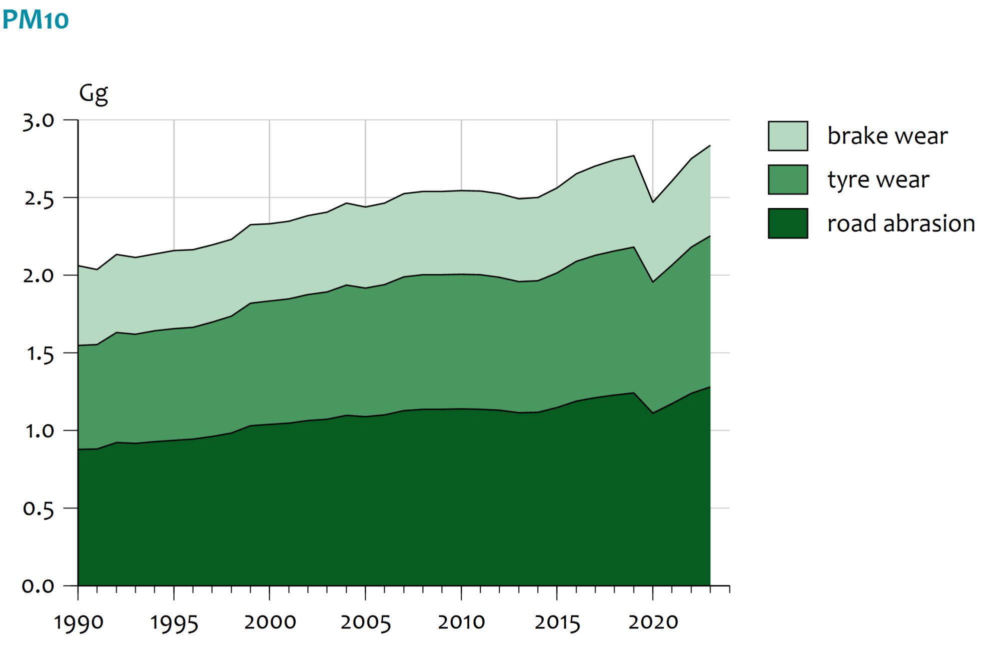


Figure 4.2 Emissions of PM_{10} resulting from brake and tyre wear and road abrasion in Gg

4.3.4 *Activity data and (implied) emission factors*
Emissions from road transport were calculated using a Tier 3 methodology. Exhaust emissions of CO, NMVOC, NO_x, NH_3 and PM from road transport were calculated, using statistics on vehicle kilometres driven and EFs expressed in grams per vehicle kilometre (g/km). Emissions of SO_x and heavy metals were calculated using fuel consumption estimates combined with the sulphur and heavy metal content of various fuel types, taking into account the tightening of the EU fuel quality standards regulating the maximum allowable sulphur and lead content of fuels used in road transport. The resulting emissions for CO, NMVOC, NO_x, NH_3 and PM were subsequently corrected for differences

between the fuel used and the fuel sold to derive fuel-sold emission totals from road transport.

Activity data on vehicle kilometres driven

The data on the number of vehicle kilometres driven in the Netherlands was derived from Statistics Netherlands. Statistics Netherlands calculates total vehicle kilometrage per vehicle type using data on:

- the size and composition of the Dutch vehicle fleet;
- the average annual kilometrage for various vehicle types; and
- the number of kilometres driven by foreign vehicles in the Netherlands.

Since 2018, a bottom-up methodology has been implemented on the basis of vehicle kilometres driven per individual vehicle. Data per licence plate number is available from RDW (the Dutch Driver and Vehicle Licensing Agency). Subsequently, each licence plate number was matched to a vehicle class, as defined by vehicle type, weight class, fuel type, emission legislation and specific exhaust gas technologies. More than 350 vehicle classes are distinguished. For each vehicle class, the road type distribution is estimated on the basis of annual vehicle kilometres driven and manufacture year.

Starting with IIR 2024, a new approach was used to calculate the activity data for the period from 2004 until 2017. The fleet information from the bottom-up years was used to reconstruct the fleet in the 2009–2017 period. After a correction by the total number of vehicle kilometres a more accurate estimate of activity data and resulting emissions could be calculated.
More detailed information on activity data is presented in Witt et al. (2025b).

Emission factors

The CO, NMVOC, NO_x and PM exhaust EFs for road transport were calculated using the VERSIT+ model (Ligterink & de Lange, 2009). Using VERSIT+, EFs can be calculated for various transport situations and scale levels. The EFs follow from several analyses fed by various kinds of measuring data. VERSIT+ LD (light-duty) has been developed for passenger cars and light-duty trucks. The model is used to estimate emissions under specific traffic situations. To determine the EFs, the effect of various types of driving behaviour and the statistical variation per vehicle are investigated. Next, the results are used in a model that currently includes more than 50 light-duty vehicle categories for each of the emission components. The resulting model separates driving behaviour from vehicle category dependencies.

VERSIT+ HD (Spreen et al., 2016) was used to estimate the EFs of heavy-duty vehicles (i.e. trucks, road tractors and buses). For older vehicles, VERSIT+ HD uses European measurement data. For newer vehicles (Euro-III – Euro-VI), measurement data is available that closely resembles the real-world use of the vehicles. This new data is based on driving behaviour, taken from both on-road measurements and measurements on test stands, and this data has been used in a model to represent emissions during standard driving behaviour. The EFs for buses often originate from test stand measurements, which include realistic driving behaviour for regular service buses.

Emissions of SO_x and heavy metals (and CO_2) are dependent on fuel consumption and fuel type. These emissions were calculated by multiplying fuel consumption by fuel- and year-specific EFs (grams per litre of fuel). Heavy metal emissions were calculated on the basis of *fuel used*. The EFs for SO_x and heavy metals were based on the sulphur, carbon and heavy metal content of the fuels, as described in Witt et al. (2025a). NMVOC evaporative emissions are estimated using the methodology from the EEA Emission Inventory Guidebook (EEA, 2007). The NH_3 EFs were derived from Stelwagen et al. (2015).

PM emission factors
PM_{10} EFs and $PM_{2.5}/PM_{10}$ ratios for brake and tyre wear and for road abrasion were derived from literature (Broeke ten et al., 2008; Denier van der Gon et al., 2008; RWS, 2008). An overview of these EFs is provided in Witt et al. (2025b: tables 3.3 and 3.13). For tyre wear, the EFs are calculated as the total mass loss of tyres resulting from the wear process and the number of tyres per vehicle category. The emissions are based on fuel used, as they are unrelated to fuel sold.

Lubricant oil
Combustion of lubricant oil is estimated on the basis of vehicle kilometres driven and consumption per kilometre. Consumption factors per vehicle type are provided in table 3.4 of Witt et al. (2025b). The resulting emissions are included in the EFs for transport and are not estimated separately, with the exception of heavy metals. These are considered to be extra emissions, which is why they are calculated separately by multiplying the consumption of lubricant oil and the lubricant oil profile (see table 3.9 of Witt et al., 2025b).

Deriving fuel-sold emissions from road transport
In order to derive fuel-sold emissions from road transport, the fuel-used emissions per fuel type are adjusted for differences between the fuel used by road transport in the Netherlands and the fuel sold as reported by Statistics Netherlands. The differences between fuel used and fuel sold can most likely be attributed to price differences between neighbouring countries leading to cross-border fuelling. The trends are described and explained elaborately in the IIR 2020, section 4.3.4.

Figure 4.3 represents both the bottom-up estimates for fuel used by road transport and the reported fuel sold to road transport per fuel type for the time series.

Because fuel-sold emissions for gasoline vehicles are estimated using a generic correction to fuel-used emissions per fuel type, the difference between fuel-used and fuel-sold emissions depends solely on the share of the various fuel types in emission totals per substance. For diesel vehicles, the difference between fuel used and fuel sold is allocated to heavy-duty trucks (dashed lines in Figure 4.3).

Diesel trucks are a major source of NO_x and PM emissions; fuel-used emissions of NO_x and PM for diesel trucks are adjusted upwards, especially in the earlier years of the time series, as can be seen in Figure 4.4. NMVOC emissions from road transport mostly stem from petrol-powered vehicles. Since the difference between fuel used and fuel sold for petrol vehicles is small, fuel-used and fuel-sold NMVOC emission totals do not differ much, as presented in Figure 4.4. PM emissions from brake and tyre wear and from road abrasion were not adjusted for differences between fuel used and fuel sold, since these emissions are not directly related to fuel use.

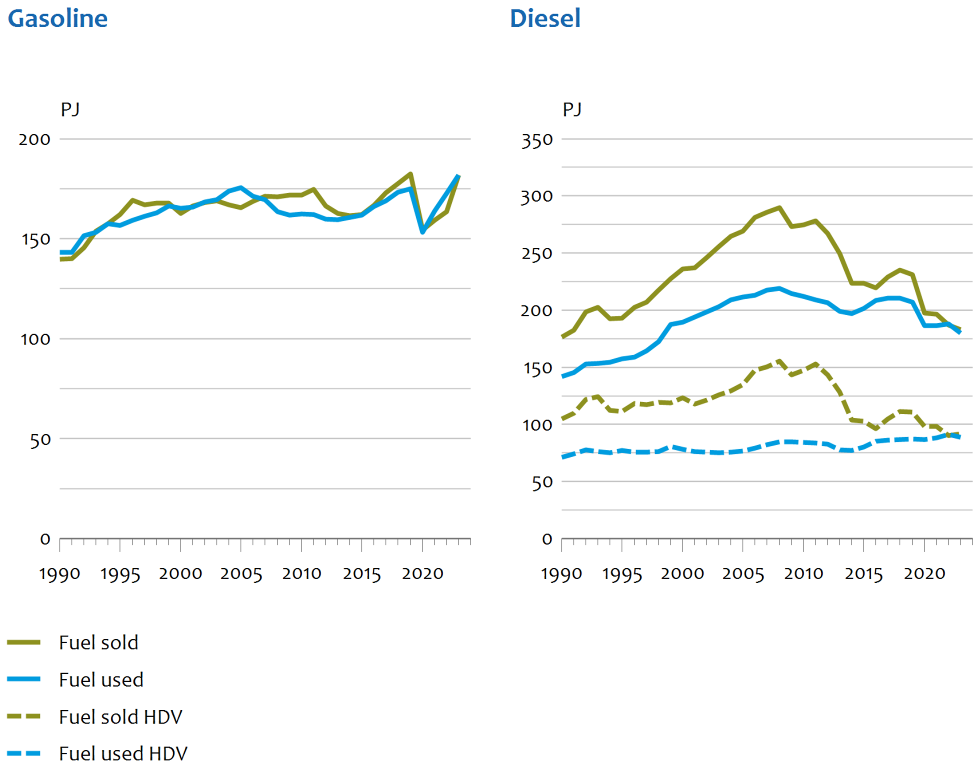


Figure 4.3 Amount of Fuel-sold and Fuel-used in the Netherlands for gasoline and diesel. For diesel the amount of fuel supplied to heavy duty vehicles (HDV) is shown separately

Biofuels

Emissions resulting from the use of biofuels in road transport are not reported separately in the NFR. Emission measurements are based on representative fuel samples, including a share of biofuels; therefore, resulting EFs are representative of the market fuels used in the Netherlands. Activity data for biofuels is included under liquid fuels.

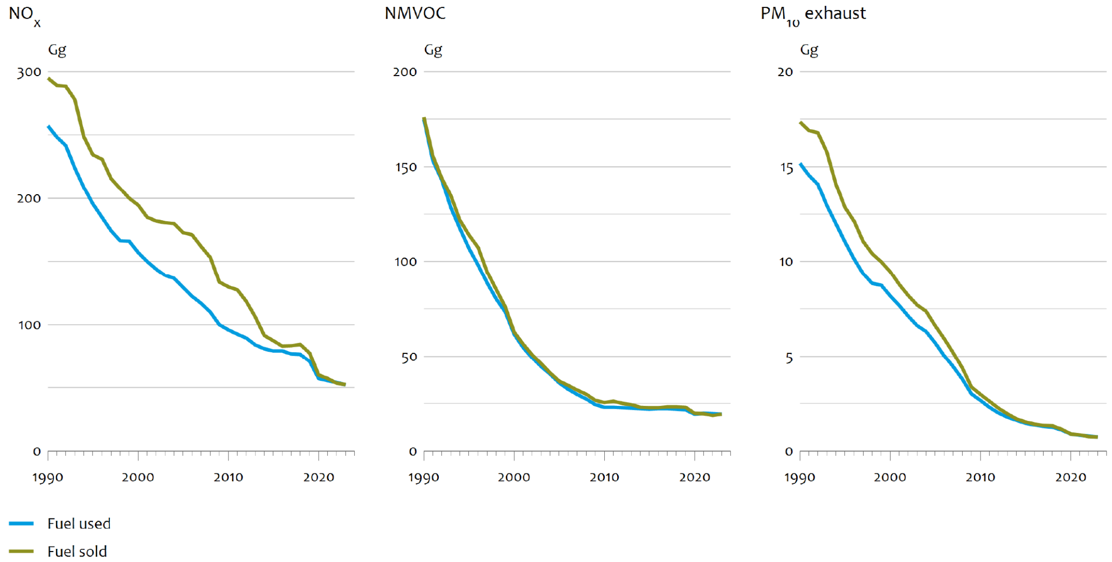


Figure 4.4 NO_x, NMVOC and PM_{10} exhaust emissions from road transport in the Netherlands based on fuel used and fuel sold

4.3.5 *Methodological issues*

Several parts of the emission calculations for road transport require improvement:

- The PM_{10} and $PM_{2.5}$ EFs for brake and tyre wear and for road abrasion are rather uncertain due to lack of recent measurements.
- The road type distribution of all vehicle categories was last updated in 2010 and needs to be verified.

4.3.6 *Uncertainties and time series consistency*

Consistent methodologies have been used throughout the time series. Uncertainties were estimated in two studies. In 2013, TNO carried out a study to improve knowledge of the uncertainties concerning pollutant emissions from road transport (Kraan et al., 2014). Using a jackknife approach, the variation in the input variables used for estimating total NO_x emissions from Euro-4 diesel passenger cars was examined, including the emission behaviour of the vehicles, on-road driving behaviour and the total vehicle kilometres driven. From this case study, it was concluded that the 95% confidence interval lies at a 100% variation in emission totals if all aspects are added up. It is unclear whether these results hold for more recent generations of (diesel) passenger cars. Testing procedures have improved in recent years, but the number of vehicles tested has decreased over time. This method of determining uncertainties has proven to be very time-consuming. For that reason, a decision was made to use an expert-based approach to estimate uncertainties for NFR categories.
In 2016, an experts’ workshop was conducted to discuss and estimate the uncertainties in the activity data and EFs used for the emission calculations for the Transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for road transport are presented in Table 4.8.

Table 4.8 Uncertainty estimates for road transport (%)

			Uncertainty: emission factor						
NFR	**Fuel**	**Uncertainty: activity data**	**NO_x**	**SO_x**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**	**$EC_{2.5}$**	**NMVOC**
1A3bi Passenger cars	Petrol	5	20	20	200	200	200	500	100
	Diesel	5	20	20	100	50	50	50	100
	LPG	5	20		200	200	200	500	50
1A3bii Light-duty vehicles	Petrol	5	20	20		200	200	500	50
	Diesel	5	20	20		50	50	50	100
	LPG	5				200	200	500	
1A3biii Heavy-duty vehicles	Petrol	10	20	20		200	200	500	
	Diesel	10	20	20	100	50	50	50	100
	LPG	10				200	200	500	
1A3biii Buses	Natural gas	5							
	Petrol	5	20	20		200	200	500	
	Diesel	5	20	20		50	50	50	
	LPG	5				200	200	500	
1A3biv Mopeds/motorcycles	Petrol	20	200	20		500	500	500	500
	Diesel	20	100	20		500	500	500	
1A3bv	Petrol, passenger cars								200
	Petrol, mopeds/ motorcycles								500
1A3bvi	Tyre wear					100	200		
1A3bvi	Brake wear					100	200		
1A3bvii	Road surface wear					200	500		

Source: Dellaert & Dröge (2017)

4.3.7 *Source-specific QA/QC and verification*

Trends in the number of vehicle kilometres driven in the Netherlands, as calculated by Statistics Netherlands using odometer readings, were compared to trends in traffic intensities on the Dutch motorway network, as reported by Rijkswaterstaat. In general, both time series tend to be in agreement, with some annual fluctuations. Trends in fuel sales data compare with trends in fuel used, as described in Section 4.3.4.

For the most part, emission factors for road transport are derived from national measurement programmes. TNO discusses resulting EFs with international research institutions, e.g. the ERMES group (https://www.ermes-group.eu/web/).

4.3.8 *Source-specific recalculations*

There are several recalculations in this year's inventory for road transport emissions (for references to the various test/measurement programmes, see Witt et al. (2025a and 2025b).

Recalculations for road traffic

Several improvements in the calculation of road traffic emissions were applied:

General

- Partial double-counting of NMVOS from road-traffic was corrected.
- New implementation of the calculation of heavy metal emissions, resulting in minor updates.
- New implementation of the calculation of PAH and break and tyre wear emissions from 2018 onwards, resulting in minor updates.
- Updated emissions factors for NO_2 from real-world measurements.

Passenger cars (A1b3i)

- Updated emission factors for cold start of petrol vehicles (VOS, NMVOS).
- Correction of the EF and activity data (mileage) for passenger cars for 2004. For the most part, this change did not result in changes in the emissions for 2004, but it did for the subsequent years 2005–2008, which are calculated by interpolating the 2004 activity data. The change did result in higher emissions from brake and tyre wear in 2004, as these are calculated on the basis of mileage rather than fuel sold.

Heavy-duty vehicles (A1b3iii)

- Updated emission factors for cooling units (NO_X) of heavy-duty vehicles.
- Inclusion of auxiliary functions on heavy-duty vehicles resulting in higher emissions of all gases throughout the time series.

4.3.9 *Source-specific planned improvements*

The ratio of PM_{10} and $PM_{2.5}$ from brake and tyre wear will be updated as soon as specific measurement results are available. Furthermore, additional results of emission measurements for cooling units and real-world emission measurements will be implemented.

4.4 Railways

4.4.1 *Source category description*

The source category Railways (1A3c) includes exhaust emissions from diesel-powered rail transport in the Netherlands from both passenger transport and freight transport. Most railway transport in the Netherlands uses electricity. Emissions resulting from electricity generation for railways are not included in this source category. Diesel is used mainly for freight transport, although there are still some diesel-powered passenger lines as well. Besides exhaust emissions from diesel trains, this source category also includes emissions of particulate matter, copper and lead (among others) from trains, trams and metros due to wear, which results from friction and spark erosion of the current collectors and the overhead contact lines. Condensables are included in PM_{10} and $PM_{2.5}$ emissions. The notation key NE is used for HCB and PCB emissions.

4.4.2 *Key sources*

Railways is a key source of Pb and Cu in the emissions inventory.

4.4.3 *Overview of emission shares and trends*

In 2023, railways are a small source of emissions in the Netherlands, accounting for less than 1% of national totals for all substances except lead, BC and copper. Between 1990 and 2000, diesel fuel consumption by railways increased from 1.2 to 1.5 PJ due to an increase in freight transport. Between 2001 and 2011, fuel consumption fluctuated around 1.4 PJ and since 2012 it has dropped to 0.8 PJ in 2021. Transport volumes have increased since 2001, especially freight transport, but this has been compensated by the ongoing electrification of rail transport. The share of passenger transport in diesel fuel consumption in the Railway category was estimated at approximately 30–35% until 2010 and have since increased to over 50% in 2021. The remainder is used for freight transport.

The trends in emissions from railways are presented in Table 4.9. NO_x and PM_{10} emissions from railways follow trends in activity data because EFs are similar for all years of the time series. Pb emissions increased between 1990 and 2023. Pb emissions from railways result from the wear on carbon brushes; they are estimated on the basis of the total electricity use by railways (in kWh). Thus, trends in Pb emissions follow trends in electricity use for railways. Railways are also an important source of copper emissions, amounting to 78 Mg (around 71% of total copper emissions in the Netherlands). Emissions of other heavy metals are very low. SO_x emissions from railways decreased by almost 100% between 2007 and 2012 due to the decrease in the sulphur content of diesel fuel for non-road applications and the early introduction of sulphur-free diesel fuel in the Netherlands (obligatory from 2011 onwards but already applied in 2009 and 2010).

Table 4.9 Trends in emissions from 1A3c Railways

	Main Pollutants				Particulate Matter				Other	Priority Heavy Metals	Other Heavy Metals
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cu
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg	Mg
1990	1.9	0.07	0.10	21.5	0.12	0.15	0.15	0.02	0.34	0.26	61.1
1995	1.9	0.07	0.10	22.2	0.13	0.16	0.16	0.02	0.36	0.30	69.9
2000	2.3	0.09	0.12	27.0	0.15	0.19	0.19	0.03	0.43	0.33	77.7
2005	2.1	0.08	0.11	25.0	0.14	0.18	0.18	0.02	0.40	0.32	76.4
2010	2.1	0.08	0.01	25.1	0.15	0.19	0.19	0.03	0.40	0.35	82.3
2015	1.5	0.07	0.00	21.7	0.12	0.15	0.15	0.02	0.35	0.33	76.9
2020	0.8	0.05	0.00	15.5	0.08	0.11	0.11	0.01	0.25	0.33	74.9
2022	0.7	0.05	0.00	14.5	0.08	0.11	0.11	0.01	0.23	0.33	74.6
2023	0.8	0.06	0.00	17.4	0.08	0.11	0.11	0.01	0.28	0.34	78.4
1990-2023 period[1]	-1.08	-0.01	-0.10	-4.1	-0.04	-0.03	-0.03	-0.01	-0.07	0.08	17.3
1990-2023 period[2]	-57%	-19%	-100%	-19%	-30%	-23%	-23%	-62%	-19%	33%	28%

1. Absolute difference
2. Relative difference from 1990 in %

4.4.4 *Activity data and (implied) emission factors*

As pointed out in the NECD-review (and as apparent in comparisons across Europe), the particulate matter wear emissions by railways have been underestimated in the Netherlands (Ligterink, 2024). In 2023, this was remedied by adding the source of track, wheel, and brake wear emissions that had been lacking up to that year. Across Europe, several studies on PM emissions from railways have been carried out. It should be noted that some studies are biased by the measurement location near or at railway stations, where emissions are substantially higher than along straight tracks where trains travel at a constant velocity. These studies were used to derive the wear emission factors. For conversions of different units, an average was derived and used on the basis of the measured driving resistances and typical train weights. The new emission factors are based on the fuel and electricity energy consumption. The total rail particulate matter emission has been corrected significantly upwards by adding this new source.

New tailpipe emission measurements on diesel passenger trains and ongoing measurements on diesel locomotives have led to an adjustment of the NO_x and PM exhaust emission factors (Ligterink et al., 2017 and 2023). With the introduction of new trains, which have to comply with more stringent emission limits, some minor reductions of the emission factors have been implemented on the basis of the various legislative classes (e.g. Stage IIIA/B) that have been measured. The change in fleet composition over time is based on the typical lifetime for locomotives of thirty years and passenger railcars of twenty years and on the introduction dates of new legislative classes.

The NH_3 emission factors are adjusted to match emission results of similar engines used in non-road mobile machines. These emission factors are considered better because they are based on more recent emission measurements than the standard emission factors, even if they are much higher. The difference in NH_3 emission factors is likely to be related to the use of oxidation catalysts to meet particulate matter emission limits (Ligterink et al., 2021). Likewise, the sulphur content of diesel fuel for railways is set equal to the sulphur content of other off-road applications, which is a minor adjustment in the 2005–2010 transition period.

PM_{10} emissions due to wear of overhead contact lines and carbon brushes from railways are calculated on the basis of a study conducted by NS-CTO (1992) on the wear of overhead contact lines and the carbon brushes of the collectors on electric trains. For trams and metros, wear on overhead contact lines has been assumed to be identical to that on railways. Emissions from wear on current collectors have not been included, because no information was available on this topic. Besides copper, carbon brushes contain 10% lead and 65% carbon. On the basis of the NS-CTO study, the percentage of particulate matter in the total quantity of wear debris was estimated at 20%. Because of their low weight, it is assumed that these particles remain airborne. It is estimated that approximately 65% of the wear debris ends up in the immediate vicinity of the railway, while 5% is deposited in ditches along the railway line (Coenen & Hulskotte, 1998). According to the NS-CTO study, the remainder of the wear debris (10%) does not enter the environment but attaches itself to the train surface and is captured in the train washing facilities. A detailed description of the methodology can be found in chapter 4 of Witt et al. (2025a).

4.4.5 *Methodological issues*

As most emission factors for railways have not been updated recently (except for NO_x), they are rather uncertain.

4.4.6 *Uncertainties and time series consistency*

Consistent methodologies have been used throughout the time series. In 2016, an experts' workshop was conducted to discuss and estimate the uncertainties in the activity data and EFs used for the emission calculations for the Transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for railways are presented in Table 4.10.

Table 4.10 Uncertainty estimates for railways (%)

				Uncertainty: emission factor						
NFR	**Type**	**Fuel**	**Uncer-tainty: activity data**	**NO_x**	**SO_x**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**	**EC**	**NMVOC**
1A3c	Freight transport	Diesel	5	100	20	-	100	100	100	-
	Passenger transport	Diesel	5	100	20	-	100	100	100	-
	Pantograph wear[1]	Electricity	-	-	-	-		200	200	-

Dellaert & Dröge (2017)
[1] Overhead line for power supply to electric rail transport

4.4.7 *Source-specific QA/QC and verification*

The current figures are compared to bottom-up results of the number of trains and typical operation hours (Van Mensch et al., 2022). These comparisons hold well.

4.4.8 *Source-specific recalculations*

Wear emission factors and their size distribution were changed.

4.4.9 *Source-specific planned improvements*

Emission factors remain uncertain, but since railways are a small emission source and not a key source of any substance, updating the EFs is currently not a priority.

4.5 Waterborne navigation and recreational craft

4.5.1 *Source category description*

The source category Waterborne navigation (1A3d) includes emissions from National navigation (1A3dii), International (1A3di(ii)) inland navigation in the Netherlands and from International maritime navigation (1A3di(i)) on the Dutch Continental Shelf. Emissions from international maritime navigation are reported as a memo item and are not part of the national emission totals. National (domestic) inland navigation includes emissions from all trips that both depart from and arrive in the

Netherlands, whereas international inland navigation includes emissions from trips that either depart from or arrive abroad. Only emissions on Dutch territory are reported. For maritime navigation, this includes emissions on the Dutch Continental Shelf. All three categories include both passenger and freight transport. From 2022 onwards, emissions from recreational craft have been reported under Inland Shipping as well. Emissions resulting from degassing of inland ships are included under 2D3i. Condensables are included in PM_{10} and $PM_{2.5}$ emissions.

For inland navigation (1A3di(ii) and 1A3dii), the notation key NE is used for HCB and PCB emissions. The reason is that there are no representative emission factors for these substances. The default emission factors in the EMEP/EEA Guidebook are based on emission measurements on seagoing vessels and cannot be used for inland shipping.

For 1A5b, the notation key NE is used for HCB and PCB emissions.

4.5.2 *Key sources*

The source categories 1A3di(ii) – International inland waterways – and 1A3dii – National navigation (shipping) – are both key sources of NO_x, $PM_{2.5}$ and BC emissions. Source category 1A3di(ii) – International inland waterways – is also a key source of PM_{10}. Recreational craft is a significant source of CO.

4.5.3 *Overview of emission shares and trends*

In 2023, the total (inter)national inland navigation was responsible for 10% of NO_x emissions, 5% of $PM_{2.5}$ emissions and 14% of BC emissions in the Netherlands. With emissions from road transport decreasing rapidly, the share of inland navigation in national totals increased throughout the time series. In 2023, the share of inland navigation as a percentage of national emissions of NMVOC, CO and SO_x was small .

Emissions from international maritime navigation are not included in the national totals, but maritime navigation is a major emission source in the Netherlands, the Port of Rotterdam being one of the world's largest seaports and the North Sea being one of the world's busiest shipping regions. Total NO_x emissions from international maritime shipping on Dutch territory (including the Dutch Continental Shelf) amounted to almost 102 Gg in 2021 and were higher than the combined NO_x emissions from all road transport in the Netherlands. PM_{10} emissions amounted to 2.6 Gg in 2020. By contrast, recreational craft were only a small emission source, with 1.9 Gg of NO_x and 0.04 Gg of PM_{10} emitted in 2021.

The trends in emissions from inland navigation in the Netherlands (both category 1A3dii and 1A3di(ii)) are presented in Table 4.11. Since the year 2000, fuel consumption in inland navigation has fluctuated between 20 and 28 PJ. The financial crisis led to a decrease in transport volumes and fuel consumption in 2009. Since then, transport volumes have increased again, resulting in an increase in fuel consumption. For the most part, emissions of NO_x, CO, NMVOC and PM from inland navigation follow the trends in the activity data. The introduction of emission standards for new ship engines (CCR stages I and II) has led to a slight decrease in the fleet average NO_x EF (per kilogram of fuel) in recent years, but since fuel consumption has increased significantly, total NO_x emissions still increased between 2009 and 2022.

Between 2009 and 2022, SO_x emissions from inland navigation decreased by 99%, due to the decrease in the maximum allowable sulphur content of diesel fuel for non-road applications. As of 2011, EU regulation requires all diesel fuel for inland navigation to be sulphur-free. Since sulphur-free diesel fuel was introduced to inland navigation in the Netherlands in 2009, SO_x emissions have decreased significantly. The decrease in sulphur content also affects PM emissions, as some of the sulphur in the fuel is emitted as PM (Denier van der Gon & Hulskotte, 2010). $PM_{2.5}$ and PM_{10} emissions from waterborne navigation likewise decreased between 2009 and 2023.

Between 1990 and 2008, energy use and resulting emissions from maritime navigation showed an upward trend. Since the start of the financial crisis, transport volumes have decreased, resulting in a reduction in energy use and emissions. This decrease was enhanced by 'slow steaming' (a decrease in speed), resulting in lower energy use and thus further lowering emissions (MARIN, 2011). In 2023, total fuel consumption by maritime navigation on Dutch territory decreased by 1% compared to 2022 and was 3% lower than in 2020.

Recreational shipping is reported under source categories 1A3dii Inland Shipping. Recreational shipping is an important source of CO emissions, amounting to 3.2% of total national CO emissions. in 2023 , the share of emissions of all other pollutants from recreational shipping in total emissions in the Netherlands was small.

Table 4.11 Trends in emissions from Inland navigation in the Netherlands (combined emissions from national and international inland navigation)

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**28.8**	**2.00**	**1.8**	**0.01**	**1.2**	**1.3**	**1.3**	**0.56**	**2.2**
1995	23.2	1.66	1.7	0.01	1.2	1.2	1.2	0.52	2.0
2000	24.6	1.56	1.8	0.01	1.1	1.2	1.2	0.50	1.9
2005	23.6	1.33	1.7	0.01	1.0	1.0	1.0	0.44	1.6
2010	19.5	1.26	0.44	0.00	0.76	0.81	0.81	0.38	1.5
2015	21.2	1.21	0.01	0.00	0.72	0.77	0.77	0.39	1.5
2020	19.0	1.10	0.01	0.00	0.71	0.75	0.75	0.32	1.6
2022	18.7	1.12	0.01	0.00	0.68	0.72	0.72	0.31	1.6
2023	**17.5**	**1.05**	**0.01**	**0.00**	**0.63**	**0.67**	**0.67**	**0.29**	**1.5**
1990-2023 period[1]	-11.3	-0.95	-1.8	0.00	-0.61	-0.64	-0.64	-0.27	-0.8
1990-2023 period[2]	-39%	-47%	-100%	-17%	-49%	-49%	-49%	-48%	-34%

1. Absolute difference
2. Relative difference from 1990 in %

4.5.4 *Activity data and (implied) emission factors*

Fuel consumption and resulting emissions from inland navigation (both national and international) were calculated using a Tier 3 methodology. The methodology was developed as part of the Emissieregistratie en -Monitoring Scheepvaart (EMS) project. The EMS methodology distinguishes between 31 vessel classes. For these vessel classes, the power demand (kW) is calculated for the various inland waterway types and rivers in the Netherlands by means of a model described by Bolt (2003). The main variable parameters within this model that determine the power demand per vessel class are the vessel's draught, its speed through water and the stream velocity. The vessel's draught is calculated by interpolating between the draught of an unloaded vessel and that of a fully loaded vessel. Starting from the reporting year 2022, the speed per vessel per geographical water segment has been calculated from vessel movement data derived from AIS (Automatic Identification System). The average cargo situation (partial load) per vessel class for one specific year (2016) was provided by Statistics Netherlands.

The resulting fleet average EFs throughout the time series are reported in Witt et al. (2025a). The formula used to estimate the impact of lower sulphur content on PM emissions is described in Hulskotte & Bolt (2013).

In the emission calculation for inland shipping, a distinction is made between primary engines intended for propelling the vessel and auxiliary engines. Auxiliary engines are used for manoeuvring the vessel (bow propellers) and generating electricity for the operation of the vessel and the residential compartments (generators). Fuel consumption by auxiliary engines is estimated at 13% of the fuel consumption of the primary engines.

No recent information was available on the fuel consumption of passenger ships and ferries in the Netherlands; for this reason, fuel consumption data for 1994 was applied to all subsequent years of the time series.

Emissions by recreational craft were calculated by multiplying the number of recreational craft (open/cabin motorboats and open/cabin sailing boats) by the average fuel consumption per boat type, times the EF per substance, expressed in emissions per engine type per quantity of fuel (Hulskotte et al., 2024). The EFs depend on the engine types per vessel. They are reported in the same report and will be cited in the method report as well (Witt et al., 2025a).

Since 2008, emissions from maritime shipping on the Dutch Continental Shelf and in the Dutch port areas have been calculated annually, using vessel movement data derived from AIS (Automatic Identification System).

To estimate emissions from a specific ship in Dutch waters, the ship's IMO number is linked to a ship characteristics database acquired from Lloyd's List Intelligence (LLI). Emission factors for each ship are determined using information on the construction year and the design speed of the ship, the engine type and power, the type of fuel used and, for engines built since 2000, the engine's maximum revolutions per minute (rpm).

Methodologies and resulting emissions for recent years are described in detail in MARIN (2019).

A detailed description of the methodology for inland navigation (chapter 5), recreational craft (chapter 5) and maritime shipping (chapter 7) can be found in Witt et al. (2025a).

4.5.5 *Methodological issues*

There are several points requiring improvement in the emission calculations for inland navigation, international maritime navigation and recreational craft:

1. Data on fuel consumption and EFs for passenger ships and ferries has not been updated for some time.
2. Data on the number of recreational craft and their average usage rates is rather uncertain and need to be verified.
3. The methodology for calculating the required engine power vs. speed and other ship characteristics needs to be verified for inland navigation.
4. Estimates of NMVOC emissions due to cargo fumes are rather uncertain and need to be improved.

4.5.6 *Uncertainties and time series consistency*

Consistent methodologies have been used for waterborne navigation throughout the time series. For inland navigation, AIS data has only become available since 2020. For the earlier years in the time series, emission totals were scaled back from 2020 using the annual fuel consumption attributed to the Netherlands as reported by SAB. The methodology for constructing the historic series will be described in full detail in an upcoming TNO report that is still in preparation.

For maritime navigation, AIS data has only become available since 2008. For the earlier years in the time series, emission totals were estimated using vessel movement data from Lloyd’s, combined with assumptions about average vessel speeds (Hulskotte et al., 2003a, -b and -c).

In 2016, an experts’ workshop was conducted to discuss and estimate the uncertainties in the activity data and EFs used for the emission calculations for the Transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for waterborne navigation and recreational craft are presented in Table 4.12. In the IIR 2020, the uncertainty estimates for NMVOC emissions from degassing cargo had been adjusted upwards from 100% to 250% compared to Dellaert & Dröge (2017).

Table 4.12 Uncertainty estimates for waterborne navigation and recreational craft (%)

				Uncertainty: emission factor						
NFR	**Type**	**Fuel**	**Uncertainty: activity data**	**NO_x**	**SO_x**	**NH_3**	**PM_{10}**	**$PM_{2.5}$**	**EC**	**NMVOC**
1A3di(i)	Anchored DCS2F[1]	HFO	20	50	50	500	50	50	200	200
1A3di(i)	Anchored DCS	MDO	20	50	50	500	50	50	200	200
1A3di(i)	Sailing DCS	HFO	20	50	50	500	50	50	200	200
1A3di(i)	Sailing DCS	LNG	50	100	100	-	-	100	200	-
1A3di(i)	Sailing DCS	MDO	20	50	50	500	50	50	200	200
1A3di(i)	Moored NL		50	50	50	500	50	50	200	200
1A3di(i)	Sailing NL	HFO	20	50	50	500	50	50	200	200
1A3di(i)	Sailing NL	LNG	50	100	100	-	-	100	200	-
1A3di(i)	Sailing NL	MDO	20	50	50	500	50	50	200	200
1A3di(ii)	Inland, international	Diesel	10	20	15	400	35	35	35	75
1A3dii	Inland, national	Diesel	10	20	15	400	35	35	35	75
1A3dii	Passenger and ferryboats	Diesel	100	50	20	500	100	100	100	200
1A3dii	Recreational shipping, exhaust gases	Petrol	200	50	20	100	100	100	100	50
1A3dii	Recreational shipping, exhaust gases	Diesel	200	200	20	100	100	100	100	100
1A3dii	Recreational shipping, petrol evaporation		100	-	-		-	-	-	200
2D3i	Inland shipping, degassing cargo		100	-	-	-	-	-	-	250

Dellaert & Dröge (2017)

[1] Dutch Continental Shelf.

4.5.7 *Source-specific QA/QC and verification*

The trends in activity data for waterborne navigation (national and international) were compared to trends in transport volumes (Mg-kms of inland shipping within and across borders) and are reasonably comparable.

4.5.8 *Source-specific recalculations*

There were no source-specific recalculations for waterborne navigation.

4.5.9 *Source-specific planned improvements*

For inland navigation, it is planned to collect additional insights into the age of the employed engines. Furthermore, there are improvements planned to the calculations of ships at berth.

4.6 Non-road mobile machinery (NRMM)

4.6.1 *Source category description*

Non-road mobile machinery (NRMM) covers a variety of equipment that is used in various economic sectors and by households in the Netherlands. Mobile machinery is defined as all machinery equipped with a combustion engine which is not primarily intended for transport on public roads, and which is not attached to a stationary unit. The main deployment of NRMM in the Netherlands is within agriculture and construction. The largest volumes of fuel are used in tillage, harvesting and earthmoving. NRMM is also used in forest, park and garden maintenance, including lawn mowers, chain saws, forest mowers and leaf blowers.

Emissions from NRMM are reported under:

1. 1A2gvii Mobile combustion in manufacturing industries and construction.
2. 1A4aii Commercial/ institutional: Mobile.
3. 1A4bii Residential: Household and gardening (mobile).
4. 1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery
5. 1A5b Other, mobile.

Source category 1A5b is used for emissions from ground support equipment at airports. 1A5b also includes emissions from recreational craft (see Section 4.5). Condensables are included in PM_{10} and $PM_{2.5}$ emissions.

4.6.2 *Key sources*

Mobile machinery in manufacturing industries and construction (1A2gvii) is a key source of NO_x, PM_{10}, $PM_{2.5}$ and BC emissions. Source category 1A4aii – Commercial/institutional: Mobile – is a key source of CO emissions. Source category 1A4bii – Residential: Household and gardening (mobile) – is a key source of emissions of CO. Source category 1A4cii – Agriculture/Forestry/Fishing: Off-road vehicles and other machinery – is a key source of NO_x and BC emissions.

4.6.3 *Overview of shares and trends in emissions*

In 2023, NRMM was responsible for 14% of CO emissions, 13% of NO_x emissions, 6% of $PM_{2.5}$ emissions and 4% of PM_{10} emissions in the

Netherlands. CO emissions mainly resulted from the use of petrol-driven equipment by households (lawn mowers) and of machinery for public green space maintenance. For the most part, NO_x, PM_{10} and $PM_{2.5}$ emissions were due to diesel machinery being used in agriculture (tractors) and construction.

Total energy use in NRMM has fluctuated between 50 PJ and 60 PJ throughout the time series. Figure 4.5 represents total energy use in the various sectors where mobile machinery is applied. Industrial (including construction) and agricultural machinery were responsible for more than 85% of total energy use by NRMM in 2023.

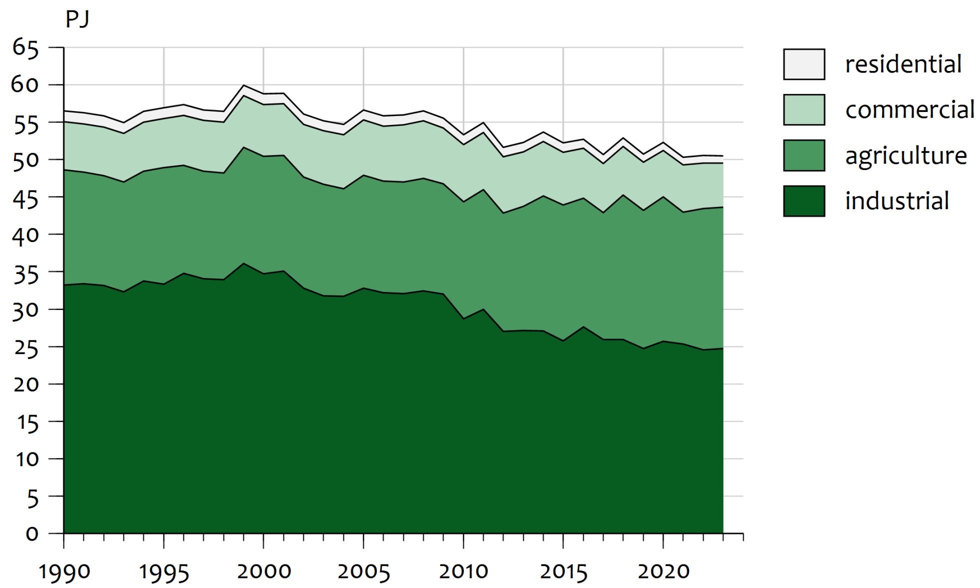


Figure 4.5 Fuel consumption in non-road mobile machinery in various sectors in the Netherlands

The trends in emissions from NRMM in the Netherlands are presented in Table 4.13. With the introduction of EU emission standards for NRMM in 1999 and the tightening of emission standards in subsequent years, NO_x emissions from NRMM have steadily decreased, as presented in Figure 4.6. Since 1990, NO_x emissions have decreased by 56%, while fuel consumption has decreased by 11%.

Emissions of most other substances have also decreased significantly throughout the time series. For PM_{10} and NMVOC, this can be attributed to the EU's NRMM emission legislation. SO_x emissions have decreased due to the EU's fuel quality standards; sulphur-free diesel has been obligatory in NRMM since 2011.

Table 4.13 Trends in emissions from Non-road mobile machinery in the Netherlands

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**52.1**	**18**	**4.3**	**0.01**	**5.4**	**5.7**	**5.7**	**2.7**	**102**
1995	53.9	16	4.1	0.01	4.8	5.1	5.1	2.4	92
2000	56.7	15	4.3	0.01	4.5	4.8	4.8	2.3	86
2005	48.1	11	4.2	0.01	3.7	3.9	3.9	1.9	78
2010	37.9	8.2	0.43	0.01	2.2	2.3	2.3	1.0	73
2015	31.9	6.7	0.02	0.02	1.6	1.7	1.7	0.8	71
2020	26.2	5.0	0.02	0.11	1.2	1.2	1.2	0.6	64
2022	24.4	4.6	0.02	0.12	1.1	1.1	1.1	0.5	61
2023	**23.0**	**4.0**	**0.02**	**0.14**	**0.9**	**0.9**	**0.9**	**0.4**	**56**
1990-2023 period[1]	-29	-14	-4.3	0.13	-4.6	-4.8	-4.8	-2.3	-46
1990-2023 period[2]	-56%	-78%	-99%	1437%	-84%	-84%	-84%	-85%	-45%

1. Absolute difference
2. Relative difference from 1990 in %

Emissions from ground service equipment (GSE) at airports are reported under source category Other, mobile(1A5b). The share of emissions from GSE at airports as a percentage of the total emissions in the Netherlands in 2020 amounted to less than 1% for all pollutants.

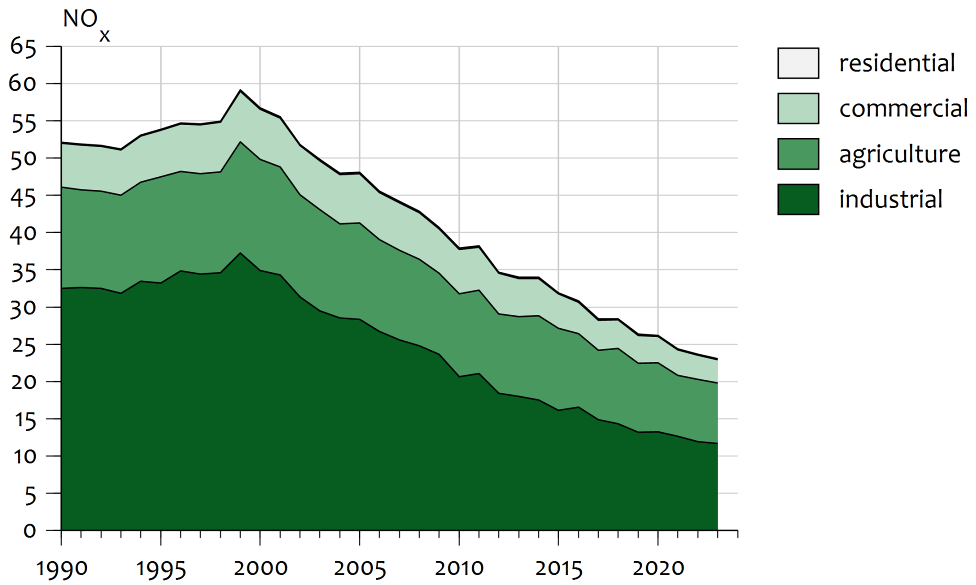


Figure 4.6 NO_x emissions by non-road mobile machinery in various sectors in the Netherlands

4.6.4 *Activity data and (implied) emission factors*

Fuel consumption by mobile machinery in the various economic sectors is not reported separately in the Energy Balance. Therefore, fuel consumption and resulting emissions from NRMM are calculated using a Tier 3 modelling approach (Hulskotte & Verbeek, 2009; Dellaert et al., 2023). The so-called EMMA model uses sales data and survival rates for various types of machinery to estimate the NRMM fleet in any given year. Total annual fuel consumption by NRMM is estimated on the basis of combined assumptions about the average usage rate (annual operating hours) and the fuel consumption per hour of operation of the various types of machinery. Emission factors have been compiled on the basis of factors from the TREMOD-MM model (Lambrecht et al., 2004; Helms et al., 2010) and updated on the basis of real-world measurements by TNO. They are described in more detail in Witt et al. (2025a) and Dellaert et al. (2023).

Annual sales data for the various types of NRMM is derived from trade organisations, such as BMWT and Fedecom, and from Off-Highway Research, a commercial consulting company. Since 2022, any mobile machinery that accesses public roads with a speed over 6 km/h also needs to be registered and receives a license plate. The registration database maintained by the National Road Traffic Agency (RDW) is now also used as a data source to complement and validate the Dutch machinery fleet.

Fuel consumption and CO_2 emissions are calculated using a Willans line approach that is explained in chapter 9 of Witt et al. (2025a).

Emissions of CO, NO_x, NH_3, PM and NMVOC are calculated using the following formula:

Emission = Number of machines x active time x Share of time in load range x Rated power x Load and power dependent emission factor

In which:

- Emission = Emission or fuel consumption (grams);
- Number of machines = the number of machines of a certain year of construction with emission factors applicable to the machine's year of construction;
- Active time = the average annual running time for this type of machinery in seconds;
- Share of time in load range = the average fraction of time that the machine engine is in a specific load range;
- Rated power = the average full power for this type of machinery (kW);
- Load- and power-dependent emission factor = Specific load-dependent emission factors, per kW of rated power for various technology levels relating to the year of construction and the emission standards, in grams/second*kW (rated).

Emissions of SO_x were calculated on the basis of total fuel consumption and sulphur content per fuel type, as provided by Witt et al. (2025a). Base EFs for NH_3 were derived from the EMEP/EEA Guidebook 2023 (EEA, 2023) but were increased for modern stage-IV and -V engines that use SCR technology to reduce NO_x emissions, while increasing emissions of NH_3.

The distribution of total fuel consumption by NRMM across various economic sectors was estimated using various data sources. First, the various types of machinery in EMMA were distributed across the five sectors. Total fuel consumption by NRMM in the commercial and industrial sector and by households was derived directly from EMMA. Fuel consumption in agriculture and construction, as reported by EMMA, was adjusted. Fuel consumption by NRMM in the agricultural sector (excluding agricultural contractors) was derived from Wageningen Economic Research of Wageningen University and Research. Fuel consumption by agricultural contractors was derived from the trade organisation for agricultural contractors in the Netherlands (CUMELA). Both data sources were combined to estimate total fuel consumption by mobile machinery in the agricultural sector.

The modelled fuel consumption in the construction sector was subsequently adjusted to take into account the impact of economic fluctuations. Statistics Netherlands also reports the resulting fuel consumption (energy use) by NRMM in the Energy Balance. The annual correction factors used to adjust the energy use as reported by EMMA are provided in Witt et al. (2025a).

Emissions from ground support equipment and vehicles used for ground transport at airports were estimated using data on diesel use and emissions for ground operations at Amsterdam Airport Schiphol that were provided by KLM Equipment Services (KES). Since KES is responsible for the refuelling and maintenance of the equipment at Amsterdam Airport Schiphol , it has precise knowledge of the types of machinery used and the amount of energy used per year. The resulting emissions were also used to derive an average EF per MTOW at Amsterdam Airport Schiphol, which was subsequently used to estimate emissions at regional airports. A detailed description of the methodology can be found in chapter 9 of Witt et al*.* (2025a).

The notation key NE is used for all HCB and PCB emissions from NRMM as no emission factor is available and no information is available from the 2019 EMEP/EEA Guidebook chapter on NRMM.

4.6.5 Methodological issues

The current methodology for estimating emissions from NRMM could be improved in the following areas:

- As recent model updates led to relatively large increases in the modelled fuel consumption for the full time series, it has become more urgent to look for additional data on fuel consumption in these sectors to further validate the emission model.
- The diesel used in the construction sector is susceptible to relatively strong economic fluctuations. At present, correcting for this phenomenon is based on economic indicators derived from Statistics Netherlands rather than on physical indicators. It should be investigated whether any enterprises or institutions have diesel consumption figures at their disposal.
- There is a lack of input data for several types of machinery and sectors. In the garden sector and private households, scarce data sources have been extrapolated to estimate the size of the fleet. With targeted research into these sectors, more insight and

confidence in these machinery types, including their relatively high VOC emissions, could be gained.
- The effect of varying engine loads on emissions has been examined and implemented. It is of great importance to investigate and further improve engine load profiles and related emission factors.Specific measurement programmes for investigating the effect of transient engine loads in the machines' daily practice are needed for a better foundation of the emission data.
- Via a specific measurement scheme, the effect of (postponed) maintenance on the emissions from machinery could be further investigated.

4.6.6 Uncertainties and time series consistency

The EMMA model was used to calculate fuel consumption and emissions for the time series since 1990.

In 2016, an experts' workshop was conducted to discuss and estimate the uncertainties in the activity data and the EFs used for the emission calculations for the transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for NRMM are presented in Table 4.14.

The uncertainty in activity data for industry (LPG), public services (diesel) and container handling (diesel) was later adjusted upwards from 35% to 50%. The reason is that a survey held among companies using mobile machinery revealed significant divergences from our current understanding, indicating a higher uncertainty in the reported emission numbers.

4.6.7 Source-specific QA/QC and verification

In the past few years, significant effort was invested into checking and verifying NRMM modelling and outcomes. In 2021, a survey was held among users of mobile machinery across multiple sectors (e.g. construction, agriculture, services) that focussed on gathering data on the fleet composition (e.g. construction year, power rating, fuel types), usage (e.g. annual operating hours, typical lifespan) and fleet size. The results allowed a comparison between the composition and usage parameters of the modelled machine fleet and the machine fleet of the respondents, giving rise to improvements in the modelling on several points.
As of 1 January 2022, all vehicles, including mobile machinery, that access the public road with a speed over 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 RDW (Dienst Wegverkeer, an administrative body of the Dutch government), can be queried and provides a relatively complete overview of the Dutch NRMM fleet. As the registry contains information on machine type, fuel type, and date of entry, this allowed a further comparison with and validation of the modelled machine fleet, again resulting in several substantial changes to the model, especially to the estimated machine sales for some machinery types.

A final verification step was the comparison of the newly modelled diesel usage for NRMM with a time series of ‘red diesel’ sales in the Netherlands between 1990 and 2012, compiled by Statistics Netherlands. Over this period, a separate tax tariff on diesel sales to NRMM existed, providing a reference value for comparison with the model outcome. After implementing several model improvements, the modelled diesel usage is now much closer to the available diesel sales statistics, going from -35% to -11% in 1990, compared to the sales statistics, and from -15% to +8% in 2000. Only for the 2009–2011 period, following the financial crisis, does the model appear to underestimate the effect of the crisis, overestimating the diesel usage by 15-20%, compared to the sales statistics, indicating that further model improvements may be needed.

4.6.8 *Source-specific recalculations*

Following the QA/QC and verification steps described above, and thanks to the availability of a national registry of NRMM in the Netherlands since 2022, a number of updates have been incorporated into the model and the input data. The new insights have led to the following improvements in the modelling of NRMM energy use and emissions:

- For several machine types, previous estimates of the historical machine sales have been improved by analysing the size and composition (including the construction year) of the current fleet for these machines, as registered in the RDW database on NRMM. For many machinery types, year-to-year additions of machinery to the registration database are now used directly as inflow to the modelled fleet.
- Cranes without an NRMM engine have been removed from the machine fleet to avoid a potential double counting with road transport. This leads to a reduction of fuel use and emissions in the construction sector.
- For 2022, an updated diesel total was provided for the agricultural sector, resulting in an increase of emissions.
- For 2021 and 2022, the correction factors for the construction sector were updated using newly available statistical data. This leads to a ~6% increase in fuel use and emissions for NRMM in the construction sector in 2021.
- Container handling statistics have been adjusted to take into account the handling of empty containers to and from empty depots. This leads to a ~15% increase in fuel use and emissions for this sector.
- The NO_x emission factor for LPG engines has been lowered by 35%, resulting in a reduction in NO_x emissions for several NRMM sectors.

Together, the changes described above result in some modest changes in the fuel use and emissions for most NRMM sectors that are estimated using the EMMA model (1A2gvii, 1A4aii, 1A4bii and 1A4cii) for the full time series.

Table 4.14 Uncertainty estimates for NRMM (%)

NFR	Sector	Fuel	Uncertainty: activity data	Uncertainty: emission factor						
				NO_x	SO_x	NH_3	PM_{10}	$PM_{2.5}$	$EC_{2.5}$	NMVOC
1A2gvii	Construction	Petrol	100	50	20	200	100	100	100	100
1A2gvii	Construction	Diesel	50	50	20	200	100	100	100	100
1A2gvii	Industry	Diesel	50	50	20	200	100	100	100	100
1A2gvii	Industry	LPG	50	50	20	200	100	100	100	100
1A4aii	Public services	Petrol	100	50	20	200	100	100	100	100
1A4aii	Public services	Diesel	50	50	20	200	100	100	100	100
1A4aii	Container handling	Diesel	50	50	20	200	100	100	100	100
1A4bii	Consumers	Petrol	100	100	20	200	200	200	200	200
1A4cii	Agriculture	Petrol	200	100	20	200	200	200	200	200
1A4cii	Agriculture	Diesel	35	50	20	200	100	100	100	100

Dellaert & Dröge (2017)

4.6.9 *Source-specific planned improvements*

As a major new source of information on the NRMM fleet has become available in 2022 (see previous sections), additional analysis of the new RDW registry is likely to lead to further updates and model improvements in the NRMM calculation. Furthermore, as the comparison with historical diesel sales (see section on QA/QC) indicated that the model may underestimate the effect of the financial crisis on NRMM activity in the period following 2008 (2009–2011), this will be analysed in more detail to see whether further model improvements are possible.

4.7 National fishing

4.7.1 *Source category description*

The source category National fishing (1A4ciii) covers emissions resulting from all fuel sold to fisheries in the Netherlands. Condensables are included in PM_{10} and $PM_{2.5}$ emissions.

4.7.2 *Key sources*

National fishing is a key source of NO_x emissions.

4.7.3 *Overview of emission shares and trends*

National fishing is a small emission source in the Netherlands. In 2023, national fishing was responsible for 1.3% of SO_x and 2.7% of NO_x emissions. The contribution to the national totals of PM_{10}, $PM_{2.5}$ and BC was 1–3%, and for other substances it was less than 1%. Fuel consumption by national fishing has been decreasing since 1999. The trends in emissions from national fishing are presented in Table 4.15.

Table 4.15 Trends in emissions from National fishing in the Netherlands

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	20.7	1.4	4.98	0.00	1.1	1.2	1.2	0.33	1.5
1995	23.3	1.4	5.94	0.00	1.2	1.3	1.3	0.36	1.5
2000	22.8	1.3	5.23	0.00	1.1	1.2	1.2	0.34	1.4
2005	15.6	0.81	3.43	0.00	0.70	0.74	0.74	0.22	0.9
2010	11.8	0.52	1.85	0.00	0.52	0.54	0.54	0.15	0.63
2015	9.00	0.36	0.54	0.00	0.32	0.34	0.34	0.10	0.46
2020	7.37	0.30	0.32	0.00	0.24	0.25	0.25	0.08	0.38
2022	6.22	0.25	0.27	0.00	0.20	0.21	0.21	0.07	0.32
2023	5.01	0.21	0.23	0.00	0.16	0.17	0.17	0.06	0.26
1990-2023 period[1]	-16	-1.2	-4.7	0.00	-0.95	-0.99	-0.99	-0.28	-1.2
1990-2023 period[2]	-76%	-85%	-95%	-71%	-85%	-85%	-85%	-83%	-82%

1. Absolute difference
2. Relative difference from 1990 in %

For the most part, emissions from national fishing show similar trends to emissions from fuel consumption. NO_x emissions decreased significantly between 1990 and 2023, as did PM_{10} emissions. SO_x emissions decreased due to the use of sulphur-free diesel fuel.

4.7.4 *Activity data and (implied) emission factors*

Fuel consumption in fishing was derived from fuel-sold statistics in the Netherlands, and emissions from all national fishing were estimated according to the fuel sold in the country and IEFs calculated on the basis of AIS data. From 2016 onwards, two methodologies based on AIS data have been applied. For deep-sea trawlers, the methodology used for maritime navigation was applied (see Section 4.5.4) because it is assumed that no fishing activities take place on Dutch national territory. This means that these vessels essentially are only sailing to and from their fishing grounds. As a result, energy use can be calculated in the same manner as for maritime shipping. For the other fishing vessel categories (smaller vessels, mostly cutters), the methodology is described in detail by Hulskotte & ter Brake (2017). This is essentially an energy-based method whereby the energy rates of fishing vessels are broken down by activity (sailing and fishing), with a distinction made in the available power of propulsion engine(s). The methodology is described in greater detail in chapter 6 of Witt et al. (2025a).

4.7.5 *Methodological issues*

The emissions by fishing vessels have not been measured. Basing EFs on measurements for most common fishing vessels during various operational conditions could improve emission estimates.

4.7.6 *Uncertainties and time series consistency*

As of 2016, the AIS-based approach to calculating emissions from fishing has been applied to the calculation of emissions. The IEFs for 2016 were subsequently adjusted to create a consistent time series for 1990–2015, using the trend in EFs for inland shipping. This trend is based on fleet renewal data and the age class of engines for inland shipping.

In 2016, an experts’ workshop was conducted to discuss and estimate the uncertainties in the activity data and EFs used for the emission calculations for the Transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for national fishing are provided in Table 4.16.

Table 4.16 Uncertainty estimates for national fishing (%)

				Uncertainty: emission factor					
NFR	**Type**	**Fuel**	**Uncer-tainty: activity data**	**NO_x**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**EC**	**NMVOC**
1A4ciii	National fishing	Diesel	15	30	20	50	50	50	100

Dellaert & Dröge (2017)

Note that the uncertainty in the activity data for fisheries applies to the bottom-up approach, using AIS data, and does not apply to the top-down approach, which uses the fuel sales from the energy statistics to estimate the activity data. The top-down approach is used for the reports of emissions for the National Emission Ceilings Directive (NECD).

4.7.7 Source-specific QA/QC and verification

This year, no source-specific QA/QC and verification procedures were carried out for national fishing.

4.7.8 Source-specific recalculations

There were no source-specific recalculations for national fishing.

4.7.9 Source-specific planned improvements

The emission calculations for heavy metals, PCBs/HCBs and dioxins and for PAHs are based on activity data that is not in line with the scope of other emissions in the inventory. Instead of on fuel sold, emissions are based on the AIS data for fishing ships on Dutch national territory. Due to technical implementation difficulties, translation to fuel-sold emissions has not yet been performed. The AIS data-based emissions are estimated to be twice as high as fuel-sold emissions. Therefore, we expect an overestimation of these emissions in the current inventory. This issue is on the list of inventory improvements.

5 Industrial Processes and Product Use

5.1 Overview of the sector

Emissions from the Industrial processes and product use (IPPU) sector include all non-energy-related emissions from industrial activities and product use. Data on the emissions from fuel combustion relating to industrial activities and product use is included in the data on the Energy sector (Chapter 3). Fugitive emissions in the Energy sector (i.e. not relating to fuel combustion) are included in NFR sector 1B (Section 3.5).

The IPPU sector (NFR 2) consists of the following source categories:

- 2A Mineral products;
- 2B Chemical industry;
- 2C Metal production;
- 2D Product and solvent use;
- 2G Other product use;
- 2H Other production industry;
- 2I Wood processing;
- 2J Production of POPs;
- 2K Consumption of POPs and heavy metals;
- 2L Other production, consumption, storage, transport or handling of bulk products.

Since 1998, the Netherlands has banned the production and consumption of Persistent Organic Pollutants (POPs). Emissions from the consumption of heavy metals are considered insignificant. Therefore, no emissions are reported in source categories 2I, 2J and 2K.

Because the 2019 Guidebook is not clear about which sources belong to source category 2L, emissions from other industrial processes are included in source category 2H3 (Other industrial processes). No emissions are reported in source category 2L.

Source category 2I (Wood processing) includes the primary processing and conservation of wood for industry and the building and construction sector, as well as for the construction of wooden objects and floors. Because of minor emissions, no emissions are reported under source category 2I.

Table 5.1 provides an overview of the emissions from the IPPU sector (NFR 2). 43.5% of the total NMVOC emissions in the Netherlands originate from the IPPU sector.

Table 5.1 Overview of emission totals from the Industrial processes and product use sector (NFR 2)

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**5.3**	**233**	**10.0**	**5.3**	**15.6**	**29.2**	**49.1**	**0.33**	**9.7**
1995	3.2	172	2.8	5.0	10.3	18.6	34.1	0.25	4.5
2000	1.8	131	1.6	3.8	6.4	12.2	18.5	0.20	3.8
2005	0.6	108	1.0	3.5	5.9	11.2	18.8	0.16	3.5
2010	0.6	109	0.9	2.5	4.8	9.1	13.6	0.14	4.0
2015	0.6	99	0.9	2.2	5.0	9.8	14.3	0.13	4.2
2020	0.7	113	1.0	2.1	4.5	8.9	12.7	0.10	4.0
2022	0.7	104	1.2	2.0	4.5	9.1	13.0	0.09	4.2
2023	**0.6**	**104**	**1.1**	**2.0**	**4.3**	**9.0**	**13.0**	**0.10**	**3.7**
1990-2023 period[1)]	-4.7	-129	-9.0	-3.3	-11.2	-20.2	-36.1	-0.23	-6.0
1990-2023 period[2)]	-89%	-56%	-89%	-62%	-72%	-69%	-74%	-70%	-62%

Table 5.1 Overview of emission totals from the Industrial processes and product use sector (NFR 2) (continued)

	Priority Heavy Metals			POPs		Other Heavy Metals					
	Pb	Cd	Hg	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	**67.2**	**2.80**	**1.24**	**37.8**	**13.8**	**0.56**	**2.96**	**7.04**	**2.85**	**0.31**	**146**
1995	66.6	2.55	0.85	38.5	5.17	0.50	2.84	8.78	2.84	0.22	103
2000	25.2	2.74	0.40	13.6	1.14	0.77	2.26	11.8	0.60	0.00	58.4
2005	27.3	3.49	0.36	11.0	1.04	0.38	1.60	10.8	1.01	0.79	38.4
2010	31.6	4.33	0.30	8.1	0.98	0.49	1.16	10.7	1.27	0.06	41.2
2015	6.36	2.62	0.23	7.0	0.86	0.59	0.89	10.5	1.07	0.06	49.2
2020	3.59	1.76	0.18	5.8	0.74	0.11	0.54	7.3	0.56	0.07	128.6
2022	2.08	0.53	0.15	5.3	0.84	0.15	0.76	5.6	0.54	0.08	102.7
2023	**1.42**	**0.20**	**0.12**	**5.0**	**0.69**	**0.08**	**0.57**	**8.8**	**0.53**	**0.06**	**18.4**
1990-2023 period[1)]	-65.7	-2.6	-1.1	-32.8	-13.1	-0.48	-2.4	1.8	-2.3	-0.25	-127.2
1990-2023 period[2)]	-98%	-93%	-90%	-87%	-95%	-86%	-81%	26%	-82%	-79%	-87%

1. Absolute difference
2. Relative difference from 1990 in %

5.1.1 *Key sources*

The key sources of this sector are discussed in Sections 5.2 to 5.7.

5.1.2 *Methodological issues*

Industrial processes

The emission totals of categories and subcategories consist of the sum of the data from individual facilities, complemented by estimated emissions from the non-reporting (small and medium-sized) facilities. To estimate these emissions, the following method is used:

Up to 2000, the emissions from non-reporting facilities were calculated as follows:

$$Em\ non\_IF = IEF * (TP \text{ -/- } P\_IF)$$

where:
IEF = implied emission factor;
TP = total production in (sub)category (Production Statistics, Statistics Netherlands);
P_IF = production in individual facilities (Production Statistics, Statistics Netherlands).

The IEFs were calculated as follows:

$$IEF = Em\_IF / P\_IF$$

where:
Em_IF = the sum of the emission data on the individual facilities.

Since 2000, due to a lack of production figures and emission data on individual facilities, the emission totals of the categories and subcategories have been calculated as follows:

$$Em\ Total\ (sub)category_{(n)} = Em\ Total\ (sub)category_{(n-1)} * (PI_{(n)} / PI_{(n-1)})$$

where:
n = year;
PI = production indices (Statistics Netherlands).

Finally, the supplemental emissions (Em_sup) from these emission sources are calculated as follows:

$$Em\_sup_{(n)} = Em\ Total\ (sub)category_{(n)} - EmComp_{(n)}$$

where:
$Em\ Total\ (sub)category_{(n)}$ = total emissions by the (sub)categories;
$EmComp_{(n)}$ = emissions by individually registered companies (PRTR-I).

If reduction measures are known to have been implemented, the emissions will be reduced by the reduction percentage achieved by these measures.

Product use
For product use, specific methodologies have been applied. Therefore, the methodological issues of the product use categories are included in Section 5.5, Solvents and product use (2D).

5.1.3 *Uncertainties and time series consistency*
Consistent methodologies were used throughout the time series for the sources in this sector.
The Netherlands implements an Approach 2 methodology for uncertainty analyses. This methodology was used for uncertainty analyses on the pollutants NH_3, NO_x, SO_x, and PM. Table 5.2 provides an overview of the results for the Approach 2 uncertainties at NFR source category level.

Table 5.2 Overview of Approach 2 uncertainties for IPPU NFR source categories

NFR source category	Pollutants uncertainty					
	NH_3	NO_x	SO_x	NMVOC	PM_{10}	$PM_{2.5}$
2A	77%	102%	87%	119%	84%	138%
2B	93%	NA	NA	53%	60%	63%
2C	94%	NA	NA	151%	99%	105%
2D	71%	NA	NA	32%	121%	120%
2G	90%	80%	116%	54%	93%	81%
2H	157%	50%	NA	100%	66%	65%
2I	NA	NA	NA	100%	199%	191%
2J	NA	NA	NA	NA	NA	NA
2K	NA	NA	NA	NA	NA	NA
2L	NA	NA	NA	NA	NA	NA
Total IPPU sector	**53%**	**96%**	**83%**	**30%**	**40%**	**58%**

5.1.4 *Source-specific QA/QC and verification*
The source categories of this sector are covered by the general QA/QC procedures, as discussed in Section 1.6.2.

5.1.5 *Source-specific planned improvements*
Source-specific planned improvements are discussed per subcategories below.

5.2 Mineral products (2A)

5.2.1 *Source category description*
This category comprises emissions relating to the production and use of non-metallic minerals in:
- 2A1 Cement production;
- 2A2 Lime production;
- 2A3 Glass production;
- 2A5a Quarrying and mining of minerals other than coal;
- 2A5b Construction and demolition;
- 2A5c Storage, handling and transport of mineral products;
- 2A6 Other mineral products.

Remarks:
- Due to allocation problems, emissions from 2A2 are included in the subcategory of Other mineral products (2A6).

- Emissions from 2A5a are currently assigned to 1A2gvii, 2A1, and 2H3. This is because companies that undertake these activities are responsible for various processes and thus for emissions from various categories. For now, it is unclear how to split emissions from Quarrying and mining of minerals other than coal (2A5a) from others.
- Only emissions from Glass production (2A3) and Cement production (2A1) could be reported separately, because emissions in these categories could be derived from the AERs of the relevant companies.
- The emission totals of 2A3 and 2A6 consist of the sum of the reported emissions from individual facilities, supplemented by estimated emissions from the non-reporting facilities. Most of the data on emissions from 2A (more than 90%) is obtained from the AERs of individual facilities (Tier 3 methodology), which are validated and approved by their competent authorities. According to the Aarhus Convention, only total emissions need to be included in the AERs. This means that production levels, if they are included, are confidential information. However, most companies do not include any production data. For this reason, it is not possible to provide activity data and determine/calculate IEFs.
  The emissions from non-reporting facilities are calculated from production indices of the mineral industry from Statistics Netherlands.
- The EMEP/EEA air pollutant emission inventory guidebook does not provide methods for calculating emissions from asphalt production. Because asphalt production plants in the Netherlands are sometimes located close to populated areas, there were requests for emission data. To calculate this data, a Tier 1 method was developed on thew basis of US-EPA emission factors. This concerns emissions of MNVOC, PM_{10}, benzene, PAH and cadmium.

5.2.2 *Key sources*

The key sources in this category are presented in Table 5.3.

Table 5.3 Key sources of Mineral products (2A))

Category / Subcategory		Pollutant	Contribution to total of 2023 (%)
2A3	Glass production	Pb	9.0
2A5b	Construction and demolition	PM_{10}	4.4
		$PM_{2.5}$	2.8
2A5c	Storage, handling, transport mineral products	PM_{10}	2.9
2A6	Other mineral products	PM_{10}	4.8
		$PM_{2.5}$	8.0
		Hg	18.3
		PAH	10.4

5.2.3 *Overview of emission shares and trends*

Table 5.4 provides an overview of the emissions from the key sources of this category.

- The reduction of Pb emissions from 2A3 between 1990 and 2023 was mainly caused by the implementation of technical measures.
- The most important source of PM_{10} and $PM_{2.5}$ emissions in 2A6 is the ceramic industry (Production of bricks, roof tiles, etcetera). An initial strong reduction of PM_{10} emissions from 2A6 in the early years (1990–2000) was a result of the implementation of technical measures. More recently, slight changes in emissions result from changes in production.

Table 5.4 Overview of emissions from the key sources of Mineral products (2A)

NFR code:	2A3	2A5b		2A5c	2A6		
NFR name:	Glass produc-tion	Construction and demolition		Storage, handling, transport	Other mineral products		
Pollutant	Pb	PM_{10}	$PM_{2.5}$	PM_{10}	PM_{10}	$PM_{2.5}$	Hg
Year	Mg	Gg	Gg	Gg	Gg	Gg	Gg
1990	7.3	0.9	0.3	1.5	2.0	1.6	-
1995	6.5	1.0	0.3	1.0	1.6	1.3	-
2000	2.9	1.2	0.4	0.6	1.0	0.9	-
2005	1.4	1.1	0.4	0.9	1.0	0.9	-
2010	0.8	1.1	0.4	0.8	1.1	1.0	0.1
2015	1.0	1.1	0.4	0.8	1.1	0.9	0.1
2018	0.6	1.1	0.4	0.7	1.3	1.2	0.1
2019	0.8	1.2	0.4	0.8	1.3	1.3	0.1
2020	1.6	1.2	0.4	0.7	1.4	1.2	0.1
2021	0.5	1.2	0.4	0.8	1.4	1.3	0.1
2022	0.5	1.4	0.5	0.8	1.5	1.4	0.1
2023	0.4	1.2	0.4	0.8	1.3	1.1	0.1

5.2.4 *Methodological issues*

See Section 5.1.2 for the calculation method for emissions from Glass production (2A3) and Other mineral products (2A6). Emissions from non-reporting facilities are calculated from production indices of the mineral industry from Statistics Netherlands.

As described above, a Tier 1 method was developed to calculate emissions from asphalt production. Calculation is based on US-EPA emission factors, and asphalt production data. This concerns emissions of MNVOC, PM_{10}, benzene, PAH and cadmium.

5.2.5 *Source-specific recalculations*

- For category 2A5b, Construction and demolition, particulate matter emissions (PM_{10}, $PM_{2.5}$) were recalculated for the entire time series because a double counting was corrected. For 2023 this results in a decrease of 0.3 Gg in PM_{10}, and 0.1 Gg in $PM_{2.5}$.
- For category 2A5c Storage, handling and transport of mineral products, particulate matter emissions (PM_{10}, $PM_{2.5}$, and TSP) were recalculated for 2021 and 2022, because there was a delay in the available data. Before, emissions from 2022 were assumed to be equal to those of 2021. For this submission, emission data became available and the emissions were updated.

5.2.6 *Source-specific planned improvements*

For 2A5a, $PM_{2.5}$ and PM_{10} are currently included elsewhere (IE). Emissions by companies responsible for these PM emissions are now reported under 1A2gvii, 2A1, and 2H3. It is currently unclear which contribution of these PM emissions actually belongs to 2A5a. Also, it needs to be investigated to what extent emissions from 2A5a are reported at all. This will be examined for future submissions.

5.3 Chemical industry (2B)

5.3.1 *Source category description*

This category comprises emissions from the following sources:

- 2B1 Ammonia production;
- 2B2 Nitric acid production;
- 2B3 Adipic acid production;
- 2B5 Carbide production;
- 2B6 Titanium dioxide production;
- 2B7 Soda ash production;
- 2B10a Chemical industry: Other;
- 2B10b Storage, handling and transport of chemical products.

Remarks:

- Adipic acid (2B3) is not produced in the Netherlands. As such, emissions do not occur (NO).
- For carbide production (2B5), only silicon carbide is produced in the Netherlands, but no calcium carbide.
- Because of allocation problems and for confidentiality reasons, emissions from 2B1, 2B2, Silicon carbide (2B5), 2B6 and 2B7 are included in 2B10a, Chemical industry: Other. The emission total for the chemical sector consists of the sum of the reported emissions from individual facilities, supplemented by estimated emissions from the non-reporting facilities.
  Most of the data on emissions from the chemical sector (ca. 80–90%) is obtained from the AERs of individual facilities (Tier 3 methodology), which are validated and approved by their competent authority. The majority of those facilities produce several products. Generally, therefore, the emission total is the sum of the emissions from all production processes. According to the Aarhus Convention, only total emissions need to be included in the AERs. This means that production levels and amounts of solvents used, if they are included, are confidential information. However, most companies do not include any production data or amounts of solvents used. For this reason, it is not possible to provide activity data or to determine/calculate IEFs. By this same reasoning, emissions from 2D3g are also included in 2B10a.
  The emissions from non-reporting facilities are calculated from production indices of the chemical sector from Statistics Netherlands.

5.3.2 *Key sources*

The key sources of this category are presented in Table 5.5.

Table 5.5 Key sources of Chemical industry (2B)

	Category / Subcategory	Pollutant	Contribution to total of 2023 (%)
2B10a	Chemical industry: Other	PM_{10}/$PM_{2.5}$	2.5/3.1
		Cd	16.7
		Pb	4.2

5.3.3 *Overview of emission shares and trends*

Table 5.6 provides an overview of the emissions from the key sources of this category.

Table 5.6 Overview of emissions from the key sources of the Chemical industry (2B)

	NFR Code: 2B10a: Chemical industry: Other				
Year	**PM_{10}**	**$PM_{2.5}$**	**Cd**	**NMVOC**	**Pb**
	Gg	**Gg**	**Mg**	**Gg**	**Mg**
1990	4.1	2.6	0.0	33.4	3.0
1995	3.0	1.9	0.1	17.9	1.3
2000	0.5	0.3	0.0	12.6	1.8
2005	1.2	0.7	0.8	7.9	2.2
2010	1.3	0.9	1.4	5.7	0.2
2015	1.1	0.7	0.1	4.7	0.2
2018	1.1	0.7	0.1	4.9	0.2
2019	0.9	0.6	0.1	4.1	0.2
2020	0.7	0.5	0.1	4.4	0.2
2021	0.8	0.5	0.1	4.4	0.2
2022	0.7	0.4	0.1	3.7	0.2
2023	0.7	0.4	0.1	3.3	0.2

Between 1990 and 2023 , the reductions in NMVOC and PM_{10} emissions were mainly caused by the implementation of technical measures.

5.3.4 *Methodological issues*

See Section 5.1.2 for the calculation method for emissions from Other chemical industry (2B10a). The production indices of the Chemical sector are obtained from Statistics Netherlands, and used to calculate the emissions from the non-reporting facilities. They are presented in Table 5.7.

Table 5.7 Overview of production indices of the Chemical sector (2015 = 100)

Chemical sector	
Year	**Production index**
2005	94.1
2006	99.7
2007	103.3
2008	97.0
2009	93.4
2010	104.3
2011	102.5
2012	108.0
2013	103.3
2014	102.8
2015	100.0
2016	106.3
2018	107.4
2019	103.8
2020	104.0
2021	107.8
2022	103.0
2023	92.2

5.3.5 *Source-specific recalculations*

For category 2B10a, multiple recalculations have been made.

- NMVOC emission decreases in the years 2018, 2019 and 2022 , and increases in 2019–2022 are due to corrections in Annual Emission Reporting of two companies, respectively.
- 2021 ammonia recalculations result from one company updating their AER.
- Metal emissions in 2B10a were recalculated for 2000, as a result of a quality check of old emission schemes.

5.3.6 *Source-specific planned improvements*

Some improvements are still planned:

- Improving transparency for this sector by assigning emissions to more subcategories of NFR 2B, instead of mostly to 2B10a, as is the current state of affairs.
- As described before, most of the data on emissions from the chemical sector (ca. 80-90%) is obtained from the AERs of individual facilities, which are validated and approved by their competent authorities. However, most emissions originate from one large chemical site that produces many different chemical products but only reports total emissions from the site. This makes it impossible to disaggregate emissions into different NFR categories, but improvements are being made in providing more detailed data from that AER.
- Furthermore, there are plans to add a more extensive summary of the industries included in 2B10a in future submissions in order to improve transparency on the emissions and industries included here.

5.4 Metal production (2C)

5.4.1 Source category description

This category comprises emissions relating to the following sources:

- 2C1 Iron and steel production;
- 2C2 Ferroalloys production;
- 2C3 Aluminium production;
- 2C4 Magnesium production;
- 2C5 Lead production;
- 2C6 Zinc production;
- 2C7a Copper production;
- 2C7b Nickel production;
- 2C7c Other metal production;
- 2C7d Storage, handling and transport of metal products.

Remarks:

- Since it is not possible to separate combustion and process emissions of SO_x and NO_x from Aluminium production, all SO_x and NO_x emissions are reported in 1A2b.
- For confidentiality reasons, emissions from 2C4 are included in the subcategory 2H3.
- There is one lead, one copper and one zinc producer in the Netherlands (2C5–2C7a).
- Emissions for categories 2C2 and 2C7b are not occurring (NO), as both ferroalloys and nickel production are non-existent in the Netherlands.
- For 2C7a, there is one copper producing operator in the Netherlands. This company does not report SO_x or PM emissions in its Annual Emission Reporting because they are below the EPRTR reporting threshold. These emissions are currently not estimated (NE).
- Since only emissions from the storage and handling of bulk products companies are available, emissions from 2C7d are included in the category of Other industrial processes (2H3).

5.4.2 Key sources

The key sources of this category are presented in Table 5.8.

Table 5.8 Key sources of Metal production (2C)

Category / Subcategory		Pollutant	Contribution to total of 2023 (%)
2C1	Iron and steel production	PM_{10}	3.3
		$PM_{2.5}$	3.56
		Pb	14.0
		Hg	8.9
2C6	Zinc production	Cd	5.4

5.4.3 Overview of emission shares and trends

Iron and steel production (2C1)

The Netherlands has one integrated iron and steel plant (Tata Steel, formerly known as Corus and Hoogovens). Integrated steelworks convert iron ore into steel by means of sintering, produce pig iron in blast furnaces and subsequently convert this pig iron into steel in basic oxygen furnaces.

Energy-related emissions are included under combustion emissions (categories 1A1c and 1A2a) and fugitive emissions (category 1B2).

Table 5.9 provides an overview of the process emissions from the key source of Iron and steel production (category 2C1), including dioxin, PAH and PCB emissions.

Table 5.9 Overview of emissions from Iron and Steel production (2C1)

2C1: Iron and steel production							
Year	**PM_{10} Gg**	**$PM_{2.5}$ Gg**	**Pb Mg**	**Hg Mg**	**Dioxin g I-Teq**	**PAH Mg**	**PCB g**
1990	9.1	5.9	56	0.4	23	1.64	19.2
1995	4.8	3.1	58	0.4	26	1.62	21.3
2000	2.0	1.3	19	0.1	1.40	0.10	0.37
2005	1.7	1.1	23	0.2	1.40	0.09	0.43
2010	1.5	1.0	30	0.2	1.72	0.08	0.38
2015	1.3	0.8	3.5	0.1	0.27	0.07	0.04
2018	1.2	0.8	2.3	0.1	0.26	0.07	0.04
2019	1.3	0.8	1.3	0.1	0.26	0.06	0.03
2020	1.2	0.7	1.1	0.1	0.25	0.06	0.03
2021	1.2	0.7	0.9	0.1	0.21	0.12	0.03
2022	1.0	0.6	0.8	0.1	0.16	0.11	0.03
2023	0.9	0.5	0.6	0.0	0.12	0.10	0.00

Over the 1990–2000 period, the emission reductions from this source were mainly caused by the implementation of technical measures. Over the 2000–2010 period, emissions remained fairly stable. Because of the replacement of electrostatic filters and the optimisation of some other emission reduction technologies at Tata Steel, most emissions decreased again after 2010. Dioxin emission fluctuations were mainly caused by the varying process conditions.

Aluminium production (2C3)
Formerly, the Netherlands had two primary aluminium smelters, of which the last one closed in 2022. Since then, no aluminium production has taken place in the Netherlands. Aluminium production caused PAH emissions, originating from ‘producing anodes’ and the ‘use of anodes’ during primary aluminium production. Over the 1990–2021 period, PAH emissions decreased from 6.9 Mg to 0.01 Mg. This reduction was mainly caused by

- the closure of one of the anode production plants; and
- the installation of three modern fume treatment plants at the other production plant.

Lead production (2C5), zinc production (2C6) and copper production (2C7a)
Table 5.10 provides an overview of the process emissions from the key sources of zinc production (2C6).

Table 5.10 Overview of emissions from Zinc production (2C6)

Year	2C6: Zinc production Cd Mg	Pb Mg
1990	1.78	0.32
1995	1.76	0.37
2000	1.75	0.52
2005	1.87	0.44
2010	1.98	0.43
2015	2.39	1.12
2018	2.00	0.42
2019	2.22	0.47
2020	1.47	0.44
2021	0.39	0.48
2022	0.32	0.41
2023	0.03	0.12

Remarks:

- Since 2009, the single copper production company has not reported PM_{10} emissions because the emissions are far below the reporting threshold of 5000 kg. For this reason, PM_{10} emissions are reported as 'NE' in 2C7a. Normally, the reported PM_{10} emissions are used to calculate $PM_{2.5}$ emissions, but that is not possible in this case. Therefore, $PM_{2.5}$ emissions are also reported as 'NE' in 2C7a. See Section 5.4.5, Source-specific planned improvements, for more information.
- For 2C7a, multiple compounds are reported as 'IE', as they are included in NFR category 1A2b. This is the case for NO_x, SO_x, CO, Hg, As, and dioxins.
- The lead production company reports no SO_x emissions because the emissions are below the reporting threshold of 20,000 kg. For this reason, no SO_x emissions are reported in 2C5.
- Because it is not possible to split SO_x emissions from 2C6, all SO_x emissions are reported in 1A2b.
- Hg emissions from lead production have remained fairly stable since 2012, while Pb emissions from zinc production doubled between 2010 and 2014.
- The zinc production company does not report any Hg emissions. The latter company reports that annual measurements at the chimney reveal that no, or very little mercury is emitted. This is also because the mercury present in the ore is removed by forming a mercury-selenium compound before the ore gets in contact with sulphuric acid in the process.
- Because of high energy prices, the zinc production company has a temporary shutdown as of 2023. This results in a strong decrease in emissions in 2023.

5.4.4 *Methodological issues*

See Section 5.1.2 for the calculation method for emissions from iron and steel, aluminium, lead and zinc production. In cases without a complete registration for the four individual PAHs, a set of factors was used to calculate the emissions of the missing PAHs. These factors were obtained from a study conducted by Visschedijk et al. (2007).

5.4.5 *Source-specific recalculations*

For category 2C1, several recalculations have been performed.

- Heavy metal emissions were recalculated for the years 2019–2022 as a result of updates of the AERs.
- For the same reason, emissions of TSP, PM_{10} and $PM_{2.5}$ were recalculated for 2022.

5.4.6 *Source-specific planned improvements*

For 2C5, TSP emissions have been reported, but $PM_{2.5}$ and PM_{10} are currently under 'NE'. Emissions for this category originate from two lead producers in the Netherlands, which do not report PM emissions in their Annual Emission Reporting (AER), as these emissions are below the E-PRTR reporting threshold. We plan to estimate $PM_{2.5}$ and PM_{10} emissions from the TSP reporting. This will be revised for future submission.

For 2C7a, there are currently no $PM_{2.5}$ or PM_{10} emissions included in the reporting. As explained before, there is currently one copper-producing operator in the Netherlands, which does not report PM emissions in their Annual Emission Reporting (AER) as these emissions are below the E-PRTR reporting threshold. We plan to improve our reporting by estimating these emissions for future submissions.

5.5 Solvents and product use (2D)

5.5.1 *Source category description*

Solvents and product use comprises the following categories:

- 2D3a Domestic solvent use, including fungicides;
- 2D3b Road paving with asphalt;
- 2D3c Asphalt roofing;
- 2D3d Coating applications;
- 2D3e Degreasing;
- 2D3f Dry cleaning;
- 2D3g Chemical products;
- 2D3h Printing;
- 2D3i Other solvent use.

Emissions NMVOC, PM, TSP and BC from Road paving have been included in the inventory since the 2023 submission, calculated using the Tier 1 method from the guidebook as described in the ENINA methodology report (Honig et al., 2024). Source category 2D3b is not a key source.

Emissions from Asphalt roofing (2D3c) were not estimated because no activity data was available.

Emissions from Chemical products (category 2D3g) are included in 2B10a (see Section 5.3.1).

35% of the total NMVOC emissions in the Netherlands originate from Solvents and product use.

5.5.2 *Key sources*
The key sources in this category are presented in Table 5.11.

Table 5.11 Key sources of Solvents and product use (2D)

	Category / Subcategory	Pollutant	Contribution to total of 2023 (%)
2D3a	Domestic solvent use, including fungicides	NMVOC	20.1
2D3d	Coating applications	NMVOC	5.8
2D3i	Other solvent use	NMVOC	6.5

5.5.3 *Overview of emission shares and trends*
Table 5.12 provides an overview of the emissions from the key sources in this category.

Table 5.12 Overview of emissions from key sources of Solvents and product use (2D)

Year	2D3a: Domestic solvent use, including fungicides	2D3d: Coating applications	2D3i: Other solvent use	
	NMVOC	NMVOC	NMVOC	Dioxin
	Gg	Gg	Gg	g I-Teq
1990	24	93	18	14.7
1995	27	67	17	12.8
2000	29	41	16	11.1
2005	31	26	14	9.6
2010	35	28	13	8.1
2015	36	19	15	6.8
2018	39	15	15	6.0
2019	40	15	15	5.8
2020	48	15	16	5.6
2021	45	15	14	5.3
2022	45	16	15	5.1
2023	48	14	16	4.9

Domestic solvent use, including fungicides (2D3a)
The emission sources within this key source are:

- cosmetics (and toiletries);
- cleaning agents;
- car products;
- others.

The increase in NMVOC emissions over the 1990–2019 period was caused mainly by cosmetics (and toiletries). The strong increase in emissions for 2020 and 2021 is due to COVID-19: the use of disinfecting hand gels increased strongly. In the submission of 2023, recalculations have been performed for this subsector due to a change of activity data. In the previous submission, data from a survey on the use of disinfecting hand gels was used for 2020 and 2021, whereas for other years, data on the use of disinfection products was estimated on the basis of work hours in hospitals. Since that submission, sales statistics from the Dutch association of soap manufacturers has been used for all years.

Coating applications (2D3d)
The emission sources within this key source are:
- industrial paint applications;
- domestic use;
- construction and buildings;
- car repairing;
- boat building.

Mainly due to the lower average NMVOC content of the paints used, the NMVOC emissions from coating applications decreased from 93 Gg in 1990 to 25 Gg in 2007. As a result of the financial crisis, paint consumption decreased in 2008 and 2009, causing NMVOC emissions to decrease to 19 Gg in 2009. In 2010, the largest market segment, i.e. construction paints, continued to decrease, while car repairs and industry overall made a modest recovery. Because car repairs and the industry are market segments with generally high NMVOC levels, total NMVOC emissions increased to 28 Gg in 2010.
During the 2010–2013 period, paint consumption decreased again, which resulted in a decline in NMVOC emissions to 19 Gg in 2013. A slight increase in paint consumption led to an increase in NMVOC emissions by 1 Gg in 2014. In 2015, a lower NMVOC content of paints resulted in a decrease in NMVOC emissions. Following decreased paint consumption from 2016 onwards (mainly in the market segments of Car repairs and Industry), NMVOC emissions have been relatively constant, only showing slight variations due to changes in paint consumption.

Other solvent use (2D3i)
For NMVOC, the following activities are included in 2D3i in the Netherlands:
- 060405 Application of glues and adhesives;
- 060406 Preservation of wood;
- 060407 Underseal treatment and conservation of vehicles;
- 060409 Vehicle dewaxing;
- 060412 Other:
  - Cosmetics sector: Trade and services;
  - Car products (mainly windscreen cleaning fluid);
  - Detergents sector: Trade and services;
  - Industrial cleaning of road tankers;
  - Office products sector: Trade and services;
- 060508 Other: Use of HFCs, N_2O, PFCs and HCFCs.

Remarks:
- Emissions from the use of HFCs, PFCs and HCFCs as refrigerants and other uses of HFCs, PFCs and HCFCs are obtained from the National Inventory Report (Van der Net et al., 2025).
- Until 2000, NMVOC emissions from most of the other sources were obtained from the Hydrocarbons 2000 project. Due to a lack of more recent data since the Hydrocarbons 2000 project, emissions in the years following 2000 were put on a par with those in 2000, the last year of the Hydrocarbons 2000 project.

- Dioxin emissions originate from PCP-treated wood. Because PCP was banned in 1989, a linear reduction in dioxin emissions was assumed. This resulted in an emission reduction from about 14.7 g I-TEQ in 1990 to about 4.9 g I-TEQ in 2023.

5.5.4 *Methodological issues*

For a detailed description of the methodology of the emission sources, see Visschedijk et al. (2025).

Domestic solvent use, including fungicides (2D3a)
Total NMVOC emissions were calculated by multiplying NMVOC emissions per product by the number of products sold. NMVOC emissions per product were calculated by multiplying the fraction of the NMVOC content that is emitted to the air by the NMVOC content of the product.

Coating applications (2D3d)
NMVOC emissions from paint use were calculated from national statistics on annual sales of paint that was both produced and sold within the Netherlands provided by the Dutch Association for Paint and Ink Producers (VVVF) and from VVVF estimations relating to imported paints. Through its members, the VVVF directly monitors NMVOC in domestically produced paints and estimates the NMVOC content of imported paints. Estimates have also been made for the use of flushing agents and the reduction effect of afterburners. For more information on these estimates, see the WESP methodology report (Visschedijk et al., 2025).

Other solvent use (2D3i)
Total NMVOC emissions were calculated by multiplying NMVOC emissions per product by the number of products sold. NMVOC emissions per product were calculated by multiplying the fraction of the NMVOC content that is emitted to the air by the NMVOC content of the product.

Other solvent non-key categories (2D3e, 2D3f, 2D3g, 2D3h)
As a response to a review question, the non-key categories are outlined here:

- 2D3e: degreasing in the metallurgical industry: The production index of this sector is used;
- 2D3f: NACE 96.012: washing and (dry) cleaning and painting: Described in chapter 3, 32 and 33 of Visschedijk et al. (2025);
- 2D3g is included in 2B10a;
- 2D3h: emissions from printing: These are calculated from annual ink sales statistics, provided by the Dutch Paint and Ink Manufacturers Association (VVVF).

5.5.5 *Activity data and (implied) emission factors*

Domestic solvent use, including fungicides (2D3a)
Sales data on products and the NMVOC content of products were obtained from annual reports by branch organisations, while the fraction of the NMVOC content that is emitted to the air was derived from studies, as described in the WESP methodology report.

Coating applications (2D3d)
In the paint application sector, annual statistics on sales are provided by the Dutch Paint and Ink Producers Association (VVVF). Total paint consumption decreased from 164 Gg in 2011 to 110 Gg in 2021, while the NMVOC content decreased from 30% in 1990 to almost 13% in 2011. During the 2012–2014 period, the NMVOC content remained fairly stable. In 2015, the NMVOC content decreased further, to 12%. From that submission onwards, no NMVOC content figures have been made available. Therefore, the NMVOC content is maintained at the 2015 value.

Other solvent use (2D3i)
Sales data on products and the NMVOC content of products were obtained from annual reports issued by branch organisations, while the fraction of the NMVOC content that is emitted to the air was derived from studies.

Dioxin emissions from wooden house frames were determined for 1990 on the basis of Bremmer et al. (1993). Because PCP was banned in 1989, a linear reduction in dioxin emission was assumed.

5.5.6 Source-specific recalculations
No recalculations were performed.

5.5.7 Source-specific planned improvements
There are no planned improvements for NFR category 2D.

5.6 Other product use (2G)

5.6.1 Source category description
The following activities are included in 2G in the Netherlands:
- Use of fireworks;
- Use of tobacco;
- Refrigeration and air conditioning equipment;
- Other: Burning of candles;
- Anaesthetic gasses.

5.6.2 Key sources
The key sources in this category are presented in Table 5.13.

Table 5.13 Key sources of Other product use (2G)

	Category / Subcategory	Pollutant	Contribution to total of 2023 (%)
2G	Other product use	PM_{10}	6.9
		$PM_{2.5}$	8.1
		Cd	16.1

5.6.3 Overview of emission shares and trends
Table 5.14 provides an overview of the emissions from the key sources in this category.

Table 5.14 Overview of emissions from key sources of Other product use (2G)

	2G: Other product use		
	PM_{10}	$PM_{2.5}$	Cd
Year	Gg	Gg	Mg
1990	1.4	1.3	0.20
1995	1.8	1.4	0.18
2000	2.2	1.6	0.18
2005	2.1	1.4	0.15
2010	1.9	1.3	0.13
2015	2.2	1.4	0.10
2017	1.9	1.2	0.10
2018	2.0	1.2	0.10
2019	1.8	1.1	0.09
2020	1.3	0.9	0.09
2021	0.9	0.6	0.09
2022	1.3	0.9	0.08
2023	1.8	1.1	0.08

5.6.4 *Source-specific recalculations*

NMVOC emissions from stationary refrigeration were recalculated for 2021 and 2022. This is due to a time-lag for data availability from this sector. In this submission, the 2021 data was replaced by the newly calculated value. In the previous submission, the 2022 emission was assumed to be equal to the 2020 submission. Due to the update in this submission, the 2022 and 2023 emissions are assumed to be equal to the 2021 emissions.

As of this submission, emissions of the anaesthetic gas sevoflurane are calculated. Therefore, emissions of NMVOC are now also included under 2G.

5.7 Other production industry (2H)

5.7.1 *Source category description*

This category comprises emissions from the following sources:

- 2H1 Pulp and paper industry;
- 2H2 Food and beverages industry;
- 2H3 Other industrial processes.

The following activities are included in category 2H2:

- NACE 10.1: processing and preserving of meat and poultry;
- NACE 10.3: processing and preserving of fruit and vegetables;
- NACE 10.4: manufacture of oils and fats;
- NACE 10.5: dairy industry;
- NACE 10.6: manufacture of grain mill products, excluding starches and starch products;
- NACE 10.9: manufacture of prepared animal feeds;
- NACE 10.8 (excluding NACE 10.81 and 10.82): other manufacture of food products.

These NACE activities include all activities listed in the 2019 EMEP/EEA Guidebook (production of bread, wine, beer, spirits, sugar, flour, meat, fish, etcetera, and frying/curing).

Since 2000, it has not been possible to provide activity data and to determine/calculate IEFs, due to the lack of production figures and emission data on individual facilities (see also Section 5.3.1).

5.7.2 *Key sources*

The key sources in this category are presented in Table 5.15.

Table 5.15 Key sources of Other production industry (2H)

	Category / Subcategory	Pollutant	Contribution to total of 2023 (%)
2H2	Food and beverages industry	NMVOC	2.3
		PM_{10}	5.0
		$PM_{2.5}$	2.0
2H3	Other industrial processes	NMVOC	4.3
		PM_{10}	2.3

5.7.3 *Overview of emission shares and trends*

Table 5.16 provides an overview of the emissions from the key sources in this category.

Food and beverages industry (2H2)

The reductions in PM_{10} emissions between 1990 and 2023 were mainly caused by strong reductions in the early years (1990–2000) resulting from the implementation of technical measures. Since that decrease, emissions have been relatively constant through the years.

Other industrial processes (2H3)

The 2H3 subcategory in the Dutch PRTR covers emissions from a wide range of activities.
The reductions in NMVOC and PM_{10} emissions between 1990 and 2020 were mainly caused by the implementation of technical measures. After 2005, PM_{10} emission fluctuations were caused by the varying volume of products handled.

Table 5.16 Overview of emissions from the key sources of Other production Industry (2H)

	2H2: Food and beverages industry			2H3: Other industrial processes		
Year	NMVOC Gg	PM_{10} Gg	$PM_{2.5}$ Gg	NMVOC Gg	PM_{10} Gg	$PM_{2.5}$ Gg
1990	9.1	4.3	1.0	25	3.0	1.1
1995	7.6	2.3	0.6	13	1.1	0.4
2000	8.2	1.7	0.4	5.9	1.4	0.4
2005	7.6	1.5	0.3	10	0.7	0.3
2010	7.5	1.2	0.3	10	0.5	0.2
2015	6.0	1.3	0.3	10	0.6	0.2
2018	5.8	1.4	0.3	10	0.7	0.2
2019	5.9	1.4	0.3	10	0.6	0.2
2020	5.5	1.4	0.3	10	0.6	0.2

Year	2H2: Food and beverages industry			2H3: Other industrial processes		
	NMVOC Gg	PM_{10} Gg	$PM_{2.5}$ Gg	NMVOC Gg	PM_{10} Gg	$PM_{2.5}$ Gg
2021	5.4	1.4	0.3	11	0.6	0.2
2022	5.5	1.3	0.3	11	0.6	0.2
2023	5.5	1.3	0.3	10	0.6	0.2

5.7.4 *Methodological issues*

See Section 5.1.2 for the calculation method for emissions from the production of food and drink (category 2H2) and from storage and handling (2H3). Emissions from non-reporting facilities are calculated from production indices of the food and beverages industry from Statistics Netherlands.

There is one exception: NMVOC emissions from bread bakeries occur as a result of using yeast in the bakery process. Since the 2020 submission, these emissions have been calculated separately by multiplying the activity data by the guidebook EF of 4.5 kg NMVOC per Mg bread produced, for European bread. The activity data is obtained by using data from the Dutch Bakery Centre (NBC). It is assumed that the import and export of bread can be ignored, because bread is a highly perishable product. As stated by the NBC, no emission reduction measures are taken.

5.7.5 *Source-specific recalculations*

For category 2H2, 2021 emissions of NMVOC have been recalculated. This recalculation is a result of the fact that one company updated their AER and also added NMVOC, which had not been included in their last submission. This leads to a small increase of NMVOC by 42.65 kg in 2021.

Furthermore, NMVOC emissions have been reallocated from 1A2e to 2H2, as a result of erroneous allocation.

6 Agriculture

6.1 Overview of emissions from the sector

The agricultural sector includes all anthropogenic emissions from agricultural activities. Emissions from fuel combustion (mainly relating to heating in horticulture and the use of agricultural machinery) are included in the source category Agriculture/Forestry/Fishing: Stationary (1A4c).
Emission sources in the agricultural sector consist of the following NFR categories:

- 3B Manure management;
- 3D Crop production and agricultural soils;
- 3F Field burning of agricultural residues.

This Informative Inventory Report (IIR) focuses on emissions of ammonia (NH_3), nitrogen oxides (NO_x), particulate matter (PM_{10}, $PM_{2.5}$), non-methane volatile organic compounds (NMVOC), hexachlorobenzene (HCB) and zinc (Zn) from the NFR source categories of 3B Manure management and 3D Crop production and agricultural soils. The source category 3F Field burning of agricultural residues is reported as Not Occurring (NO), since field burning was prohibited in the Netherlands throughout the time series (article 10.2 of the Environmental Management Act, or 'Wet Milieubeheer' in Dutch).

Emissions of the greenhouse gases methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) from the agricultural sector are reported in the annual National Inventory Report (NIR). All emissions from manure management and crop production are calculated according to the methods described in Van der Zee et al. (2025). All activity data is summarised in Van Bruggen et al. (2025), except the activity data on N excretion, which is reported by CBS (2024). The method and activity data for the calculation of the NMVOC and Zn emissions from the use of pesticides are provided in Section 6.3 and in Kruijne et al. (2022).

In 2023, the agricultural sector was responsible for 90% of all NH_3 emissions in the Netherlands. Emissions of NO_x from agriculture amounted to 17% of the national total. Agriculture contributed 36% of the national NMVOC emissions, 20% of the national PM_{10} emissions, 4% of the national $PM_{2.5}$ emissions and 2% of the national HCB emissions in 2023. Although Zn is not a priority heavy metal, emissions from drift following pesticide use are reported for the sake of completeness (3% of the national total).

The currently reported time series (1990–2023) differs from the previous time series (1990–2022) as six recalculations have been implemented.

- The first recalculation concerns the amount of treated manure. From 2010 onwards, the N content of the manure has been based on the mandatory transport certificates instead of defaults. This affects the NH_3 and the NO_x emission from manure treatment and manure storage.

- The second change concerns the NH_3 emissions from manure application. The INITIATOR model, which distributes manure over the different soil types, has been rerun for the years 2000–2022. The INITIATOR model now takes bedding material into account resulting in small changes compared to the previous time series.
- The third recalculation results from the previous recalculations. As the emissions of NH_3 from storage and manure application change, NMVOC emissions from manure storage and manure application change, too.
- The fourth recalculation concerns the NMVOC emissions from dairy cows. These emissions increase for 2022, due to updated activity data.
- The fifth recalculation concerns the emissions from crop residues. The NH_3 and NO_x emissions from crop residues have been recalculated for the years 2006–2022. For these years, the percentage of renewed grasslands was based on total grasslands, including natural grasslands. Natural grasslands are not renewed. As a result, the percentage of renewed grasslands excluding natural grasslands is higher. The years 1990–2005 are based on a different source that does not include natural grasslands.
- The sixth recalculation is caused by a change in the LULUCF sector, which increased the area of organic soils. The NO_x emissions from organic soils increased for the entire time series.

6.1.1 *Key sources*

In 2023, several key sources were identified, as presented in Table 6.1 (see Appendix 2 for details).

6.1.2 *Trends*

Ammonia

Ammonia emissions decreased between 1990 and 2023, representing the largest reduction in the first few years of the time series (Tables 6.2 and 6.9). This was mainly caused by a ban on surface spreading of manure enforced in the 1991–1995 period, which made it mandatory to incorporate manure into the soil either directly or shortly after application. In addition, it became mandatory to cover outdoor slurry manure stores. More recently, the introduction of low-emission housing for animals further decreased ammonia emissions.

Maximum application standards for manure and fertiliser (in accordance with the Nitrates Directive) and systems of livestock production rights have increased efficiency in animal production. One example of this is the ongoing improvement in nutritional management (precision feeding), where a reduction of dietary crude protein in concentrate feed has resulted in a lower N intake per animal and thus in a lower N excretion, and has consequently reduced NH_3 emissions. Between 1990 and 2023, however, the N excretion of dairy cattle increased as more grass was fed instead of maize. Grass has a higher N content than maize, resulting in overall higher N excretion. The increase is due to the derogation system, which allows dairy farmers to apply more manure on their land than the maximum set by the EU in the Nitrates Directive. Until 2014, one of the eligibility requirements for derogation was to use a minimum of 70% of the land as grassland. In 2014, this minimum was increased to 80% of the land. In 2023 the N excretion of dairy cattle increased as the N content of the roughages increased. As of 2023, the amount of manure that can be applied under the derogation is being gradually reduced until 2026, when the derogation will be completely abolished.

Table 6.1 All NFR categories that were identified as key sources of the agricultural sector on level (L) and/or trend (T)

NFR Category	NH_3	NO_x	PM_{10}	$PM_{2.5}$	NMVOC	HCB
3B Manure management						
Cattle						
Dairy cattle	L				L, T	
Non-dairy cattle	L				L	
Swine	L, T		L			
Poultry						
Laying hens	L		L			
Broilers			L			

NFR Category	NH_3	NO_x	PM_{10}	$PM_{2.5}$	NMVOC	HCB
3D Crop production and agricultural soils						
Inorganic N fertilisers	L	L				
Animal manure applied to soils	L, T	L			L, T	
Cultivated crops			L			
Farm-level agricultural operations including storage, handling and transport of agricultural products					L	
Urine and dung deposited by grazing animals						
Use of pesticides						T

The milk quota set by the EU (1984–2015) led to an increase in milk production per dairy cow. Increased production per animal led to a decrease in animal numbers and consequently lower emissions. Due to the abolishment of the milk quota in 2015, more dairy cattle have been kept from 2014 onwards, resulting in a further increase in milk production as well as in an increase in manure. The increased manure production caused the national phosphate production ceiling, as set in European agreements, to be exceeded. In turn, this led to an introduction of phosphate quota for dairy cattle as of 1 January 2018. This quota limited the number of dairy cattle a farmer may keep and resulted in a decreasing trend in animal numbers from 2017 onwards. An additional effect of the phosphate quota was an increase in average body weight, milk yield and N uptake. These changes are the result of farmers keeping their biggest and most productive cows and culling smaller cows with lower productivity. In 2023 the average weight of dairy cows increased again.

The amount of manure exported increased fourfold in the 1990–2016 period, after which it decreased in 2017 and 2018, increased again in 2019, but has decreased in the years since. The increase can be explained by stricter Dutch application requirements resulting in a decreased demand for manure in the Netherlands. From 1997 onwards, part of the NH_3 emissions from animal housing have been contained in the washing liquid of air scrubbers, which was used as an inorganic N fertiliser, shifting some N to category 3D Crop production and agricultural soils.

As of 1 January 2019, the application of liquid manure using a trailing shoe on peat and clay soils has only been allowed if the manure was diluted with one part water to two parts manure. This reduces the emission of NH_3.

Since most of the Netherlands' total NH_3 emissions originate from the agricultural sector, the trend in agricultural NH_3 emissions seen from 1990 to 2023 was reflected in a decreasing trend in the national total.

Nitrogen oxides
Nitrogen oxide emissions decreased over the 1990–2023 period, due to a lower inorganic N fertiliser use, a decrease in N excretion during grazing, less manure N being applied to soil and, in recent years, a decrease in cattle numbers (Tables 6.2 and 6.9).

Particulate matter
Particulate matter emissions for most animal categories decreased slightly over the 1990–2023 period, due to decreased animal numbers (Tables 6.6 and 6.7); however, PM emissions from laying hen houses almost tripled for PM_{10} and doubled for $PM_{2.5}$. This was caused by a shift from battery cage systems with liquid manure to floor housing or aviary systems, with solid manure and higher associated emissions of PM_{10} and $PM_{2.5}$. This gradual transition between 1990 and 2012 was initiated by a ban on battery cage systems from 2012, and led to an overall increase in PM emissions from manure management (Table 6.2). PM emissions peaked in 2014, after which they decreased.

NMVOC
Overall, NMVOC emissions from agriculture decreased over the 1990–2023 period (Tables 6.2 and 6.9). However, the emissions reported under manure management increased significantly, due to an increased share of silage feeding and its NMVOC emissions in animal housing. A decrease in emissions from animal manure applied to soils compensated for the increase in manure management emissions. This decrease was caused by low-ammonia-emission application techniques.

HCB
Hexachlorobenzene (HCB) emissions from agriculture decreased over the 1990–2023 period (Table 6.9). This is due to the reduction in the amount of applied pesticides containing HCB, as well as to a reduction in the maximum amount of HCB allowed as a contaminant in pesticides.

6.2 Manure management (3B)

6.2.1 *Source category description*

The category Manure management (3B) includes emissions from the treatment and storage of animal manure. Emissions were allocated to the following NFR subcategories:

- 3B1a Dairy cattle;
- 3B1b Non-dairy cattle;
- 3B2 Sheep;
- 3B3 Swine;
- 3B4d Goats;
- 3B4e Horses;
- 3B4f Mules and asses;
- 3B4gi Laying hens;
- 3B4gii Broilers;
- 3B4giii Turkeys;
- 3B4giv Other poultry;
- 3B4h Other animals: fur-bearing animals;
- 3B4h Other animals: rabbits.

Category 3B4a (Buffalo) does occur in the Netherlands. However, these emissions are included with 3B1a and 3B1b according to the purpose of the buffalo. Emissions from the category 3B4giv Other poultry include emissions from ducks. Emissions resulting from the application of animal manure or during grazing were related to land use; they are not reported under 3B Manure management, but are included in 3D Crop production and agricultural soils.

6.2.2 *Key sources*

Approach1

In 2023, within sector 3B, dairy cattle (3B1a) made the largest contribution to NH_3 emissions, amounting to 18% of the national total. Swine (3B3, 10%), non-dairy cattle (3B1b, 8%) and laying hens (3B4gi, 7%) were also key NH_3 sources. The largest source of PM_{10} emissions within sector 3B was laying hens (3B4gi), amounting to 8% of the national total. Broilers (3B4gii, 3%) and swine (3B3, 3%) were also key sources of PM_{10}. For NMVOC emissions, dairy cattle (3B1a) made the largest contribution to the national total, with 18%. The category non-dairy cattle (3B1b) was also a key source, with a contribution of 5%. For emissions of $PM_{2.5}$ and NO_x, the manure management sector had no key sources.

Approach 2

The approach 2 key sector analysis is only performed at the level of GNRF sectors for the pollutants NO_x, NMVOC, SO_x, NH_3, PM_{10} and $PM_{2.5}$. From this analysis the GNFR-sector AgriLivestock is a:

- 2023 level key source of NH_3 and NMVOC;
- 1990–2023 trend key source of NMVOC and PM_{10}.

6.2.3 *Overview of emission shares and trends*

Table 6.2 presents an overview of emissions of the main pollutants NMVOC, NO_x and NH_3, together with the emissions of PM_{10} and $PM_{2.5}$, originating from sector 3B Manure management.

Table 6.2 Emissions of main pollutants and particulate matter from sector 3B Manure management

	Main Pollutants			Particulate Matter		
	NO_x	NMVOC	NH_3	$PM_{2.5}$	PM_{10}	TSP
Year	Gg	Gg	Gg	Gg	Gg	Gg
1990	**3.7**	**42**	**100**	**0.46**	**4.1**	**4.1**
1995	4.0	41	97	0.46	4.1	4.1
2000	3.4	45	78	0.48	4.6	4.6
2005	3.0	42	69	0.46	4.6	4.6
2010	3.2	59	71	0.49	5.2	5.2
2015	3.7	66	65	0.50	5.5	5.5
2020	3.8	65	61	0.43	4.7	4.7
2022	3.5	64	58	0.41	4.3	4.3
2023	**3.5**	**64**	**56**	**0.40**	**4.2**	**4.2**
1990-2023 period[1)]	-0.2	22	-44	-0.06	0.11	0.11
1990-2023 period[2)]	-5%	53%	44%	-13%	3%	3%

1. Absolute difference in Gg
2. Relative difference from 1990 in %

N emissions
The Netherlands uses an N-flow model, the National Emission Model for Agriculture (NEMA), to calculate N emissions (Van der Zee et al., 2025). Figure 6.1 presents a schematic overview of the N-flows.

Between 1990 and 2023, NH_3 emissions from manure management were reduced by 44% (Table 6.2). Higher production rates per animal and restrictions through quotas resulted in a decreasing trend in the numbers of cattle, sheep, and swine. Nitrogen excretions per animal decreased in the course of the time series, due to a decrease in dietary crude protein in all animal categories. In 2017 and 2018, N excretion increased again for cattle, which can be explained by an increase in nutrient requirements through a higher average milk production and body weight. In 2019, N excretion decreased as a lower amount of N was fed. In 2020, N excretion increased due to a higher amount of N fed. In 2021 and 2022, N excretion decreased as the roughages contained less nitrogen. In 2023, the roughages contained more nitrogen.

A study published by Statistics Netherlands shows that some forms of low-emission housing did not reach the emission reduction targets (Van Bruggen & Geertjes, 2019). Therefore, it was decided to adjust the NH_3 emissions on the basis of the Nitrogen:Phosphate ratio in the manure. A complete description of the method applied to calculate the EFs of all housing types is included in the methodology report (Van der Zee et al., 2025).

As NO_x emissions were also influenced by the above-mentioned developments, NO_x emissions decreased by 5% from 1990 to 2023.

Particulate matter
PM_{10} emissions from animal housing showed an increasing trend in the time series, which was caused mainly by the increased proportion of solid manure housing systems for poultry. The increased available floor space per animal added to this effect. In recent years, the increased usage of abatement techniques for PM removal and a lower number of poultry resulted in a decrease in PM. $PM_{2.5}$ emissions decreased over the entire time period as a result of lower animal numbers.

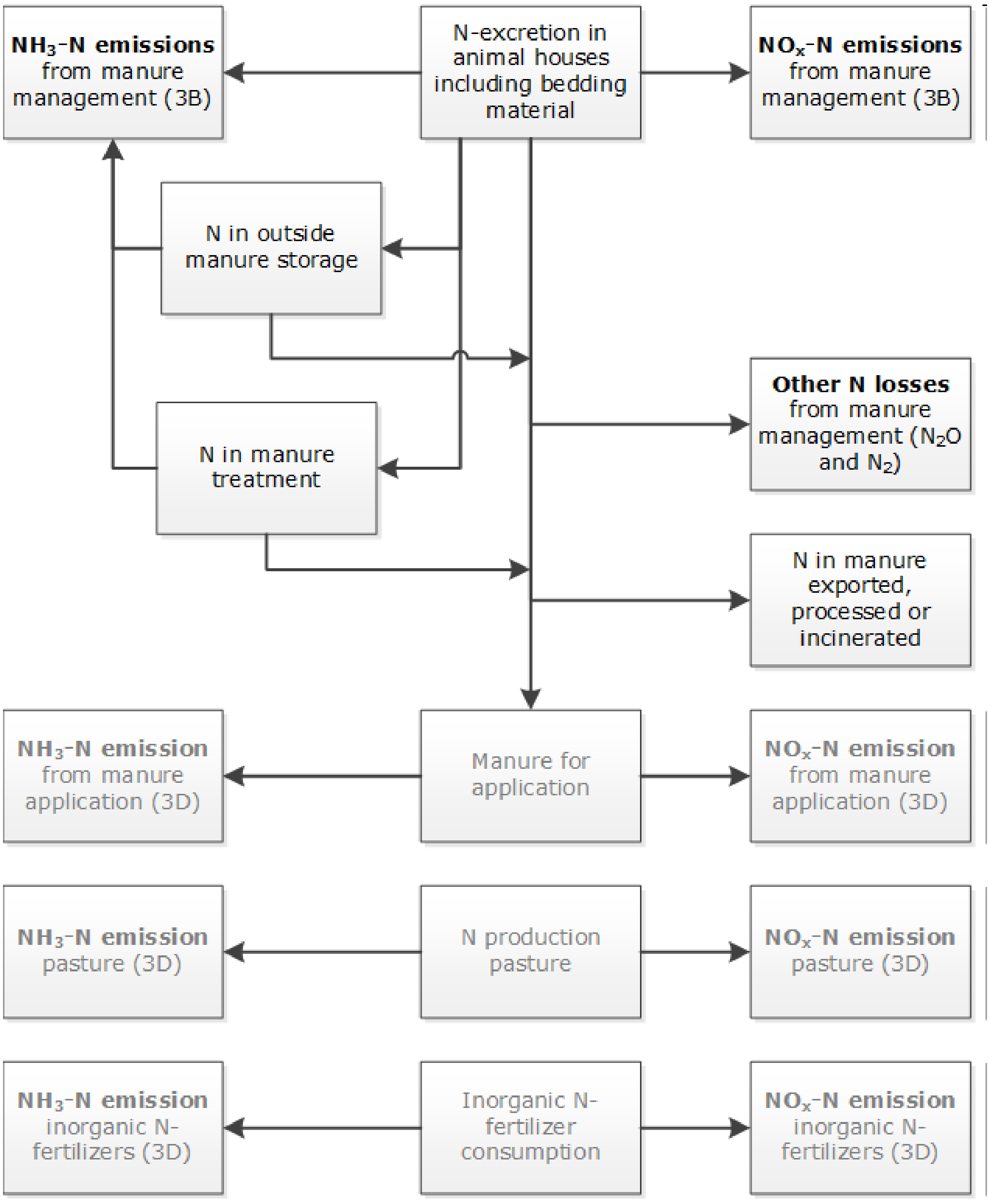


Figure 6.1 Nitrogen flows in relation to NH3 and NOx emissions, where the boxes with black type show the emissions included in 3B Manure management and the boxes with grey type show emissions included in 3D Crop production and agricultural soils

NMVOC
Emissions of NMVOC showed an increasing trend of 53% from 1990 to 2023, mostly caused by an increase in silage feeding to dairy cattle in

animal housing, resulting in more NMVOC emissions from animal housing. The increase in poultry numbers also added to this increasing trend.

6.2.4 *Activity data and (implied) emission factors*

Activity data includes animal numbers as determined by the annual agricultural census and the I&R system (see the summary in Table 6.3 and, for a full list of subcategories and years, Van Bruggen et al. (2025). More information on the collection of animal numbers can be found in section 2.2.1 of Van der Zee et al. (2025).
Animal numbers were distributed over the various housing types using information from the agricultural census (Van Bruggen et al., 2025).

N emissions
Emissions of NH_3 and NO_x from manure in animal housing, manure treatment and outdoor manure storages were calculated using the NEMA model at a Tier 3 level. N excretions per animal are calculated annually by the Working Group on the Uniformity of Calculations of Manure and Mineral Data (WUM; CBS, 2012). The historical data was recalculated in 2019 (CBS, 2019) and has since been supplemented annually, ensuring consistency (publication series CBS, 2019 to 2024).

The Total Ammoniacal Nitrogen (TAN) in manure was calculated from the faecal digestibility of the N in the various components of animal feed. From the N excretion data, the TAN excretion per animal type and NH_3 EF per housing type were calculated, taking into account mineralisation and immobilisation. The Tier 1 default N_2O EFs from the IPCC 2006 Guidelines were applied to both N_2O and NO_x emissions, following research from Oenema et al. (2000), which set NO_x emissions equal to N_2O emissions. According to this same study, N_2 losses were set to a factor of 5 (solid manure) or 10 (liquid manure) of the N_2O/NO_x factors, all expressed as percentages of the total N available.

NH_3, N_2O, NO_x and N_2 emissions from animal housing were calculated and subtracted from the excreted N. Subsequently, the amount of manure stored outside of animal housing, and its corresponding NH_3 emissions, were calculated. NH_3, N_2O and NO_x emissions from manure that was treated (manure separation, nitrification/denitrification, mineral concentrates, incineration, pelleting/drying and digesting of manure) were calculated (Melse and Groenestein, 2016). The sums of emissions from animal housing, manure treatment and outdoor manure storage per livestock category were reported under their respective subcategories in sector 3B Manure management, except for emissions associated with the digesting of manure, which are allocated to 5B2 Biological treatment of waste – Anaerobic digestion at biogas facilities. The amount of N available for application was calculated by subtracting all N emissions during manure management, the N removed from agriculture by manure treatment and the net export of manure. The N in applied manure is used to calculate emissions from manure application, allocated to sector 3D. As a result of new insights into the feed intake of horses and ponies, N excretion increased in 2018 (Bikker et al., 2019).

Table 6.3 Animal numbers over the 1990–2023 period (in 1,000 heads)

Animal type	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
dairy cattle	1,878	1,708	1,504	1,433	1,479	1,622	1,593	1,571	1,563
non-dairy cattle	3,048	2,946	2,565	2,364	2,497	2,512	2,126	2,195	2,193
Sheep[1]	1,702	1,674	1,305	1,361	1,130	946	954	907	888
Swine	13,915	14,397	13,118	11,312	12,255	12,603	11,860	11,235	10,770
Goats	61	76	179	292	353	470	633	645	647
Horses[1]	370	400	417	433	441	417	410	417	419
Mules and asses[1]	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
laying hens	51,592	45,734	53,078	48,418	56,500	57,656	50,828	50,212	50,314
broilers	38,086	40,542	47,118	41,160	41,393	45,426	44,325	38,160	35,961
turkeys	1,052	1,207	1,544	1,245	1,036	863	566	474	530
other poultry	950	760	839	902	951	816	712	607	453
Other animals	1,340	951	981	1,058	1,261	1,404	770	300	265
Fur-bearing animals	554	463	589	697	962	1023	435	0	0
Rabbits	786	488	392	360	299	381	335	300	265

[1] Including privately held animals
Source: Van Bruggen et al. (2025)

IEFs for NH_3 emissions in sector 3B Manure management were calculated for the main NFR categories (Table 6.4). The NH_3 emission per animal decreased for all animal species (except cattle) due to improved efficiency, low-NH_3 emission housing systems and covering outside manure stores. The IEF of cattle increased due to an increased living area per animal, as well as due to an increase in productivity per animal, and thus in N intake and N excretion. This resulted in a net increase in cattle IEF. Although the living area per animal was also increased for swine and poultry, emission reduction techniques, such as air scrubbers and manure drying, more than counterbalanced the effect of the increased living area. The fluctuating N content of grass silage caused annual changes in the IEF for cattle.

Table 6.4 IEFs for NH_3 from sector 3B Manure management (in kg NH_3/animal)

Animal type	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2022**	**2023**
Cattle	6.8	6.9	5.8	6.5	6.9	7.4	8.8	8.0	8.1
Dairy cattle	11.9	12.0	9.6	11.7	12.0	12.4	14.6	13.5	13.7
Non-dairy cattle	3.7	3.9	3.6	3.4	3.8	4.3	4.4	4.0	4.0
Sheep	0.4	0.4	0.4	0.3	0.1	0.1	0.1	0.1	0.1
Swine	3.5	3.4	2.8	2.4	2.2	1.5	1.1	1.1	1.0
Goats	1.7	1.7	1.5	1.3	1.3	1.4	1.7	1.6	1.7
Horses	4.8	4.8	4.8	4.7	4.4	4.4	5.3	5.3	5.3
Mules and asses	3.6	3.6	3.6	3.5	3.3	3.3	3.7	3.7	3.7
Poultry	0.15	0.16	0.15	0.15	0.14	0.13	0.12	0.13	0.12
Laying hens	0.16	0.17	0.17	0.18	0.17	0.17	0.17	0.17	0.16
Broilers	0.11	0.12	0.10	0.09	0.08	0.06	0.06	0.06	0.06
Turkeys	0.80	0.79	0.80	0.85	0.95	0.95	0.81	0.65	0.68
Other poultry	0.33	0.32	0.29	0.26	0.23	0.19	0.18	0.17	0.16
Other animals	0.40	0.38	0.32	0.28	0.22	0.24	0.24	0.34	0.32
Fur-bearing animals	0.37	0.36	0.29	0.22	0.17	0.19	0.16	NO	NO
Rabbits	0.42	0.39	0.37	0.40	0.36	0.38	0.34	0.34	0.32

Table 6.5 IEFs for NO_x from sector 3B Manure management (in kg NO_x/animal)

Animal type	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2022**	**2023**
Cattle	0.32	0.35	0.33	0.31	0.33	0.38	0.42	0.38	0.39
Dairy cattle	0.46	0.49	0.44	0.46	0.46	0.51	0.56	0.53	0.54
Non-dairy cattle	0.23	0.28	0.27	0.23	0.25	0.30	0.31	0.28	0.29
Sheep	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Swine	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Goats	0.26	0.26	0.23	0.22	0.24	0.25	0.30	0.29	0.29
Horses	0.29	0.29	0.29	0.29	0.26	0.26	0.35	0.35	0.34
Mules and asses	0.15	0.15	0.15	0.15	0.14	0.14	0.17	0.17	0.17
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Laying hens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Broilers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Turkeys	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other animals	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.00	0.01
Fur-bearing animals	0.02	0.02	0.02	0.01	0.01	0.01	0.01	NO	NO
Rabbits	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Particulate matter
Emissions of PM_{10} and $PM_{2.5}$ from agriculture mainly consist of animal skin, manure, feed and bedding particles originating from animal housing. Animal housing produces a large amount of PM_{10} compared to $PM_{2.5}$. The general input data used for these calculations related to animal numbers and housing systems taken from the annual agricultural census and environmental permits. From 2015 onwards, farmers have also implemented additional measures to decrease PM emissions from poultry housing. IEFs for PM_{10} and $PM_{2.5}$ are shown in Table 6.6 and Table 6.7.

Table 6.6 IEFs for PM_{10} from sector 3B Manure management (in g PM_{10}/animal)

Animal type	1990	1995	2000	2005	2010	2015	2020	2022	2023
Cattle	85.4	82.8	78.3	78.7	77.8	80.3	82.2	80.7	81.2
Dairy cattle	114.8	114.8	114.8	119.9	123.7	127.4	125.1	125.0	125.0
Non-dairy cattle	67.3	64.3	56.9	53.7	50.6	50.0	50.0	49.0	49.9
Sheep	4.2	4.2	4.2	3.9	1.8	1.8	1.8	1.8	1.8
Swine	113.3	112.2	112.4	109.9	103.8	77.3	69.3	67.3	65.9
Goats	19.0	19.0	19.0	19.0	19.0	19.0	18.8	18.6	18.6
Horses	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0	220.0
Mules and asses	IE	IE	IE	IE	160.0	160.0	124.1	122.4	121.7
Poultry	21.8	22.9	26.4	32.0	35.2	38.7	35.6	35.5	35.3
Laying hens	14.9	16.1	22.8	33.6	39.3	46.8	43.9	43.0	42.6
Broilers	26.8	26.8	26.8	26.7	26.6	26.3	24.3	23.7	23.4
Turkeys	100.2	98.1	95.1	95.1	95.1	95.1	94.1	94.0	93.5
Other poultry	104.5	104.5	104.5	104.5	104.5	101.8	100.1	101.1	97.1
Other animals	4.2	4.7	5.4	5.8	6.5	6.3	5.1	1.2	1.2
Fur-bearing animals	8.1	8.1	8.1	8.1	8.1	8.1	8.1	NO	NO
Rabbits	1.4	1.4	1.4	1.4	1.4	1.4	1.2	1.2	1.2

Table 6.7 IEFs for $PM_{2.5}$ from sector 3B Manure management (in g $PM_{2.5}$/animal)

Animal type	1990	1995	2000	2005	2010	2015	2020	2022	2023
Cattle	23.5	22.8	21.6	21.7	21.4	22.1	22.6	22.2	22.4
Dairy cattle	31.7	31.7	31.7	33.1	34.1	35.1	34.5	34.5	34.5
Non-dairy cattle	18.5	17.7	15.7	14.8	13.9	13.8	13.8	13.5	13.7
Sheep	1.2	1.2	1.2	1.2	0.5	0.5	0.5	0.5	0.5
Swine	5.8	5.7	5.7	5.4	5.1	3.7	3.3	3.1	3.1
Goats	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.6	5.6
Horses	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0
Mules and asses	IE	IE	IE	IE	100.0	100.0	77.6	76.5	76.0
Poultry	2.2	2.4	2.5	2.7	2.7	2.8	2.5	2.5	2.5
Laying hens	1.4	1.5	1.7	2.1	2.5	2.9	2.7	2.6	2.6
Broilers	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.8	1.8
Turkeys	47.0	46.0	44.6	44.6	44.6	44.6	44.1	44.1	43.8
Other poultry	5.0	5.0	5.0	5.0	5.0	4.9	4.8	4.8	4.6
Other animals	1.9	2.2	2.6	2.9	3.3	3.1	2.5	0.2	0.2
Fur-bearing animals	4.2	4.2	4.2	4.2	4.2	4.2	4.2	NO	NO
Rabbits	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2

NMVOC
The NMVOC emissions reported under Manure management include emissions from manure in animal housing, manure in outside stores and silage feed in animal housing. Most NMVOC emissions occur during the feeding of silage. The increase in IEF that can be seen with cattle is caused by increased feeding of silage (Table 6.8). NMVOC is also released from the storage of manure in animal housing and outside manure storage. All NMVOC emissions were calculated at a Tier 2 level on the basis of default EFs from the 2016 EMEP Guidebook (EEA, 2016), using the NEMA model. The activity data used for these calculations related to animal numbers and feeding data as reported by the WUM (CBS, 2024).

Table 6.8 IEFs for NMVOC from 3B Manure management (in kg NMVOC/animal)

Animal type	1990	1995	2000	2005	2010	2015	2020	2022	2023
Cattle	5.98	6.17	7.96	8.41	12.14	13.28	14.54	14.52	14.52
Dairy cattle	8.15	7.96	15.07	16.92	24.13	25.67	27.38	27.73	27.96
Non-dairy cattle	4.64	5.14	3.78	3.24	5.05	5.28	4.93	5.08	4.94
Sheep	0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.02	0.02
Swine	0.42	0.39	0.35	0.32	0.29	0.27	0.28	0.23	0.23
Goats	0.86	0.79	0.42	0.82	0.87	0.86	0.97	0.98	0.48
Horses	0.61	0.61	0.61	0.59	0.59	0.59	0.59	0.59	0.59
Mules and asses	0.26	0.26	0.26	0.25	0.25	0.25	0.25	0.25	0.25
Poultry	0.06	0.07	0.07	0.07	0.06	0.07	0.07	0.06	0.07
Laying hens	0.05	0.06	0.05	0.05	0.06	0.06	0.06	0.06	0.06
Broilers	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
Turkeys	0.08	0.08	0.08	0.07	0.07	0.07	0.12	0.13	0.14
Other poultry	0.03	0.04	0.04	0.04	0.04	0.03	0.07	0.07	0.08
Other animals	0.14	0.17	0.21	0.23	0.26	0.25	0.19	0.01	0.01
Fur-bearing animals	0.34	0.34	0.34	0.34	0.34	0.34	0.34	NO	NO
Rabbits	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

6.2.5 *Uncertainties and time series consistency*
A propagation of error analysis on NH_3 emissions was performed in 2022. Using reassessed uncertainty estimates of activity data and the judgement of experts (Van der Zee et al., 2025), an uncertainty of 21% in total NH_3 emissions from sector 3B Manure management was calculated. Including the emissions in sector 3D Crop production and agricultural soils, the combined uncertainty in NH_3 emissions from the Agriculture sector was 23%. A Monte Carlo analysis of uncertainties of the total inventory (including sectors outside of agriculture) was performed in 2024 and the results are presented in Section 1.5.

When available, the same information sources were used throughout the time series. The agricultural census was the most important information source. This census has been conducted in the same way for decades. The same methodology for emission calculations was used throughout the time series, ensuring the consistency of the emission calculations.

6.2.6 *Source-specific QA/QC and verification*

This source category is covered in Chapter 1, under general QA/QC procedures. QA/QC measures taken for the sector Agriculture are described in the methodology report (Van der Zee et al*.,* 2025).

6.2.7 *Source-specific recalculations*

Three recalculations have been implemented for the Manure management sector.

- The first recalculation concerns the emissions from manure storage and treatment. 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 on the basis of 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 to the calculated values shows that the transport certificates are reliable (further details can be found in Van Bruggen et al. (2025)). The total effect of the recalculation on NH_3 emissions from 3B varies between -0.02% and +0.15%. The total effect of the recalculation on NO_x emissions from 3B varies between -0.57% and +0.34%.
- The second recalculation is caused by the first recalculation affecting NH_3 emission from storage. NMVOC emissions from manure storage are partly based on the ratio of NH_3 emissions from housing and storage. As the ratio is changed, NMVOC emissions from manure storage change by between -0.08% and +0.04% for the 2015–2022 period.
- The third recalculation is caused by updating the number of calves born per dairy cow in 2022. The preliminary number was lower than the ultimate number of calves born. Therefore, the VS intake and excretion of dairy cows increases, thus resulting in a higher NMVOC emission (+0.02%).

6.2.8 *Source-specific planned improvements*

The nutrients that bedding material incorporate into the manure and the corresponding emissions have been estimated taking only straw into account. In the Netherlands, various types of bedding material are used, such as straw, wood shavings, but also the dry fraction of separated manure. The Tier 1 method does not account for the latter type of bedding material, and it is expected that the emissions from this type of bedding material are higher than from straw and wood shavings. The agricultural census will include a question on the use of bedding material, thus enabling the calculation of emissions from the various types of bedding material for the IIR of 2026.

6.3 Crop production and agricultural soils (3D)

6.3.1 Source category description

The category Crop production and agricultural soils (3D) includes emissions relating to the agricultural use of land. Emissions were allocated to the following NFR subcategories:

- 3Da1 Inorganic N fertilisers;
- 3Da2a Animal manure applied to soils;
- 3Da2b Sewage sludge applied to soils;
- 3Da2c Other organic fertilisers applied to soils;
- 3Da3 Urine and dung deposited by grazing animals;
- 3Da4 Crop residues applied to soils;
- 3Db Indirect emissions from managed soils;
- 3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products;
- 3Dd Off-farm storage, handling and transport of bulk agricultural products;
- 3De Cultivated crops;
- 3Df Use of pesticides.

Category 3Dc contains PM emissions from the use of inorganic N fertilisers and pesticides, the supply of concentrate feed to farms, haymaking and crop harvesting. NMVOC emissions from silage storage are also reported under 3Dc. NMVOC emissions are allocated to the categories 3Da2a, 3Da3, 3Dc 3De and 3Df. Zinc and HCB emissions are allocated to category 3Df.

6.3.2 Key sources

Approach1

Within sector 3D, Animal manure applied to soils (3Da2a) was the largest key source of NH_3 emissions, amounting to 28% of the national total. Inorganic N fertilisers (3Da1) were also a key source of NH_3, making up 8% of the national total. For NO_x, animal manure applied to soils (3Da2a, 8%) and inorganic N fertilisers (3Da1, 5%) were key sources. For NMVOC emissions, Farm-level agricultural operations including storage, handling and transport of agricultural products (3Dc, 5%) and Animal manure applied to soils (3Da2a, 4%) were key sources. For emissions of PM_{10}, Cultivated crops (3De, 3%) is the only key source from the crop production sector. For $PM_{2.5}$, the crop production and agricultural soils sector contained no key sources. HCB emissions from the use of pesticides (3Df) were not a key source.

Approach 2

The approach 2 key sector analysis is only performed at the level of GNRF sectors for the pollutants NO_x, NMVOC, SO_x, NH_3, PM_{10} and $PM_{2.5}$. From this analysis, the GNFR sector AgriOther is a:

- 2023 level key source of NO_x, NH_3, PM_{10} and NMVOC;
- 1990–2023 trend key source of NO_x and PM_{10}.

6.3.3 Overview of shares and trends in emissions

Table 6.9 presents an overview of emissions of the main pollutants NH_3, NMVOC and NO_x, together with the particulate matter fractions PM_{10} and $PM_{2.5}$, the other heavy metal, Zn, and the persistent organic pollutant HCB, originating from sector 3D Crop production and agricultural soils (3D).

Table 6.9 Emissions of main pollutants and particulate matter from the category of Crop production and agricultural soils (3D)

	Main Pollutants			Particulate Matter			POPs	Heavy Metals
	NO_x	NMVOC	NH_3	$PM_{2.5}$	PM_{10}	TSP	HCB	Zn
Year	Gg	Gg	Gg	Gg	Gg	Gg	kg	Mg
1990	**47.1**	**55.8**	**236.9**	**0.1**	**1.2**	**1.2**	**21.1**	**0.0**
1995	45.5	24.7	110.4	0.1	1.1	1.1	39.3	0.0
2000	38.4	26.1	83.6	0.1	1.2	1.2	15.6	0.0
2005	32.7	23.5	72.5	0.1	1.2	1.2	1.8	6.8
2010	29.6	21.4	51.7	0.1	1.2	1.2	1.1	4.5
2015	31.0	23.2	53.4	0.1	1.1	1.1	0.7	4.4
2020	30.2	22.8	51.9	0.1	1.0	1.0	0.1	4.4
2022	28.5	23.1	51.7	0.1	1.1	1.1	0.0	2.2
2023	**28.5**	**22.2**	**49.4**	**0.1**	**1.1**	**1.1**	**0.0**	**2.2**
1990-2023 period1)	-19.0	-34.0	-188.0	0.0	-0.1	-0.1	-21.0	2.2
1990-2023 period2)	-39%	-60%	-79%	-5%	-8%	-8%	-100%	

1. Absolute difference in Gg, except for HCB (kg) and Zn (Mg)
2. Relative difference from 1990 in %

N emissions
Emissions of NH_3 from crop production and agricultural soils decreased by 79% between 1990 and 2023, with an initial sharp fall between 1990 and 1995. This was mainly the result of changed manure application methods, which were enforced during this period (i.e. incorporation of manure into the soil instead of surface spreading). The use of inorganic N fertiliser also decreased during the time series, following policies aimed at reducing the nutrient supply to soils (i.e. implementation of the EU Nitrates Directive).

NO_x emissions decreased by 39% between 1990 and 2023, mainly because of lower N input through the use of inorganic N fertiliser and reductions in grazing time and manure application.

Particulate matter
The particulate matter emissions reported in this source category originate from the use of inorganic N fertiliser and pesticides, the supply of concentrate feed to farms, haymaking and crop harvesting. The decreasing trend in PM emissions is entirely explained by fluctuations in the acreage of crops.

NMVOC
NMVOC emissions from crop production and agricultural soils show a 60% decrease between 1990 and 2023, as a result of changing manure application methods to reduce emissions of ammonia between 1990 and 1995. The increase in emissions from farm-level agricultural operations was caused by an increase in silage feeding, and thus silage storage.

Zinc
Zinc emissions decreased by 67% from 2005 to 2023, due to a reduction in pesticide use. Before 2005, there were no zinc emissions relating to the pesticides used.

HCB
From 1990 to 2023, HCB emissions decreased by 100%, due to a reduction in pesticide use, more stringent requirements for the allowed HCB impurity in pesticides and a ban on some pesticides containing HCB impurities.

6.3.4 *Activity data, (implied) emission factors and methodological issues*

N emissions
For N emission calculations in sector 3D, activity data was calculated from N excretion including bedding material in sector 3B minus N emissions from animal housing, manure treatment and outside storage (Figure 6.2). After subtracting the N in manure removed from agriculture (exported, incinerated or otherwise used outside of agriculture), the remaining N was allocated to grassland and arable land. Implementation percentages of application techniques were derived from the agricultural census. The associated NH_3 EFs were reported in Van der Zee et al. (2025). NO_x emissions relating to manure, inorganic N fertiliser and sewage sludge application, compost use and the grazing of animals were calculated using the EMEP default EF.

NH_3 emissions from the use of inorganic N fertilisers were calculated using data on the amount of inorganic N fertiliser used in agriculture. Several types of inorganic N fertiliser were distinguished – each with a specific NH_3 EF. In recent years, the amount of applied urea fertiliser has increased, and a growing share is used in liquid form or coated with urease inhibitors to reduce NH_3 emissions and/or is applied with NH_3 low-emission techniques. To account for this development, additional subcategories of urea fertiliser were specified for the 1990–2023 time series, as described in the methodology report by Van der Zee et al. (2025). The subcategories and the EFs for each subcategory can be found in Van Bruggen et al. (2025).

Calculations of NH_3 emissions from crop residues were based on activity data taken from the agricultural census. Given the large uncertainty in the emissions from crop ripening, a fixed estimate of 1.8 Gg NH_3/year was reported (De Ruijter et al., 2013).

IEFs for sector 3D in kg NH_3/kg N supply were calculated for the NFR categories, as depicted in Table 6.10. IEFs for animal manure and sewage sludge application dropped considerably between 1990 and 1995 due to mandatory incorporation into the soil. The reduction in emissions from urine and dung deposited by grazing animals was mainly explained by a reduction in cattle grazing.

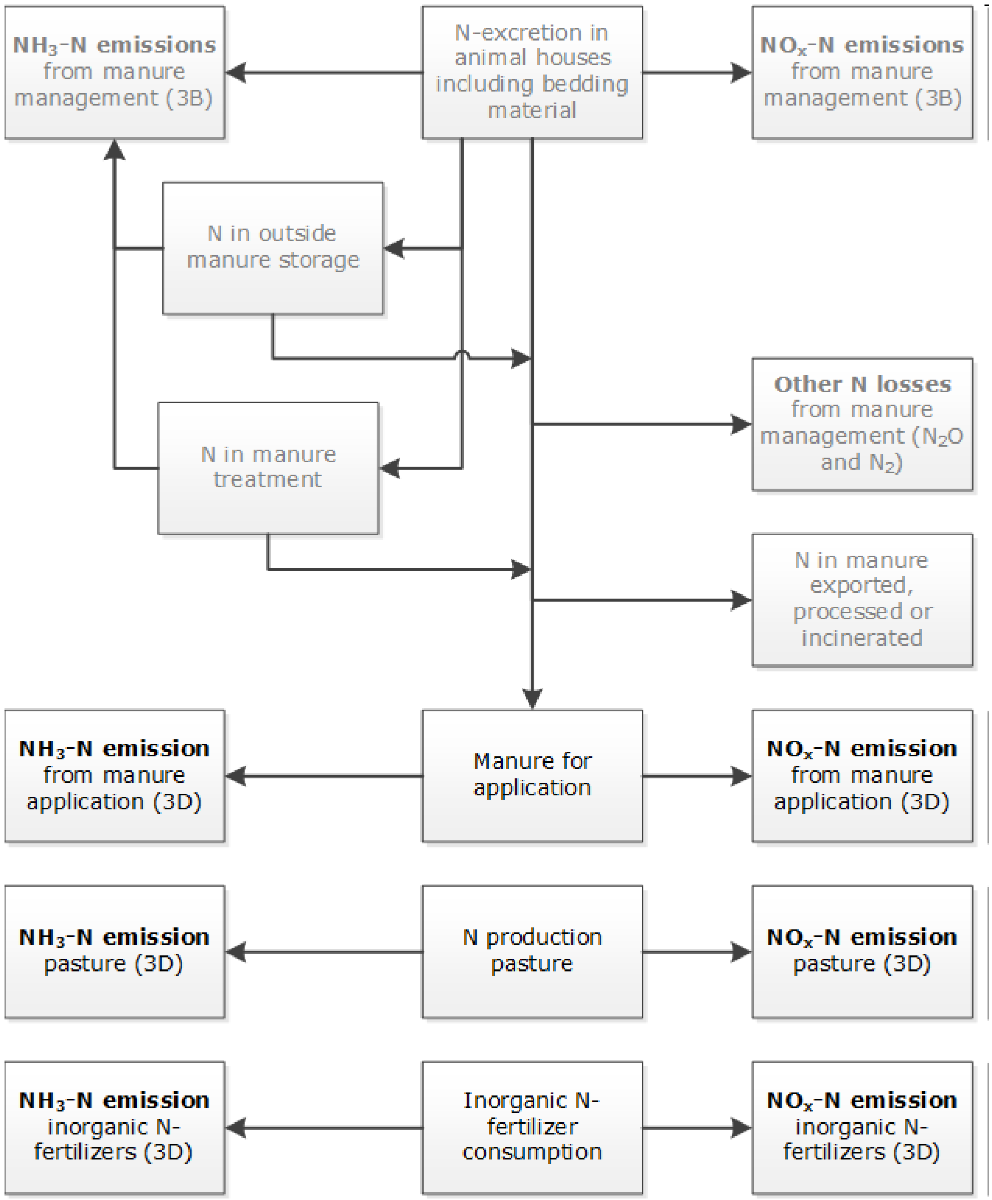


Figure 6.2 Nitrogen flows in relation to NH3 and NOx emissions, where boxes with black type show the emissions included in 3D Crop production and agricultural soils and boxes with grey type show emissions included in 3B Manure management

Table 6.10 IEFs for NH_3 from 3D Crop production and agricultural soils (in kg NH_3/kg N supply)

Supply source	1990	1995	2000	2005	2010	2015	2020	2022	2023
Application of inorganic N fertilisers	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Application of animal manure	0.49	0.19	0.18	0.17	0.12	0.11	0.10	0.11	0.10
Application of sewage sludge	0.29	0.08	0.09	0.10	0.10	0.10	0.10	0.10	0.09
Application of other organic fertilisers (compost)	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Urine and dung deposited by grazing animals	0.08	0.08	0.04	0.03	0.03	0.03	0.03	0.03	0.03
Crop residues	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Crop ripening	NA	NA	NA	NA	NA	NA	NA	NA	NA

Particulate matter
Small sources of PM_{10} and $PM_{2.5}$ emissions reported under category 3D were the application of inorganic N fertilisers and pesticides, the supply of concentrate feed to farms, and haymaking. To calculate PM emissions, both EMEP default and country specific EFs were applied (Van der Zee et al., 2025). PM emissions from other agricultural processes (e.g. the supply of concentrate feed to farms, the use of pesticides and haymaking) were estimated using fixed factors (Van der Zee et al., 2024). Crop harvesting was calculated from agricultural census acreage data and EMEP default EFs (EEA, 2019).

NMVOC
The NMVOC emissions reported under category 3D were from animal manure applied to soils, urine and dung deposited by grazing animals, farm-level agricultural operations including storage, handling and transport of agricultural products, cultivated crops and use of pesticides. All were calculated on the basis of EMEP default EFs, using a Tier 2 method. Only the emissions from cultivated crops were calculated using a Tier 1 method. The emissions from the use of pesticides were calculated using a Tier 3 method.

NMVOC emissions from the use of pesticides originate from the use of mineral oil, metaldehyde and formic acid. Usage of and emissions from these pesticides were calculated by the National Environmental Indicator Pesticides (NMI4) (Kruijne et al., 2022). Subsequently, it is assumed that 20% of the mineral oil emissions are NMVOC and 100% of the metaldehyde and formic acid emissions are NMVOC.

Zinc
Zinc emissions were based on the amount of pesticides used in agriculture as calculated by the National Environmental Indicator Pesticides (NMI4) model (Kruijne et al., 2022).

HCB

Hexachlorobenzene has been prohibited for use as a pesticide for the entire time series. However, HCB can still be found in certain pesticides as an impurity. The sales figures of the pesticides containing HCB are presented in Table 6.11. The impurity factor was based on the maximum amount that is allowed (EMEP, 2019).

Table 6.11 Sales figures of pesticides containing HCB impurities in 1,000 kg active substance

	Sales figures of pesticides containing HCB impurities in 1,000 kg active substance				
Year	**Lindane**	**Atrazine**	**Simazine**	**Chloro-thalonil**	**Clopyra-lid**
1990	19.5	172.3	60.5	62.3	0.0
1991	20.6	189.1	63.0	67.6	0.0
1992	25.9	201.5	52.7	80.9	0.0
1993	25.0	205.3	52.9	93.9	0.0
1994	19.6	221.5	50.4	102.4	0.0
1995	19.3	218.4	50.7	126.7	2.9
1996	21.3	209.3	48.5	101.2	1.9
1997	22.5	183.7	48.1	209.0	1.5
1998	22.9	154.6	52.1	420.8	2.4
1999	44.3	134.6	71.4	323.1	2.2
2000	0.0	0.0	30.2	388.5	4.8
2001	0.0	0.0	19.8	81.5	3.3
2002	0.0	0.0	0.0	539.2	3.3
2003	0.0	0.0	1.2	102.7	2.1
2004	0.0	0.0	0.0	159.5	2.2
2005	0.0	0.0	0.0	179.6	2.3
2006	0.0	0.0	0.0	164.6	1.8
2007	0.0	0.0	0.0	206.4	2.2
2008	0.0	0.0	0.0	153.6	1.8
2009	0.0	0.0	0.0	105.3	1.2
2010	0.0	0.0	0.0	106.2	1.6
2011	0.0	0.0	0.0	113.9	1.8
2012	0.0	0.0	0.0	104.6	1.6
2013	0.0	0.0	0.0	90.2	2.3
2014	0.0	0.0	0.0	77.1	4.6
2015	0.0	0.0	0.0	73.4	6.2
2016	0.0	0.0	0.0	82.2	5.8
2017	0.0	0.0	0.0	68.0	18.7
2018	0.0	0.0	0.0	63.9	18.1
2019	0.0	0.0	0.0	43.6	19.9
2020	0.0	0.0	0.0	9.5	18.1
2021	0.0	0.0	0.0	0.0	13.3
2022	0.0	0.0	0.0	0.0	19.0
2023[1]	0.0	0.0	0.0	0.0	19.0

1. Sales figures from 2022 were used as preliminary figures for 2023

6.3.5 *Uncertainties and time series consistency*

A propagation of error analysis of NH_3 emissions was performed in 2022. Using reassessed uncertainty estimates of activity data and expert judgement, an uncertainty of 31% was calculated for NH_3 emissions from animal manure application, 36% for inorganic N fertiliser use and 48% for grazing emissions. The total uncertainty in the ammonia emissions from sector 3D Crop production and agricultural soils then amounts to 25%. Including the emissions in sector 3B Manure management, the combined uncertainty in total NH_3 emissions from agriculture amounts to 23%. A Monte Carlo analysis on the uncertainties of the total inventory was performed in 2024 and the results are presented in Section 1.5.
When available, the same information sources were used throughout the time series. The agricultural census was the most important information source. This census has been conducted in the same way for decades. The same methodology for emission calculations was used throughout the time series, ensuring consistency of the emission calculations.
A propagation of error analysis of HCB emissions was performed in 2021. The EMEP Guidebook estimates the uncertainty of the emission factor to range between 15 and 30%. For the calculations, the HCB contamination was set at the maximum allowed under the regulations, while producers have an incentive to ensure their products remain below the threshold. Therefore, the uncertainty was set at 30%.

The amount of pesticides sold was derived from the confidential 'RAG list' (Regeling administratievoorschriften gewasbeschermingsmiddelen) for the 1990–2009 period. For the 2010–2022 period, the data was provided by the Dutch Food and Consumer Safety Authority; this data is publicly available. For 2023, the value of 2022 was used, as no new value had been provided in time (NVWA, 2024). Both sources provide the same information: the quantity of pesticides sold in kg active substance. Both sources used sales figures submitted by companies selling pesticides. No time series inconsistency is caused by the two sources.

6.3.6 *Source-specific QA/QC and verification*

This source category is covered in Chapter 1 under general QA/QC procedures. QA/QC measures taken for the sector Agriculture are described in section 2.5 of the methodology report (Van der Zee et al., 2025).

6.3.7 *Source-specific recalculations*

Four recalculations have been implemented for the sector Crop production and agricultural soils.

- The first recalculation concerns the emissions from manure application. The Initiator model has been rerun for the years 2000–2022. The Initiator model now takes the N from bedding material into account, which slightly changes the manure distribution across the various soil types. The amount of manure available for application also changes for the 2010–2020 period, due to the recalculation concerning manure transport and treatment (see Section 6.2.7). The NH_3 emissions from manure application change by between -4% and +0.1%. The NO_x

emissions from manure application change by between -0.8% and +0.7%.
- The second recalculation concerns the NMVOC emissions from manure application. The NMVOC emissions from manure application depend on the ratio of NH_3 emitted from housing and from manure application. As the emissions from application have been recalculated, the NMVOC emissions from manure application change as well. The changes range between -8.9% and +0.1%.
- Emissions from grassland renewal were recalculated for the 2006–2022 period. 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. NO_x emissions from grassland renewal increased by between 1% and 6%. NO_x 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 1990–2005 period did not have to change as it did not include natural grasslands. The NH_3 emissions from crop residues were affected by this change as well. Emissions increased by between 0% and 0.1%.
- The area with organic soils in the Netherlands has been recalculated for the entire time series. This causes NO_x emissions to change by between -0.04% and +0.3%. Further information on the calculation of the area of organic soils can be found in Van Baren et al. (2025).

6.3.8 Source-specific planned improvements
The IIR 2026 will include the sales figures of pesticides in 2023 instead of using sales figures from 2022 as a proxy.

7 Waste

7.1 Overview of the sector

Waste sector emissions (Table 7.1) include emissions from industrial activities. The waste sector (NFR 5) consists of the following source categories:

- 5A Solid waste disposal on land;
- 5B Anaerobic digestion and composting;
- 5C Waste incineration;
- 5D Wastewater handling;
- 5E Other waste.

7.1.1 Solid waste disposal on land (5A)

Emissions in this source category comprise those from landfills and those from recovered and flared landfill gas. Part of the recovered landfill gas is used for energy purposes, and these emissions are allocated to the Energy sector (source category Other: Stationary (1A1a)). If landfill gas is only flared off, the emissions are allocated to 5A.

Mineral waste may be disposed of in landfills, recycled or recovered as backfill material, depending on its composition and origin. Landfilling of mineral waste is more likely for inert materials, or for disposal of waste after primary, such as chemical, treatment. In all cases, mineral waste treatment implies multiple handling activities, such as unloading/loading activities. Emissions of particulate matter occur during mineral waste handling activities.

7.1.2 Composting and anaerobic digestion (5B)

Emissions in this source category comprise those from facilities for the composting and/or fermenting of manure and from separately collected organic waste for composting and/or biogas production (sometimes also used as co-substrate in manure digestion).

During processing, emissions of NH_3, SO_x and NO_x occur that are relevant to the total national emission. The biogas produced is used for energy purposes, so these emissions are allocated to the Energy sector (source category Small combustion (1A4)).

7.1.3 Waste incineration (5C)

Emissions in this source category are emissions from municipal, industrial, hazardous and clinical waste incineration, from the incineration of sewage sludge and from crematoria. Since all waste incineration plants in the Netherlands produce electricity and/or heat that is used for energy purposes, emissions from these source categories are explained and included in the Energy sector (source category Public electricity and heat production (1A1a)).

NO_x and SO_x emissions from crematoria (category 5C1bv) originate mainly from fuel use (natural gas). Therefore, these emissions are included in the source category Commercial/Institutional: Stationary (1A4ai).

7.1.4 *Wastewater handling (5D)*

In the Netherlands, all wastewater is treated in municipal wastewater treatment plants (5D1) or in industrial treatment plants (5D2), both in a biological process. During the water treatment, small amounts of NMVOC are emitted.
The produced sludge is often used for methane production in an anaerobic digester and dried afterwards for transport to a sludge processor where the sludge is usually incinerated.

Natural gas, on-site produced biogas from anaerobic sludge digestion and very small amounts of domestic fuel oil are used in the sludge drying installations. The emissions from incineration of fuels are reported under Commercial/Institutional: Stationary (1A4ai).

In pursuit of waste minimisation and circular use of raw materials, WWTP operators and sludge processors are working on new ways of treating the wastewater and processing the produced sludge (for instance producing Kaumera Nereda® gum, alginates, cellulose, struvite, etcetera). Developments relating to emissions from these new processes are closely monitored.

7.1.5 *Other waste (5E)*

Emissions in the source category Other waste (5E) comprise emissions from waste preparation for recycling, scrapped fridges/freezers and accidental building and car fires.

7.1.6 *Key sources*

Approach 1
The source category Other waste (5E) is a:
- 2023 level key source of PM_{10}, $PM_{2.5}$, BC, Cd, dioxins and total PAH;
- No key source for trend and level 1990.

All sources in this NFR category are calculated with a CS methodology.

Approach 2
The Approach 2 key source analysis is only performed at the level of GNRF sectors for the pollutants NO_x, NMVOC, SO_x, NH_3, PM_{10} and $PM_{2.5}$. From this analysis, the GNFR sector Waste is a 1990–2023 trend key source of SO_x, NH_3, PM_{10} and $PM_{2.5}$.

7.2 Overview of shares and trends in emissions

An overview of the trends in emissions is presented in Table 7.1. Emissions from the waste sector are low compared to national total emissions (*cf.* Tables 2.1, 2.2 and 2.3). This is mainly so because most emissions from incineration are reported under the Energy sector.

With the exception of NMVOC, emissions of the main pollutants have increased since 1990. This increase has been caused by gradually increased activity. The increase is sometimes dampened by the implementation of abatement technologies for some sources.

With the exception of dioxins (from building fires) and PAHs (from building and car fires), the emissions of all pollutants are low compared to national total emissions (*cf*. Tables 2.1, 2.2 and 2.3).

Table 7.1 Overview of emission totals in the Waste sector (NFR 5)

Year	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**0.15**	**2.4**	**0.03**	**0.2**	**0.48**	**0.52**	**0.5**	**0.11**	**7.2**
1995	0.19	2.3	0.05	1.1	0.51	0.56	0.6	0.12	8.6
2000	0.19	2.1	0.04	1.3	0.52	0.56	0.6	0.12	8.7
2005	0.18	1.7	0.03	1.3	0.50	0.54	0.6	0.11	8.1
2010	0.22	1.7	0.04	1.3	0.56	0.61	0.6	0.13	8.8
2015	0.30	1.5	0.04	1.2	0.55	0.60	0.6	0.13	8.5
2020	0.28	1.3	0.04	1.4	0.44	0.48	0.5	0.11	7.8
2022	0.30	1.3	0.04	1.3	0.50	0.55	0.6	0.12	8.5
2023	**0.43**	**1.3**	**0.06**	**1.4**	**0.51**	**0.56**	**0.6**	**0.13**	**8.5**
1990-2023 period1)	0.28	-1.1	0.03	1.2	0.03	0.04	0.07	0.02	1.3
1990-2023 period2)	184%	-44%	128%	806%	7%	8%	12%	16%	18%

Table 7.1 Overview of emission totals in the Waste sector (NFR 5) (continued)

Year	Priority Heavy Metals			POPs		Other Heavy Metals					
	Pb	Cd	Hg	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	**0.05**	**0.02**	**0.09**	**13**	**0.79**	**0.02**	**0.03**	**0.01**	**0.00**	**0.00**	**1.1**
1995	0.05	0.02	0.10	14	0.83	0.02	0.04	0.02	0.00	0.00	1.5
2000	0.05	0.02	0.10	14	0.85	0.02	0.04	0.02	0.00	0.00	1.2
2005	0.05	0.02	0.09	14	0.83	0.02	0.04	0.02	0.00	0.00	1.1
2010	0.06	0.03	0.f04	16	0.93	0.02	0.04	0.02	0.00	0.00	1.3
2015	0.05	0.03	0.01	16	0.92	0.02	0.04	0.02	0.00	0.00	1.3
2020	0.05	0.02	0.01	16	0.60	0.00	0.04	0.01	0.00	0.00	0.9
2022	0.05	0.02	0.01	16	0.82	0.01	0.04	0.01	0.00	0.00	1.2
2023	**0.05**	**0.03**	**0.01**	**17**	**0.84**	**0.01**	**0.04**	**0.01**	**0.00**	**0.00**	**1.2**
1990-2023 period1)	0.01	0.00	-0.08	3.7	0.05	0.00	0.01	0.00	0.00	0.00	0.09
1990-2023 period2)	15%	17%	-89%	28%	6%	-22%	22%	4%	6%	-19%	8%

1. Absolute difference
2. Relative difference from 1990 in %

7.2.1 *Methodological issues*

The methodology used to calculate most of the emissions from the source categories in the Waste sector is described by Honig et al. (2025). The exceptions are emissions from cremations, accidental building and car fires, and from bonfires, the methodologies of which are explained in Visschedijk et al. (2025), and from the source Livestock manure digestion, which is explained in Van der Zee et al. (2025).

There are no specific methodological issues.

7.2.2 *Uncertainties and time series consistency*

As explained in Section 1.6.3, the Netherlands implemented an Approach 2 methodology for uncertainty analysis in 2018. This methodology is used for uncertainty analysis of the pollutants NH_3, NO_x, SO_x and PM. Table 7.2 provides an overview of the results for the Approach 2 uncertainties at NFR source category level.

Table 7.2 Overview of the Approach 2 uncertainties for Waste NFR source categories

	Pollutants uncertainty					
NFR source category	**NH_3**	**NO_x**	**SO_x**	**NMVOC**	**PM_{10}**	**$PM_{2.5}$**
5A	NA	101%	101%	94%	71%	86%
5B	75%	102%	102%	NA	NA	NA
5C	347%	114%	116%	126%	345%	346%
5D	NA	NA	NA	126%	NA	NA
5E	202%	85%	113%	192%	192%	196%
Total Waste sector	**70%**	**69%**	**73%**	**154%**	**170%**	**175%**

The Approach 2 uncertainty analysis shows relatively high uncertainties at the level of the source categories. However, since these source categories either have no key sources for these pollutants or their contribution to the uncertainty at national level will be relatively small, there is no reason for prioritising methodological improvements.

7.2.3 *Source-specific QA/QC and verification*

There are no source-specific QA/QC procedures. The categories in this sector are covered by the general QA/QC procedures, as discussed in Chapter 1.

7.2.4 *Source-specific recalculations*

The source category 5A has been recalculated for the years 2021 and 2022 as new activity data has become available.

The source category 5B has been recalculated as the amount of digested manure has been re-estimated. Some manure digesters were found to have been in operation earlier in the year than previously assumed in the 2018–2022 period. The recalculation causes the NH_3 emissions from manure digestion to increase by between 5% and 21%.

NMVOC emissions from industrial wastewater treatment are recalculated for the time series 2016–2022 on the basis of activity data provided voluntarily by individual industrial companies in their AERs (Honig et al., 2025).

7.2.5 *Source-specific planned improvements*

In 2024, a model was created to calculate propellant emissions (CFCs) from insulation panels in the waste phase. CFCs are part of the reported

NMVOC emissions. In 2025, the model will be validated with information from literature (plausibility checks of emission factors) and checked for double counting with CFC emission sources, such as the production and use phase of the panels.

7.3 Solid waste disposal on land (5A)

7.3.1 Source category description

The source category Solid waste disposal on land (5A) comprises direct emissions from landfills and from recovered and flared landfill gas and PM emissions from the landfilling process.

This source category includes all waste landfill sites in the Netherlands that have been managed and monitored since 1945, i.e. both historical and current public landfills, and waste landfill sites on private land. These waste sites are considered to be responsible for most of the emissions in this source category. Emissions from landfill sites before 1945 are regarded as negligible (Van Amstel et al., 1993).

The total amount of landfill gas produced in the Netherlands is calculated using a first-order degradation model that calculates the degradation of degradable organic carbon (DOC) in waste (Table 7.3). From this information, the amount of methane is calculated using a methane conversion factor (Table 7.4).

It is assumed that 10% of the non-recovered methane will be oxidised in the top layer of the landfill.

Table 7.3 Amounts of waste landfilled and degradable organic carbon content

Year	Amount landfilled (Tg)	Degradable organic carbon (kg/Mg)	Degradable organic carbon that dissimilates (%)
1990	13.9	131	58
1995	8.2	125	58
2000	4.8	110	58
2005	3.5	62	41
2010	2.1	33	34
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

The amounts of recovered and combusted landfill gas (mainly for energy purposes) is collected by the Working Group on Waste Registration (WAR). All landfill operators report this data to WAR (Table 7.6).

Part of the recovered landfill gas is used as an energy source (combined heat and power production or transferred to the natural gas network); emissions from this source are reported under 1A1a. The remainder of the recovered landfill gas is flared and the emissions from flaring are reported under sector 5A.
Flaring of landfill gas also emits small amounts of NMVOC to the atmosphere. The individual compounds that form NMVOCs mainly originate from volatile organic compounds that were dumped as waste in the past. A small part is produced as a by-product during the biodegradation of organic materials within the waste. Direct NMVOC emissions from landfills are calculated on the basis of individual pollutants in the landfill gas.

Table 7.4 Input parameters used in the landfill degradation model

Parameter	Parameter values	References
Oxidation factor (OX)	0.1 (10%)	Coops et al. (1995)
DOC_f = fraction of degradable organic carbon	0.58 from 1945 to 2004; from 2005 onwards, annually determined on the basis of the composition of waste disposed. This is an elaboration of the refinement points from the 2019 IPCC refinements	Oonk et al. (1994)
Degradable speed constant k	0.094 from 1945 to 1989 (half-life 7.5 yrs); from 1990 reducing to 0.0693 in 1995; thereafter constant at 0.0693 (half-life 10 yrs); from 2000 reducing to 0.05 in 2005; thereafter constant at 0.05 (half-life 14 yrs)	Oonk et al. (1994)
$DOC_{(X)}$ = concentration of biodegradable carbon in waste that was dumped in year x	132 kg C/Mg dumped waste from 1945 to 1989; from 1990 through a linear gradient reducing to 125 kg C/Mg in 1995; 120 kg/Mg in 1996 and 1997, and after 1997 determined annually by Rijkswaterstaat	Based on De Jager & Blok (1993) determined by Spakman et al. (1997) and published in Klein Goldewijk et al. (2004)
F = fraction of CH_4 in landfill gas	0.574 from 1945 to 2004; thereafter constant at 0.5	Oonk (2016)
$MCF_{(x)}$ = Methane correction factor for management	1	
Delay time	6 months	

7.3.2 *Overview of shares and trends in emissions*

NMVOC emission levels relating to this source category are relatively low, at 1.48 Gg and 0.22 Gg in 1990 and 2023, respectively.

$PM_{2.5}$ emissions are also relatively low, at 0.0039 Gg and 0.0052 Gg in 1990 and 2023, respectively.

The landfilling of waste, particularly of combustible waste products and biodegradable material, is discouraged in the Netherlands. For this reason, the amount of waste landfilled has dropped considerably (see Table 7.3), from 13.9 Tg in 1990 to only 2.2 Tg in 2023 (-84%). Moreover, due to the separation of degradable materials, the amount of degradable carbon in the waste has dropped from 131 kg C per Mg waste in 1990, to 37 kg C per Mg in 2023 (-71%). Additionally, the separated collection of household organic waste led to a decrease in the fraction of organic carbon that dissimilates from 58% in 1990 to 30% in 2023. These two developments have had a clear effect on methane (and also NMVOC) production by landfill sites, which has decreased over 80% during the same period. This downward trend is expected to continue in future.

7.3.3 Emissions, activity data and (implied) emission factors

Emissions of the individual compounds of NMVOC have been calculated as fractions of the emission total, using a landfill gas emission model for methane that is based on the IPCC Guidelines. The fractions were based on measurements of the composition of landfill gas. An overview of the EFs used is provided in Table 7.5.

Table 7.7 provides the emission factors used for the combustion of recovered landfill gas.

For each waste site, landfill site operators systematically monitor the amount of waste that is dumped (weight and composition). Since 1993, monitoring has been conducted by weighing the amount of dumped waste using weighbridges. Since 2005, landfill operators have been obliged to register their waste on the basis of European Waste List (EWL) codes (Decision 2000/532/EC). Table 7.8 represents the EFs used for calculating the PM emissions during treatment of mineral waste.

Table 7.5 Emission factors used for the free emission of landfill gas

Pollutant	**Free emitted landfill gas mg/m^3**
Benzene	7
Toluene	120
Trichlorofluoromethane (R-11)	5
1,1,2-Trichloro-1,2,2-trifluoroethane (R-113)	1
1,2-Dichlorotetrafluoroethane (R-114)	2
Chloropentafluoroethane (R-115)	1
Dichlorodifluoromethane (R-12)	20
Dichlorofluoromethane (R-21)	10
Chlorodifluoromethane (R-22)	10
1,2-Dichloroethene	1
Dichloromethane	20
Tetrachloroethylene (Perc)	10
1,1,1-Trichloroethane	2
Trichloroethylene (Tri)	10

Pollutant	Free emitted landfill gas mg/m³
Chloroform (Trichloromethane)	1
Vinyl chloride (Chloroethene)	10
Methanethiol (methyl mercaptan)	10
Hydrogen sulphide	100
Other hydrocarbons	700

Table 7.6 overview of the amounts of landfill gas and methane recovered and combusted

Year	Free emission of landfill gas (million m³)	Free emission of methane (Gg)	Recovered landfill gas (million m³)	Amount used for energy purposes (million m³)	Amount combusted in flares (million m³)	Percentage of methane in recovered landfill gas (%)	Amount recovered methane (Gg)	Amount recovered methane useful applied (Gg)	Amount recovered methane flared (Gg)
1990	1,564	547	63.7	47.8	15.9	57.4	24.8	18.6	6.19
1995	1,367	478	182	136	45.4	57.4	70.6	52.9	17.6
2000	1,055	369	162	119	43.0	57.4	62.8	46.1	16.7
2005	770	233	130	97.9	32.5	53.2	47.0	35.3	11.7
2010	532	162	102	79.1	22.4	51.3	35.3	27.5	7.79
2015	376	115	60.4	43.4	16.9	49.6	20.3	14.6	5.69
2016	349	107	61.7	36.0	25.7	45.5	19.0	11.1	7.90
2017	321	98.2	62.1	36.1	26.0	48.0	20.2	11.7	8.47
2018	308	94.6	54.2	27.9	26.3	45.3	16.6	8.55	8.06
2019	292	89.7	48.9	23.4	25.5	45.7	15.1	7.26	7.88
2020	270	82.8	50.8	22.5	28.3	46.1	15.9	7.04	8.84
2021	254	78.0	46.3	19.7	26.6	45.6	14.3	6.09	8.21
2022	236	72.4	45.7	22.1	23.6	45.5	14.1	6.81	7.27
2023	220	68.2	46.5	24.0	22.5	46.5	12.7	6.57	6.15

Table 7.7 Emission factors used for the combustion of landfill gas

Pollutant	Combusted landfill gas Flared	Gas engine
Total hydrocarbons (incl. methane)	0.389763 kg/m³	0.389763 kg/m³
Hydrocarbons (C_xH_y)	0.27% hydrocarbons	6 g/m³
Dioxins	0.9E^{-9} g/m³	0.3E^{-9} g/m³
SO_x (based on all sulphur)	104 mg/m³	104 mg/m³
NO_x (as NO_2)	0.3 g/m³	3 g/m³
CO	2.7% C	3.4 g/m³
Soot	0.05% hydrocarbons	0.05% hydrocarbons

Particulate matter emissions are calculated on the basis of the amount of processed mineral waste. The emissions are calculated using the Tier 3 method from the 2023 guidebook. Important parameters are the quantities of processed mineral waste, the moisture content of the waste stream and the average wind speed.
Member States report quantities of waste produced and processed biannually to Eurostat in the context of EU Regulation 2150/2002. The amount of mineral waste is reported in the categories:

- Soils;
- Dredging spoils;
- Mineral waste from construction and demolition;
- Mineral wastes from waste treatment and stabilised wastes;
- Other mineral waste.

The last three categories have been combined in Table 7.8, because the same moisture percentage is used in the calculations for these categories. The wind speed is measured by the KNMI at the Cabauw weather station, located in the centre of the Netherlands.

Table 7.8 Activity data used for emissions of PM during mineral waste handling

Year	Amount contaminated soil (Tg)	Amount dredging spoils (Tg)	Amount other mineral waste (Tg)	Average wind speed (m/s)
1990	5.987	48.182	21.080	4.9
1995	5.019	40.395	17.673	4.4
2000	5.902	47.504	20.784	4.5
2005	6.910	50.872	24.332	4.1
2010	7.327	46.730	25.801	3.9
2015	6.727	64.852	25.113	4.5
2016	7.279	68.394	24.929	4.0
2017	7.500	68.937	25.914	4.1
2018	7.721	69.479	26.898	4.1
2019	7.495	60.080	26.395	4.2
2020	7.270	50.681	25.892	4.5
2021	7.279	49.791	25.452	4.0
2022	7.288	48.900	25.012	4.1
2023	7.288	48.900	25.012	4.5

7.4 Composting and anaerobic digestion (5B)

7.4.1 Source category description

The source category Composting and anaerobic digestion (5B) comprises emissions from the following source categories:

- 5B1;
  - Composting of organic waste from households;
  - Composting of organic waste from gardens and horticulture;
- 5B2;
  - Anaerobic digestion of organic waste from households;
  - Anaerobic digestion of organic waste from gardens and enterprises.

Emissions in this source category originate from facilities for the composting and/or fermenting of separately collected organic household, garden and horticultural waste and the anaerobic digestion of livestock manure. During processing, emissions of NH_3, SO_x and NO_x occur.

Since 1994, it has been a statutory requirement for communities in the Netherlands to collect all biodegradable organic waste (i.e. garden waste, horticulture waste and household waste such as fruits and vegetables) separately from other (domestic) waste. The main part of this waste is then treated by composting or digestion (for biogas production). Additionally, part of the manure produced by pigs and cattle is used in anaerobic digesters (biogas production).

Composting (5B1)
During composting, organic household waste is converted into compost. This process is carried out in enclosed facilities (industrial halls and tunnels), allowing waste gases to be filtered through a biobed before being emitted into the air. The material in the biobed is renewed periodically.

The processes for composting organic garden and horticulture waste are mostly carried out in the open air, in rows that are regularly turned over to optimise aeration.
A completeness check in 2022 revealed that this source was missing in the inventory and that significant emissions of NH_3 could be expected. In the 2023 submission, this source is included in the inventory.

Composting generates emissions of NH_3.

Anaerobic digestion (5B2)
Emissions from anaerobic digestion originate from the digestion of biodegradable organic waste. Feedstocks used in the Netherlands are: livestock manure; domestic organic waste; crops and crop residue from agriculture; food waste from food processing industries, households and restaurants; and organic waste from municipalities.

The process of anaerobic digestion takes place in gas-tight processing plants that do not release any emissions. Relatively small emissions of NH_3, NO_x and SO_x come mainly from storage of feedstocks and digestates. The most relevant feedstock as to emissions of NH_3 is livestock manure.

The biogas from anaerobic digesters is used for energy production or is processed and transferred to the natural gas network. Emissions from this use are included in the Energy sector (source category Small combustion (1A4)).

7.4.2 *Overview of shares and trends in emissions*

Composting

With the introduction of the new emission source for composting of organic garden and horticulture waste, the total emissions of NH_3 relating to composting became substantial (0.05 Gg and 0.91 Gg for 1990 and 2023, respectively). Since 1996, emission levels from this source have been relatively constant in time.

Anaerobic digestion

Manure digesters were introduced in 2006. Emissions relating to anaerobic digestion date from 1994, when the first domestic organic waste digestion plants started operations. NO_x, SO_x and NH_3, emission levels relating to anaerobic digestion are relatively low (0.002 Gg, 0.0001 Gg and 0.0003 Gg, respectively, in 1994, and 0.085 Gg, 0.005 Gg and 0.33 Gg, respectively, in 2023). Emissions are small, which is why shares and trends are not elaborated here.

7.4.3 *Emissions, activity data and (implied) emission factors*

Composting

The amounts of biodegradable waste processed by composting and fermentation plants (per year) are taken from the annual report by WAR, which is based on questionnaires completed by operators. When an operator does not complete a questionnaire, the estimated amount processed is based on data from the National Waste Notification Bureau (‘Landelijk meldpunt afvalstoffen’, LMA). LMA tracks all waste transport in the Netherlands. Most separately collected organic waste is used in composting. Table 7.9 provides an overview of the total amounts of separately collected organic household and other organic waste from operators in the composting and digestion industry.

Table 7.9 Overview of separately collected organic waste for composting and digestion

Year	Organic waste from households (Tg)		Organic waste from gardens and operators (Tg)	
	Composted	Digested	Composted	Digested
1990	228	-	-	-
1995	1,409	44	2,057	-
2000	1,498	70	2,473	2
2005	1,326	41	2,770	14
2010	1,066	154	2,424	13
2015	882	475	1,992	85
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
2021	1,280	419	2,246	68

Year	Organic waste from households (Tg)		Organic waste from gardens and operators (Tg)	
	Composted	Digested	Composted	Digested
2022	1,101	422	1,929	73
2023	1,207	400	1,928	70

The EFs used for composting have been derived from the sparse literature on emissions from the composting of separated biodegradable and other organic waste. It appears that hardly any monitoring is conducted on biobed reactors. The literature cannot be considered relevant, due to the diverse operational methods used in the Netherlands. The EFs for NH_3 from composting are taken from the environmental effect report for the Dutch national waste management plan 2002–2012 (VROM, 2002). The information in this report is based on a monitoring programme in the Netherlands (DHV, 1999).

For composting of organic waste, the following EFs have been used:
- For NH_3 from composting of household organic waste, an EF of 200 g/Mg is used;
- For NH_3 from composting of organic garden and horticultural waste, an EF of 350 g/Mg is used.

Anaerobic digestion
Table 7.10 provides an overview of the amounts of manure used for anaerobic digestion. Activity data on the anaerobic digestion of livestock manure are based on registered manure transports (data from the Netherlands Enterprise Agency, RVO) and their N content.

Table 7.10 Overview of manure used in anaerobic digesters

	Manure used for anaerobic digestion (Mg)	
Year	Wet weight (Gg)	Nitrogen (Mg)
2005	NO	NO
2006	214	1,310
2010	1,243	7,620
2015	1,582	10,328
2020	2,056	12,827
2022	2,623	15,499
2023	2,860	16,681

The anaerobic digestion of biodegradable domestic waste (i.e. garden waste, horticultural waste and household waste, such as fruits and vegetables) and of livestock manure is carried out in various specialised plants. As digester installations differ per type of waste, the emissions are calculated per waste type. Most of the NH_3 emissions originate from the digestion of livestock manure (as manure digesters themselves are air tight containers, the emissions mainly originate from feedstock and digestate storage).

The EFs used for the anaerobic digestion of livestock manure have been derived from a literature study carried out by Melse and Groenestein

(2016) aimed at compiling the most suitable EFs for the various manure treatments used under conditions in the Netherlands. For the anaerobic digestion of livestock manure, the following EFs have been used:

- NH_3 from anaerobic digestion of pig manure, 0.02 kg/kg N;
- NH_3 from anaerobic digestion of cattle manure (excluding veal calves), 0.01 kg/kg N.

The emission calculation methodology can be found in Van der Zee et al. (2024). The calculations are performed using the NEMA model for calculating agricultural emissions (Van Bruggen et al., 2024).

The EFs used for the anaerobic digestion of biodegradable domestic waste have been derived from the environmental effect report for the Dutch national waste management plan 2002–2012 (VROM, 2002). The information in this report was based on a monitoring programme in the Netherlands (DHV, 1999).

For the anaerobic digestion of biodegradable domestic waste the following EFs have been used:

- NH_3 from fermentation, 2.3 g/Mg of biodegradable domestic waste;
- NO_x from fermentation, 180 g/Mg of biodegradable domestic waste;
- SO_x from fermentation, 10.7 g/Mg of biodegradable domestic waste.

7.5 Waste incineration (5C)

7.5.1 Source category description

The source category Waste incineration (5C) comprises emissions from the following categories:

- 5C1a Municipal waste incineration;
- 5C1bi Industrial waste incineration;
- 5C1bii Hazardous waste incineration;
- 5C1biii Clinical waste incineration;
- 5C1biv Sewage sludge incineration;
- 5C1bv Cremations;
- 5C1bvi Other waste incineration;
- 5C2 Open burning of waste.

In the Netherlands, municipal waste, industrial waste, hazardous waste, clinical waste and sewage sludge are incinerated. The heat generated by waste incineration is used to produce electricity and heat buildings. These categories, therefore, are reported under the Energy sector (source category Public electricity and heat production (1A1a)).

Emissions from cremations (category 5C1bv) originate from the incineration of human remains (process emissions) and from natural gas combustion. The emissions from natural gas combustion are reported under the Energy sector (source category Commercial and institutional services (1A4ai)). From the cremation process, emissions of Hg, PM and dioxins occur. Since 2012, all cremation centres have complied with the Dutch Atmospheric Emissions Guideline (NeR), using a special filter (cloth or electrostatic).

There is no incineration of carcasses or slaughter waste in the Netherlands. Carcasses and slaughter waste are processed into reusable products, including biofuels.

Because of a ban on other waste incineration (5C1bvi) and open waste burning (5C2), these emission sources are assumed not to occur in the Netherlands. The open burning of waste has been banned in the Netherlands since the beginning of the 1980s. The Netherlands is a densely populated country, and any burning of wastes is likely to cause nuisance in the surrounding area and result in complaints to the authorities. Therefore, the ban on stoking unreported fires is strictly enforced by the local authorities. However, local authorities can lawfully make an exception for the burning of pruning wood, on condition that any fire must be reported to the local fire brigade in advance, to enable supervision and enforcement. Unfortunately, these individual reports are not registered. Such exemptions by local authorities have been under discussion recently, and more and more authorities now stop granting them. Additionally, most local municipalities accept pruning wood free of charge to be shredded for composting or used for energy purposes, and nowadays, if the amounts of these pruning woods are big enough to make it economically viable, they are also commercially collected and shredded to be used for energy purposes. Also, part of pruning wood is used in bonfires, which are reported in the IIR. Mostly, these pruning activities have to do with maintaining cultural landscapes (hedges and so on) and as such are no agricultural activity. With regard to pruning, only commercially operated orchards are regarded as agricultural activity. However, this situation is complex as most of the pruned orchard wood is being used for domestic (fireplaces and stoves) as well as commercial energy purposes (whole trees are shredded and used as biomass). The use of biomass for energy purposes is reported in the sector Energy. Using the tier1 approach would lead to double counting and a (substantial) overestimation for this source. Therefore, emissions from these sources are assumed not to occur in the Netherlands.

7.5.2 Overview of shares and trends in emissions

Emission levels in this source category are relatively low. Therefore, the shares and trends in these emissions are not elaborated here.

7.5.3 Emissions, activity data and (implied) emission factors

Cremations (5C1bv)

The number of cremations in the Netherlands is published online by the Dutch National Association of Crematoria (LVC), at www.lvc-online.nl (LVC, 2024). An overview of the number of cremations in compliance with the NeR is provided in Table 7.11.

Emission factors from the EMEP/EEA guidebook were used for calculating emissions from crematoria that do not have any emission reducing technology in place.

Table 7.11 Overview of the number of cremations in compliance with NeR

Year	Deceased	Cremated	% cremated	% cremated in compliance with NeR
1990	128,790	57,130	44	0
1995	135,675	63,237	47	0
2000	140,527	68,700	49	5
2005	136,402	70,766	52	18
2010	136,058	77,465	57	75[1]
2011	135,741	78,594	59	86[2]
2012	140,813	83,379	59	100
2015	147,134	93,177	63	100
2020	168,537	111,881	66	100
2021	170,802	115,135	67	100
2022	169.937	114,438	68	100
2023	169,320	115,757	68	100

1. Interpolation from year 2011
2. Calculation is based on list of crematoria under the NeR (LVC, 2025)

For crematoria equipped with emission reducing technology, an evaluation of the effectivity of the use of this technology was performed. To this end, the substances emitted by crematoria are considered to be gaseous, vaporous, particulate or particle-bound. On the basis of measurements at crematoria in Geleen and Bilthoven (Visschedijk et al. 2022), a 71% effectiveness for particulates and particle-bound substances was calculated. For Hg, the emission factor with technology in place is based on the reported Hg emissions for the Netherlands in EC (2012) Annex L and OsPar (2011) (Visschedijk et al., 2024). Table 7.12 provides an overview of emission factors without and with emission reducing technology in place.

Table 7.12 Overview of emission factors used for calculating emissions from cremations without and with emission reducing technology in place

Pollutant	State	Emission factor before introduction NeR[1] (kg per cremation)	Emission factor with NeR[2,3] (kg per cremation)
NO_x	Gaseous	0.825	0.825
CO	Gaseous	0.14	0.14
NMVOC	Gaseous	0.013	0.013
SO_x	Gaseous	0.113	0.113
PCB	Particle bound	$4.1\ 10^{-7}$	$1.18\ 10^{-7}$
PCDD/F	Particle bound	$2.7\ 10^{-11}$	$7.8\ 10^{-12}$
B(a)P	Particle bound	$1.32\ 10^{-8}$	$3.80\ 10^{-9}$
B(b)FA	Particle bound	$7.21\ 10^{-9}$	$2.08\ 10^{-9}$
B(b)FK	Particle bound	$6.44\ 10^{-9}$	$1.86\ 10^{-9}$
I-pyrene	Particle bound	$6.99\ 10^{-9}$	$2.01\ 10^{-9}$
HCB	Particle bound	$1.5\ 10^{-7}$	$4.32\ 10^{-8}$
Pb	Particle bound	$3.0\ 10^{-5}$	$8.65\ 10^{-6}$
Cd	Particle bound	$5.03\ 10^{-6}$	$1.45\ 10^{-6}$
As	Particle bound	$1.36\ 10^{-5}$	$3.92\ 10^{-6}$

Pollutant	State	Emission factor before introduction NeR[1] (kg per cremation)	Emission factor with NeR[2,3] (kg per cremation)
Cr	Particle bound	$1.36\ 10^{-5}$	$3.91\ 10^{-6}$
Cu	Particle bound	$1.24\ 10^{-5}$	$3.58\ 10^{-6}$
Ni	Particle bound	$1.73\ 10^{-5}$	$4.99\ 10^{-6}$
Se	Particle bound	$1.98\ 10^{-5}$	$5.70\ 10^{-6}$
Zn	Particle bound	$1.6\ 10^{-4}$	$4.61\ 10^{-5}$
PM_{10}	Particulate	0.0347	0.01
$PM_{2.5}$	Particulate	0.0347	0.01
Hg	Vaporous	$1.49\ 10^{-3}$	$2.0\ 10^{-5}$

1: EEA guidebook 2023
2: Emissions of particulates and particle bound substances are estimated to be 71% less after implementation of NeR
3: Emissions of Hg are estimated to be 98 – 99.5 % less after implementation of NeR

Open burning of waste (5C2)f
Traditionally, a number of festive days are brightened by bonfires. These celebrations have a strong cultural and regional background, mostly taking place in specific parts/regions of the Netherlands. Scrap pallets; orchard, hedgerow and wooded bank pruning; and forest residues are used for these bonfires, which are exempted from the general ban on waste incineration and are regulated and controlled by local enforcing authorities. Emissions from bonfires are reported under Open burning of waste (5C2).

The number of bonfires in the Netherlands fluctuates per year, mainly depending on how strongly tradition is respected and on the local weather at the time. Table 7.13 provides an overview of the known bonfires reported in this category, with the date/period of occurrence and the geographical location. Spontaneous (small) bonfires and non-registered/regulated fires have not been included.

The activity data used is largely derived from specific websites, regional newspapers, news articles and sometimes permits. Estimates of the annual amounts of pallet and pruning wood burned are based on this information and supplemented by expert judgement.

Table 7.13 Overview of known bonfires

Name	Date/period	Location(s)
New Year's Eve	1 January	Scheveningen/Duindorp
Christmas tree burning	1 January	Nationwide
Easter fires	Easter (March/April)	Northern and eastern areas
Meierblis	30 April	Texel (the largest island of the Dutch Wadden Islands)
Luilak	Saturday before Whitsunday (May/June)	Northwest
St.-Martin's day	11 November	The northernmost and southernmost provinces

Easter fires

Table 7.14 provides an overview of the total amount (m^3) of pruning burned in the four large Easter fires.

Table 7.14 Estimated amounts (m^3) of pruning wood burned in the four largest Easter fires

	Total amount of pruning wood per Easter fire (m^3)			
Year	**Dijkershoek**	**Espelo[1]**	**Beuseberg**	**Holterbroek**
2015	5,308	5,783	2,289	1,634
2020	0	0	0	0
2021	0	0	0	0
2022	4,293	3,644	1,852	1,468
2023	1,000	1,000	1,000	1,000

1 The Easter fire at Espelo is on the UNESCO list of immaterial heritage

For earlier years, the activity data has been based on the trend in inhabitants (a 10% increase in inhabitants results in a 10% increase in the amount of pruning burned).

All other Easter fires in the Netherlands are much smaller and the occurrence of these bonfires depends on local initiatives and organisation. In most Dutch municipalities, no permits are needed if the volume of the bonfire is below 1,000 m^3. The average volume of the smaller Easter bonfires is estimated at 250 m^3. The number of Easter fires is estimated at roughly 400. In 2019, the Easter bonfires were smaller as a result of drought. Most municipalities banned Easter fires and the remainder only allowed small fires

In 2020 and 2021 there were no Easter bonfires as result of the COVID-19 restrictions.

New Year's Eve fires

Both the Scheveningen and Duindorp fires were regarded as the biggest bonfires in the Netherlands (each 12,000 m^3 of pallets in 2019) due to fierce competition between both neighbourhoods. The volume of pallets burned can be measured accurately because of the competition to have the biggest bonfire.
There were no fires in Scheveningen and Duindorp in 2019–2021, due to safety restrictions (2019) and COVID-19 (2020 and 2021). From 2022 onwards, the size of the piles has been limited to 1,000 m^3 due to nitrogen restrictions applied.

Picture 7.1 The piles of pallets at Scheveningen and Duindorp for the 2019 New Year's Eve bonfires

All other bonfires on New Year's Eve in the Netherlands are much smaller, and the occurrence of these bonfires depends on local initiatives and organisation. In most Dutch municipalities, no permits are needed if the volume of the bonfire is below 1,000 m^3. As a result, the number of (small) New Year's Eve fires and the volumes of these fires are not registered and can only be estimated on the basis of articles in local newspapers.

As a result of the nitrogen restrictions applied from 2022 onwards, the total volume of wood burned on New Year's Eve is estimated to be 4,000 m^3 (around 2,000 m^3 for Scheveningen and Duindorp + 2,000 m^3 for the other smaller non-registered bonfires). This volume is used for the complete time series.

The bonfires Meierblis, Luilak and St Maarten are not spread wider. And the total amounts of wood burned is estimated at 16,250 m^3, 500 m^3 and 5,000 m^3 respectively.

Wood density and heating value of pallets
The density of pruning wood is based on a Belgian report from the Flemish government on waste from 2014 (www.Lne.be) and equals 0.15 Mg/m^3.

The density of pallets is based on a standard pallet size of 0.8 x 1.2 x 0.144 m and a standard pallet weight of 25 kg, resulting in a density of 0.18 Mg/m^3.

The heating value of pallets has been derived from Jansen's (2010) 'kachelmodel'. This equals 15.6 MJ/kg.

In terms of EF, a distinction is made between the burning of pallets and the burning of pruning wood. The EFs for the burning of pallets have been derived from EMEP/EEA (2016; NFR Category 1A4 – table 3.39 Open fireplaces burning wood); the EFs for the burning of pruning wood from EMEP/EEA (2016; NFR Category 5C2 – table 3.2 Open burning of agricultural wastes/forest residue).

7.6 Wastewater handling (5D)

7.6.1 Source category description

In the Netherlands, almost all wastewater is treated in domestic (5D1) or industrial (5D2) wastewater treatment plants (WWTPs). WWTPs produce small amounts of NMVOC emissions.

Normally, industrial wastewater is also treated at domestic WWPTs. However, this wastewater stream is charged on the basis of the average amount of pollutants and volume. Thus, for some industries it is cheaper to treat their own wastewater on-site before discharging directly to surface water or to the sewage system (depending on the level of remaining pollutants and volume). Thus, the incoming wastewater at domestic WWPTs comprises household wastewater, industrial wastewater and urban run-off (mainly off rooftops and streets).

The on-site treated industrial wastewater comprises water from the industrial process, and in some cases, water used for cooling processes and run-off from the paved industrial site.

Part of the WWTPs process their sewage sludge in an anaerobic digester to produce methane. The methane is captured and used in energy production or flared. Therefore, emissions from WWPTs are reported under the source category Commercial/Institutional: Stationary (1A4ai).

7.6.2 Overview of shares and trends in emissions

Emission levels in this source category are relatively low. Therefore, the shares and trends in these emissions are not elaborated here.

7.6.3 Emissions, activity data and (implied) emission factors

Domestic WWTPs

Activity data from domestic WWTPs come from a separate inventory performed by Statistics Netherlands (CBS) in partnership with Netherlands Enterprise Agency (RVO), the Dutch Water Authorities and consultancy firm Arcadis (Honig et al., 2024). Table 7.15 provides an overview of the activity data used over time. In 2023, the volume of domestic wastewater treated increased substantially as a result of abnormally higher rainfall collected in the sewage system.

NMVOC is calculated using the default Tier 1 emission factor of 15 mg NMVOC/m^3 wastewater treated (EEA, 2023).

Industrial WWPTs

Information on the industrial biological wastewater treatment plants and related volumes of wastewater treatment is compiled from a Statistics Netherlands database for the years 1993–2016 as well as from data from the AERs on volumes of wastewater. For a short description of the method to determine the volumes of industrial wastewater treated in industrial biological wastewater treatment plants, see Geertjes & Baas (2022). In previous submissions, data for 2017–2021 was a copy of the 2016 values but corrected for new plants and plants taken out of service. In the 2024 submission (1990–2022), a concise pilot survey among companies in the AER register already provided some updated data on the population for 2022 (see Table 7.15). In the current submission, this survey was scaled up to all relevant companies submitting AERs. That means that in the 2025 submission (data 1990–2023) the time series of 2017–2021 is revised (see Section 7.2.4).

NMVOC is calculated using the Tier 1 emission factor of 15 mg NMVOC/m^3 wastewater handled (EEA, 2023).

Table 7.15 Wastewater volume data (key years) of biological wastewater treatment plants

	Total volume of wastewater treated (Mio m^3)	
Year	**Domestic WWTP**	**Industrial WWTP**
1990	1,643	338
1995	1,854	316
2000	1,997	316
2005	1,841	239
2010	1,934	369
2015	1,957	248
2020	1,938	245
2021	1,964	244
2022	1,808	244
2023	2,245	244

7.7 Other waste (5E)

7.7.1 Source category description

The source category Other waste (5E) comprises the following emission sources:

- Sludge spreading;
- Waste preparation for recycling;
- Scrapped refrigerators/freezers;
- Accidental building and car fires.

Sludge spreading

WWTPs produce sewage sludge. In the Netherlands, sewage sludge can be used as a fertiliser in agriculture if it meets the legal environmental quality criteria. In line with the EMEP/EEA Guidebook, emissions from this source are reported under Sewage sludge applied to soils (3Da2b).

Waste preparation for recycling

Waste preparation for recycling is carried out mainly by companies that process waste to turn it into new base materials. These processes entail small emissions of NO_x, NMVOC, SO_x, CO, particulate matter, several metals, PAHs and dioxins.

Scrapped refrigerators /freezers
Since 1995, the production and sale of refrigerators and freezers (R/F) using chlorofluorocarbons as refrigerant has been prohibited in the European Union. However, given an average lifetime of at least 15 years, R/F units using CFCs are still in use, and significant numbers are discarded each year. In the Netherlands, discarded R/F units are collected and processed by specialised companies that remove and destroy the CFCs still present in the units. Still, in some cases the CFCs have leaked into the environment before the R/Fs were discarded and processed. This emission source represents the leakage emissions of CFCs and possible processing inefficiencies that lead to the emission of CFCs into the environment.

Accidental building and car fires
Mainly by accident (but sometimes on purpose), cars and houses are damaged or destroyed by fire. The smoke caused by such fires is the source of emissions. The amount of material burned is determined by the response time of (professional) fire-fighters. Accidental building and car fires produce, among others, emissions of particulate matter and dioxins.

7.7.2 Overview of shares and trends in emissions
Emission levels in this source category are relatively low. Therefore, the shares and trends in these emissions are not elaborated here.

7.7.3 Emissions, activity data and (implied) emission factors
Waste preparation for recycling
Data on emissions from the process of waste preparation for recycling was based on environmental reports by large industrial companies. Where necessary, extrapolations were made to produce emission totals per industry group, using either IEFs and production data, or production data based on environmental reports in combination with specific EFs (Honig et al*.,* 2024).

Scrapped refrigerators/freezers
When recycling scrapped refrigerators/freezers, a small amount of NMVOC (as dichlorodifluoromethane (CFC12), used as refrigerant) is emitted. In the calculations, an EF of 105 g CFC12 per recycled refrigerator/freezer (after correction for recovered CFC12) was used.

To estimate the number of CFC R/F equipment discarded annually from 1990 to 2030, a combination of multiple data is needed. First, the number of R/F units put on the market between 1960 and 1994 in the Netherlands was extracted from CBS data. These R/Fs are all assumed to use CFC-12 as a refrigerant.

The Weibull distribution is used to estimate the number of CFC R/F units discarded annually. On the basis of data from CBS, the average lifetime of a refrigerator is estimated at 16.4 years, and that of a freezer at 18.6 years. Furthermore, the shape of the Weibull function is 2.2 for refrigerators and 1.3 for freezers (Magalini et al., 2014).

As a last step, corrections are applied for exported scrap refrigerators and freezers (Visschedijk et al*.,* 2025).

Accidental building and car fires

Further details regarding the methodology are provided in Visschedijk et al. (2023).
The number of buildings and cars exposed to fire was collected by the joint fire brigades in the Netherlands and reported annually via Statistics Netherlands, until the year 2013. Those numbers are used for the time series 1990–2013.

Since 2013, data by the Dutch Association of Insurers has been used for car fires. This data only includes insured cars for which the insurance company covered the damage. One third of the car fires is estimated to comprise uninsured vehicles, so the raw numbers reported by the Association of Insurers are increased by a factor of 1.5 to estimate the total number of car fires.

For the number of indoor fires from 2014 onwards, no accurate data are available from Statistics Netherlands. Before 2014, the reported number of indoor fires seemed roughly proportional to the total number of buildings. On an annual basis, a relatively constant fraction of all buildings was affected by a fire incident. On the basis of this percentage, the number of indoor fires occurring from 2014 to 2018 was estimated, indicating about 14,000–15,000 indoor fires annually.

According to multi-year statistics on the number of fatal house fires in the Netherlands (Nederlands Instituut Publieke Veiligheid), in about 55% of the cases, studied, the destruction is confined to a single room; in 17%, it is confined to a single floor; and in 28%, the entire house burns down. Table 7.16 provides an overview of the estimated amounts of combustible material burned, based on an average Dutch situation of a one-family home consisting of 3 floors and 4 rooms per floor.

Table 7.16 Amounts of burned combustible materials average housefire in the Netherlands

Average Dutch situation of a one-family home made up of 3 floors and 4 rooms per floor		
Destruction by fire (limited to)	**Combustible materials burned (%)**	**Combustible materials burned (Mg)**
Same room	10	1.48
Same floor	33	4.9
Complete house	100	14.8

When this data on fire destruction and occurrence is combined, it results in the following amount of combustible materials burned:

$$1.48 \times 55\% + 4.9 \times 17\% + 14.8 \times 28\% = 5.8 \text{ Mg}$$

For house fires, country-specific EFs have been derived from the amount of combustible materials in an average Dutch house combined with a percentage burned in each fire as explained in this section. The emissions of all pollutants (except dioxin) from the combustible materials of the construction and the combustible materials of the interior materials are calculated using the EFs in table 3.39 in chapter 1A4 of the Guidebook. The emissions of dioxin are calculated using the EF from Aasestad (2007) of 170 µg I-TEQ per Mg burned material.

For car fires, the default EFs from the EMEP/EEA Guidebook (2023) are used. Table 7.17 provides an overview of the number of house and car fires.

Table 7.17 number of house and car fires

Year	Number of housefires	Number of car fires
1990	12,592	4,827
1995	13,634	5,766
2000	13,910	6,064
2005	13,147	4,411
2010	15,563	4.280
2015	15,176	5,084
2020	15,784	8,373
2021	15,933	7,130
2022	16,091	7,539
2023	16,250	7,593

8 Other

8.1 Overview of the sector

The Other sources sector (NRF 6) includes emissions from sources that cannot be placed under any specific NFR.

8.2 Other sources (6A)

8.2.1 Source category description

This source category includes only NH_3 emissions from the following sources:

- Human transpiration and respiration;
- Domestic animals (pets).

Human transpiration and respiration

Through the consumption of food, nitrogen (N) is introduced into the human system. Most nitrogen is released into the sewage system through faeces and urine. Part of the nitrogen is released as ammonia through sweating and breathing and is reported in this emission source.

Domestic animals (pets)

Emissions from domestic animals consist mainly of NH_3 coming from dung and urine. This source comprises the combined emissions from:

- Dogs;
- Cats;
- Birds (undefined);
- Pigeons;
- Rabbits.

8.2.2 Key sources

There is no key source in this category.

8.2.3 Overview of shares and trends in emissions

An overview of emissions and the trends for this sector is provided in Table 8.1.

8.2.4 Emissions, activity data and (implied) emission factors

Human transpiration and respiration

NH_3 emissions from this source gradually increased in the course of the time series, in line with the increase in the human population, from 1.50 Gg in 1990 to 1.79 Gg in 2023.

Population numbers in the Netherlands are derived from CBS Statline (http://statline.cbs.nl/). They increased from 14,892,574 in 1990 to 17,811,291 in 2023.

To avoid underestimation, the high-end EF of 0.1004 kg NH3 per person per year (Sutton et al., 2000) was used to calculate emissions from this source.

Table 8.1 Overview of emission totals in the Other sector (NFR 6)

	Main Pollutants				Particulate Matter		
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**0.00**	**0.00**	**0.00**	**2.7**	**0.00**	**0.00**	**0.00**
1995	0.00	0.00	0.00	2.8	0.00	0.00	0.00
2000	0.00	0.00	0.00	2.9	0.00	0.00	0.00
2005	0.00	0.00	0.00	3.0	0.00	0.00	0.00
2010	0.00	0.00	0.00	3.1	0.00	0.00	0.00
2015	0.00	0.00	0.00	3.2	0.00	0.00	0.00
2020	0.00	0.00	0.00	3.3	0.00	0.00	0.00
2021	0.00	0.00	0.00	3.3	0.00	0.00	0.00
2022	0.00	0.00	0.00	3.4	0.00	0.00	0.00
2023	**0.00**	**0.00**	**0.00**	**3.4**	**0.00**	**0.00**	**0.00**
1990-2023 period[1)]	0.00	0.00	0.00	0.7	0.00	0.00	0.00
1990-2023 period[2)]				28%			

1. Absolute difference
2. Relative difference from 1990 in %

Domestic animals (pets)
NH_3 emissions from this source increased slightly in the course of the time series from 1.17 Gg in 1990 to 1.61 Gg in 2023.

Emissions are calculated using an EF per household. The number of households is derived from Statistics Netherlands. The EF used is based on Booij (1995), who calculated a total emission of 1.220 Gg NH_3 from all domestic animals (cats, dogs, rabbits and birds) for the year 1990. On the basis of the total emission in 1990 and the number of households in 1990, an EF of 0.2 kg NH_3 per household was calculated.

8.2.5 *Methodological issues*
The methodology used for calculating emissions from the sources Human transpiration and respiration and Domestic animals is described in Visschedijk (2024).

There are no specific methodological issues.

8.2.6 *Uncertainties and time series consistency*
No accurate information was available for assessing uncertainties about emissions from sources in this sector.

8.2.7 *Source-specific QA/QC and verification*
Verification for the source Domestic animals (pets) is carried out using a survey conducted by order of the branch organisation DIBEVO (entrepreneurs in the pet supplies branch). The numbers of cats and dogs derived from this survey combined with the EFs for cats and dogs from Sutton et al. (2000) represent 70% of the total emissions from pets (Booij, 1995).

There are no further source-specific QA/QC procedures in place in this sector. The remainder of sources in this sector are covered by the general QA/QC procedures, as discussed in Chapter 1.

8.2.8 Source-specific recalculations
There were no source-specific recalculations for the sector Other sources.

8.2.9 Source-specific planned improvements
There are currently no planned improvements.

9 Large Point Sources

All point sources in the Netherlands that meet the criteria have the legal obligation to report their emissions electronically as part of an Annual Environmental Report (AER)(see Section 1.3.2). Following validation and data checking, the data is stored in the Pollutant Release Transfer Register (PRTR). The European Pollutant Release Transfer Register (EPRTR) and the Large Point Sources (LPS) are extracts from this PRTR.

The 2025 LPS submission comprises all EPRTR facilities that reported emissions for one or more pollutants above the thresholds specified in table 1 of the reporting guidelines (Executive body for the Convention on Long-range Transboundary Air Pollution; decision ECE/EB.AIR/125). For NH_3, this threshold is the same as for EU Directive 2010/75/EU.

For inclusion of agricultural facilities in the LPS submission, a different approach is used, as some of these point sources do not meet the EPRTR criteria, but do have emissions above the threshold. To derive emissions per agricultural facility, the national total emissions are spatially disaggregated to single facilities using data on animal numbers and housing from the Geographic Information on Agricultural Businesses (GIAB). The method is described here. The 2025 LPS submission includes all facilities that reported emissions above the thresholds as specified in the reporting guidelines (e.g. 10,000 kg for NH_3).

10 Response to the Reviews

10.1 CLRTAP reviews 2015 and 2024

At its 25th session in 2007, the Executive Body for the Convention on Long-Range Transboundary Air Pollution approved methods and procedures for the review of national emission inventories. On the basis of this decision, the national inventories (CLRTAP and NECD) have been subject to five-year cycles of in-depth technical reviews since 2008. The technical review of national inventories checks and assesses parties' data submissions with a view to improving the quality of emission data and associated information reported to the Convention. The review process is aimed at making inventory improvements by checking the transparency, consistency, comparability, completeness and accuracy (TCCCA criteria) of the submitted data (see http://www.ceip.at/).

The review also seeks to achieve a common approach to prioritising and monitoring inventory improvements under the Convention together with other organisations that have similar interests, such as the United Nations Framework Convention on Climate Change (UNFCCC), the European Union National Emission Ceilings (NEC) Directive and the European Pollutant Release and Transfer Register (E-PRTR).

The submission by the Netherlands was last fully reviewed in 2015. In the review report, several recommendations were made for improvements to the inventory and inventory reporting. All these recommendations have been implemented.
In 2017, the third joint session of WGE and the Steering Body (SB) to EMEP:

a) welcomed the efforts under the European Union to harmonise the national inventory reviews under the National Emission Ceilings Directive with those under the Convention;
b) recommended that the two review processes be coordinated with respect to priorities, scopes, resources (reviewers) and timelines, to ensure consistency and complementarity and to avoid possible overlaps, duplication of efforts and inconsistent conclusions.

In 2024, the focus of the CLRTAP in-depth review was on:

- emissions from the sector IPPU solvents with a particular focus on NMVOC emissions;
- gridded data for the sector IPPU solvents with a particular focus on NMVOC emissions.

Appendix 4, Table A4.2 represents the status of the implementation of the recommendations from this CLRTAP review.

10.2 NECD review 2024

Article 10(3) of the revised NECD introduces a regular annual review of EU Member States' national emission inventory data in order to:

- verify, amongst others, the transparency, accuracy, consistency, comparability and completeness of the information submitted;
- check the consistency of prepared data with LRTAP requirements;

- calculate technical corrections where needed.

The 2024 NFR and IIR submission by the Netherlands was reviewed. Several recommendations were made to improve the inventory and the inventory report. Within the limitations of resources, the actions that were based on these recommendations were given a high priority and were added to the work plan in order to ensure a follow-up to the majority of recommendations before the next NFR submission in 2025. Appendix 4, Table A4.1 presents the status of the implementation of the recommendations from this NECD review.

As part of the 2021 review, the 2021 submissions of the Large Production Sites (LPS) and the so-called ‘Gridded data’ were reviewed. The status of following up on the recommendation from these parts of the review can be found in Appendix 4, Tables A4.3 and A4.4.

In 2023, the Netherlands Projections submission of 2023 was reviewed. The status of following up this review is presented in Appendix 4. Table A4.5.

11 Recalculations and Other Changes

11.1 Recalculations and improvements of certain elements of the IIR

Compared to the IIR 2023 (Wever et al., 2024), several improvements in source allocation and emission factors used were implemented in the Pollutant Release and Transfer (PRTR) system. These recalculations were initiated by the internal QA/QC cycle and recommendations from external reviews, improving the comparability with the methodologies as elaborated in the EMEP/EEA guidebook. The main changes in the inventory are:

Overall

- Whenever updated/improved activity data became available these are used to improve the emission calculation (all sectors).
- Due to changes in the energy statistics, the fuel use and, subsequently, the emissions in various categories changed (1990–2021).
- Changes in the emissions by individual companies for the 2009–2022 period, as reported under Sectors 1 and 2, result from improvements or error corrections in the emission estimates as reported in their Annual Environmental Reports (AERs).

Energy

- Improvement of heavy metal emissions in 2000, 2004 and 2005 in 1A1a and 1A1b. For several power plants and refineries, heavy metals were missing in their AERs. Additional estimates have been made, resulting in an increase of emissions for 2000 and 2005. This same procedure also led to an increase in emissions from chemical industry in 2B10a.
- Error correction of copper and nickel emissions for 2004 and CO emissions for 2022, in 1A1a.
- Recalculation of the NO_x emission factor for natural gas combustion in 1A4 (2010–2022). This leads to a decrease in emissions for 1A4ai, 1A4bi and 1A4ci.
- Error correction for activity data of gaseous fuels and solid fuels in 1A4bi, in response to NECD recommendation NL-1A4bi-2024-0001. This only affects activity data, not emissions.
- Activity data correction for frying meat for the full time series. This led to a decrease in emissions for 1A4bi.
- Updated NMVOC emissions in 1B, due to updated CH_4 emissions for gas distribution, resulting from the Oil and Gas Methane partnership (OGMP).

Specific for transport:

- Update of PAH profiles for jet engines, resulting in strong increases of PAH emissions.
- Recalculations following aircraft type corrections for Amsterdam Airport Schiphol for 1998–2001, resulting in small increases in emissions.
- Updated emission factors for road transport.
- Error correction of double-counting NMVOS for road transport.

- For heavy-duty vehicles, auxiliary functions have also been included, resulting in higher emissions of all gases for the full time series.
- For railways, the emission factors for wear and their size distributions have been changed.
- The NO_x emission factor for LPG engines has been lowered, resulting in a decrease of emissions for non-road mobile machinery.
- Update of machine fleet of NRMM. For further details, see Section 4.6.8.
- Container handling statistics have been adjusted to consider handling of empty containers to and from empty depots. This leads to an increase in fuel use and emissions.

IPPU

- In 2B10a, for some companies, heavy metals were missing in their AERs. Additional estimates have been made, resulting in an increase of emissions for 2000 and 2005.
- Error correction leading to recalculations in $PM_{2.5}$ and PM_{10} emissions for the full time series in 2A5b. This leads to a decrease in emissions.
- Recalculations because of a delay in data availability. This holds for TSP, PM_{10}, and $PM_{2.5}$ emissions in 2A5c, as well as for NMVOC emissions from stationary refrigeration in 2G, both for 2021 and 2022.
- Increase in emissions for NMVOC, PM_{10}, benzene, PAH, and cadmium in 2A6, resulting from a Tier1 method to calculate emissions from asphalt production that were not estimated before.

Agriculture

- Recalculation of NO_x and NH_3 emissions for 2010–2022 from updates in manure storage and treatment, due to updates in the amount of treated manure and the N content of the treated or exposed manure.
- Recalculations of NMVOC emissions from manure storage (3B) and manure application (3D), as they are affected by changes in NH_3 emissions from housing and storage. As we mentioned in the first bullet point, they were recalculated.
- Recalculation of NMVOC emissions for 2022, resulting from updates on the number of calves born per dairy cow. This led to increases in VS intake and excretion of dairy cows.
- NH_3 and NO_x recalculations for 2000–2022, caused by updates of model inputs for manure distribution of soil types and the amount of manure available for applications.
- Recalculation of NO_x and NH_3 emissions for 2006–2022 resulting from an error correction for the rate of grassland renewal. This leads to an increase in NH_3 and NO_x emissions for most years. For 2022, NO_x emissions decreased, as they were preliminary numbers before.
- Recalculation of NO_x emissions for the entire time series, due to a recalculation for the area of organic soils in the Netherlands.

Waste

- Recalculations of particulate matter emissions from mineral waste handling (5A), due to a change in methodology.
- Increase of NH_3 emissions in 5B for 2018–2022, due to recalculation of the amount of digested manure.
- NMVOC emissions from industrial wastewater treatment are recalculated for the time series 2016–2022 on the basis of activity data provided voluntarily by individual industrial companies in their AERs.

Further details on the above changes can be found in the respective sectoral chapters.

11.1.1 Effects of recalculations and improvements

Tables 11.1 to 11.3 show the changes in total national emission levels for the various pollutants, compared to the inventory report of 2024.

In general, the national emissions of the various pollutants only show limited changes compared to the previous submission (on average less than 5%) except for heavy metal emissions in 2000 and PAH emissions for the full time series. The heavy metal emissions in 2000 result from additional estimates to fill gaps in company reporting in AERs, which for chemical industry, refineries, and power plants sometimes were missing heavy metal emissions.
The increase in PAH 1-4 emissions originates from addition of asphalt production as a new emission source in 2A6, which was not estimated before.

Table 11.1 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010, 2020 and 2022 (NO_x, NMVOC, SO_x, NH_3 and particulate matter)

National total			**NO_x** (as NO_2)	**NMVOC**	**SO_x** (as SO_2)	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**
			Gg	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**
1990	IIR 2024		681.2	606.0	197.5	346.6	57.3	80.8	102.4	14.2	1,172.0
	IIR 2025		682.2	600.8	198.1	346.6	57.2	80.5	102.2	14.2	1,177.1
Difference		absolute	1.0	-5.2	0.6	0.0	-0.1	-0.3	-0.3	0.0	5.0
		%	0.2%	-0.9%	0.3%	0.0%	-0.2%	-0.3%	-0.3%	0.1%	0.4%
2000	IIR 2024		493.6	337.1	78.5	174.9	35.0	50.5	57.4	10.6	752.5
	IIR 2025		491.3	334.6	78.5	174.9	34.7	50.0	57.0	10.6	757.5
Difference:		absolute	-2.3	-2.4	-0.1	0.1	-0.3	-0.5	-0.5	-0.1	5.0
		%	-0.5%	-0.7%	-0.1%	0.0%	-0.9%	-1.0%	-0.8%	-0.5%	0.7%
2010	IIR 2024		343.0	273.9	36.1	135.1	22.2	36.0	43.4	5.0	651.4
	IIR 2025		345.9	271.9	36.1	134.4	22.0	35.6	43.0	4.9	655.2
Difference:		absolute	3.0	-2.0	0.0	-0.7	-0.2	-0.4	-0.4	0.0	3.8
		%	0.9%	-0.7%	0.0%	-0.5%	-1.0%	-1.0%	-0.9%	-0.3%	0.6%
2020	IIR 2024		211.7	249.9	19.6	125.0	14.4	26.9	31.4	2.4	422.1
	IIR 2025		209.0	252.9	19.6	124.6	14.2	26.6	31.1	2.4	426.8
Difference:		absolute	-2.7	3.0	0.0	-0.4	-0.2	-0.4	-0.4	0.0	4.7
		%	-1.3%	1.2%	0.0%	-0.3%	-1.4%	-1.3%	-1.2%	0.0%	1.1%
2022	IIR 2024		194.6	241.7	19.6	121.2	14.3	26.9	31.3	2.1	397.9
	IIR 2025		191.6	240.1	19.6	120.4	14.1	26.5	30.9	2.2	401.4
Difference:		absolute	-3.0	-1.6	0.0	-0.8	-0.2	-0.4	-0.4	0.0	3.5
		%	-1.5%	-0.7%	-0.1%	-0.6%	-1.4%	-1.5%	-1.3%	0.4%	0.9%

Table 11.2 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010, 2020 and 2022 (metals)

National total		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
		Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	IIR 2024	335.7	4.1	3.7	1.5	12.0	91.0	75.7	0.4	225.7
	IIR 2025	335.6	4.1	3.7	1.5	12.0	92.5	75.7	0.4	225.7
Difference:	absolute	-0.1	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0
	%	0.0%	0.1%	0.0%	0.0%	0.0%	1.6%	0.0%	0.0%	0.0%
2000	IIR 2024	28.4	3.0	1.2	1.1	5.1	107.5	20.0	0.5	96.4
	IIR 2025	29.1	3.1	1.2	1.7	5.3	109.9	20.8	0.8	99.8
Difference:	absolute	0.7	0.1	0.1	0.6	0.2	2.4	0.8	0.3	3.4
	%	2.6%	2.0%	6.9%	57.2%	3.2%	2.2%	4.1%	64.7%	3.6%
2010	IIR 2024	37.6	4.7	0.8	0.8	3.9	114.6	2.5	1.6	103.0
	IIR 2025	37.7	4.7	0.8	0.8	3.9	116.2	2.5	1.6	103.0
Difference:	absolute	0.1	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0
	%	0.2%	0.1%	-0.4%	0.0%	-0.2%	1.4%	0.0%	0.0%	0.0%
2020	IIR 2024	5.8	2.0	0.5	0.3	3.2	102.1	1.8	0.2	178.2
	IIR 2025	5.8	2.0	0.5	0.3	3.2	103.9	1.8	0.2	178.1
Difference:	absolute	0.1	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
	%	1.2%	0.1%	-2.2%	0.2%	-0.6%	1.8%	0.2%	-0.1%	0.0%
2022	IIR 2024	4.5	0.8	0.5	0.3	3.5	104.8	1.7	0.2	155.6
	IIR 2025	4.6	0.8	0.5	0.3	3.5	106.6	1.7	0.2	155.6
Difference:	absolute	0.1	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
	%	2.1%	0.3%	-2.5%	0.2%	-0.6%	1.7%	0.3%	-0.2%	0.0%

Table 11.3 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010, 2020 and 2021 (PCDD/F, PAHs, HCB and PCB)

National total		**PCDD/ PCDF**	**benzo(a) pyrene**	**benzo(b) fluor-anthene**	**benzo(k) fluor-anthene**	**Indeno (1.2.3 -cd) pyrene**	**Total 1-4**	**HCB**	**PCB**
		g I-Teq	**Mg**	**Mg**	**Mg**	**Mg**	**Mg**	**kg**	**kg**
1990	IIR 2024	744.9	5.5	8.1	4.2	3.0	20.8	66.4	38.4
	IIR 2025	744.9	5.5	8.1	4.2	3.0	21.4	66.4	38.4
Difference	absolute	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0
	%	0.0%	0.0%	0.0%	0.0%	0.0%	3.0%	0.0%	0.0%
2000	IIR 2024								
	IIR 2025	37.5	2.0	2.0	1.1	1.0	6.0	17.1	0.3
Difference	absolute	37.5	2.0	2.0	1.1	1.0	6.6	17.1	0.3
	%	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
2010	IIR 2024	0.0%	0.0%	0.0%	0.0%	0.0%	11.5%	0.0%	0.0%
	IIR 2025								
Difference	absolute	40.1	2.2	2.2	1.2	1.1	6.7	3.5	0.3
	%	40.1	2.2	2.2	1.2	1.1	7.5	3.5	0.3
2020	IIR 2024	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
	IIR 2025	0.0%	0.0%	0.0%	0.0%	0.0%	11.8%	0.0%	0.0%
Difference	absolute								
	%	30.0	1.5	1.3	0.7	0.7	4.3	3.4	0.1
2022	IIR 2024	30.3	1.6	1.5	0.8	0.8	4.8	3.3	0.2
	IIR 2025	30.3	1.6	1.5	0.8	0.8	5.4	3.3	0.2
Difference	absolute	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0
	%	0.0%	0.2%	0.0%	0.0%	0.0%	13.9%	0.3%	-0.2%

11.2 Planned improvements

The remaining actions with respect to content will be prioritised and are planned for implementation in future inventories. Appendix 4 includes relevant plans that result from review recommendations but may not yet have been implemented in this submission.

11.3 Status of implementation of review recommendations

Appendix 4 describes the status of implementation of review recommendations. This includes tables showing an overview of the implementation of actions from the NECD-2024 inventory review, EMEP-2024 inventory review, NECD-2021 LPS review, NECD-2021 gridded data review, and the NECD-2023 projections review.

12 Projections

12.1 Projected trends in emissions of air pollutants for the Netherlands

Air pollutant emissions, especially NO_x, $PM_{2,5}$ and SO_x, have been declining steadily over the last two decades. Restriction of emission limit values has played a major role and resulted in abatement technologies, such as the application of $DeNO_x$, and application and/or switching to cleaner fuels. The emission of NH_3 declined since 2000 up until 2013, resulting in stagnation. This stagnation is mainly due to the abolition of milk quota, which ultimately led to growth for dairy cattle farms up until 2017. Emissions of NMVOC declined steadily, due to policies focused on NMVOC up until 2004. From that moment onwards, this decline has decreased.

This trend of declining air pollutant emissions in the past will continue in future according to these projections under the *WaM scenario*, for all relevant NEC pollutants. It is remarkable that according to current projections for NO_x and NH_3 for the 2022–2030 period, the relative pace of this reduction will increase. For NO_x, this is the result of an intensifying reduction for vans and seaborne shipping and remains strong due to electrification in (cargo) road transport. For NH_3, current projections are the result of a decrease of cattle stock, due to diminution and expiration of the (manure) derogation for the Nitrates Directive, as well as various buyout schemes to terminate cattle and livestock farming. In the long run, NH_3 reduction is not very strong, since most relevant policies are applicable for the 2022–2030 period.

This trend of declining air pollutants contributes to cleaner air and a reduction of nitrogen deposition on nature. Moreover, the NEC targets in place for 2030 and beyond are extremely likely to be met according to both the *WM scenario* and the *WaM scenario* (see Table 12.1). The reason for meeting these targets is, among others, that by the time of agreement in 2016, only limited co-benefits could be taken into account as a result of (the restriction of) climate and energy policies, as well as national nitrogen policies. Despite the contribution of this declining trend to cleaner air and nature and meeting the NEC targets, the nitrogen deposition targets according to the Environmental and Planning Act of the Netherlands will not be met.

12.2 Projections have been prepared in the framework of the Netherlands Climate and Energy Outlook 2024

The emission projections of air pollutants for the IIR 2025 have been prepared within the framework of the Netherlands Climate and Energy Outlook 2024 (PBL, TNO, CBS & RIVM, 2024). This Outlook is called Klimaat- en Energieverkenning 2024 in Dutch, abbreviated as ‘KEV2024’. The projections in this report are consistent with the projections of energy and greenhouse gas emissions for the Netherlands. Projections of air pollutants in the Netherlands have been prepared for target year 2030 as well as for 2035. For 2040, a qualitative perspective on future trends has been drafted.

The preparation of the Outlook is the responsibility of the Netherlands Environmental Assessment Agency (PBL) in cooperation with the National Institute for Public Health and the Environment (RIVM) and the Netherlands Organisation for Applied Scientific Research (TNO).

The corresponding KEV 2024 report can be found on the website of the PBL (https://www.pbl.nl/kev (in Dutch), an English summary is available). Underlying reports and datasets for the KEV can also be found on this website (via the links https://www.pbl.nl/kev/publicaties and https://www.pbl.nl/kev/rekenmodellen-klimaat-en-energieverkenning-kev (in Dutch)), including:

- a description of the model system used for calculating projections of greenhouse gases and air pollutants;
- a complete overview of all policies and measures that have been taken into account, with detailed descriptions of the assumed effects.

For international reporting to the European Commission, an English report has been written for the National Energy and Climate Plans, which is available here. A substantial part of this report is based on the KEV2023, thus providing insights into relevant aspects of the Dutch climate and energy outlooks.

12.3 National report with projections for air pollutants

The projections for the emissions of air pollutants are described in the report 'Emissieramingen luchtverontreinigende stoffen 2025' (PBL, 2025a; in Dutch). This report describes the emission trends starting from the base year 2022 up to the year 2030 and 2035 for the five air pollutants under the new National Emission reduction Commitments Directive (NEC Directive, 2016/2284/EU), i.e. NO_x, NH_3, $PM_{2.5}$, SO_x and NMVOC. In addition projections have been prepared for PM_{10}. A qualitative perspective on trends up to 2040 has been included as well.

This outlook report complies with the requirement within the NEC Directive (Directive 2016/2284/EU) to report emission projections every two years. Moreover, these projections are required to calculate the future developments with respect to air quality and nitrogen deposition in the Netherlands.

Projected activity data can be found in the Annex IV reporting template.

12.4 Measures and policies

The submitted projections take into account all relevant information about measures up to 1 May 2024. Three projections haven been prepared:

- *Adopted policy* includes all climate and relevant environmental policies implemented on 1 May 2024. This projection has been used to report according to the *With Measures (WM)* scenario, according to the guidelines for international reporting.
- *Planned policy* includes all climate and relevant environmental policies that, by 1 May 2024, had been made public, officially announced in Letters to Parliament and worked out in sufficient detail. This projection has been used to report according to the

With Additional Measures (WAM) scenario, according to the guidelines for international reporting.
- *Proposed policy* includes policy plans and intentions that, by 1 May 2024, had been made public, but had not yet been worked out in sufficient detail. This projection, including proposed policies, has been prepared for the first time. This has been executed to provide additional information to Dutch policy makers concerning the possible impacts of (so-called 'non-specific') measures that still have to be worked out properly. This is mainly relevant for the governmental plans of the current Cabinet-Schoof, which were published around 1 May 2024. This projection has not been used for international reporting.

Most of the content of the Dutch reports serving the Netherlands Climate and Energy Outlook 2024, is based on the *adopted policies (i.e. WM scenario)* and *planned policies (i.e. WAM scenario)*, including detailed calculations for the outlook report.

Part of the proposed policy measures have only been assessed with respect to a conceivable emission reduction impact by 2030. For several other measures, no assessments have been made for the *proposed policy* projection due to insufficient information. Proposed measures are clearly different from planned measures; therefore, they have not been incorporated into the reported WAM scenario.

The projections made for the *adopted policies (i.e. WM scenario)* and *planned policies (i.e. WAM scenario)* have been used for the published outlook report and for this IIR. The projections reported in this IIR are the adopted (WM) and the planned (WAM) projections, and these are fully consistent (concerning policy definitions) with Dutch projections in previous IIR-reports. Several climate and energy policies and measures are incorporated into the calculated emission trends for the relevant air pollutants. Also, relevant national (adopted and planned) environmental policies have been incorporated into the emission projections, such as measures stemming from the Dutch air quality agreement and the Dutch action plan to tackle nitrogen pollution in Natura 2000 conservation areas. A full overview of relevant climate and energy policies and environmental policies has been published in the side publication for the KEV *'Beleidsoverzicht en factsheets beleidsinstrumenten'* (PBL, TNO & RIVM, 2024; in Dutch). In this publication, substantial background information has been provided for individual policy measures in factsheets.

The complete list of (environmental) policies included in the KEV2024 projections is presented in tables 1.1 and 1.2 of the referenced report (PBL, TNO, CBS & RIVM, 2024; in Dutch).

Relevant climate and energy policies, which have been incorporated into the *WM scenario* and the *WAM scenario* include:
- SDE++ subsidy scheme to stimulate renewable energy and CO_2 reduction techniques; this is the major subsidy scheme for renewable energy in the Netherlands;
- Various other financial instruments, such as the European Emission trading scheme (ETS), deployment of ETS2 scheme, a

national CO_2 tax for industry and greenhouse horticulture, energy taxes, subsidy schemes, tax reduction schemes for energy-saving technologies. These schemes include various, recent modifications;
- Ban on coal-fired power plants by 2030 and recent developments with respect to the development (and delays) of large projects for renewable energy, e.g. large wind farms;
- Various regulations and subsidy schemes for the built environment, including Ecodesign requirements, policies to stimulate insulation and district heating and policies to abandon the use of natural gas for new buildings;
- Various regulations and subsidy schemes for mobility, including policies with respect to biofuels, RED III, electric vehicles, restriction of the number of flights at Amsterdam Airport Schiphol, zero-emission zones in cities for delivery vans and trucks and levies on heavy duty trucks, policies to make inland and seaborne shipping more sustainable;
- Various regulations and subsidy schemes for the industry, greenhouse horticulture and agriculture, including stimulation to implement CCS, sustainable hydrogen production, stimulation of a circular economy and LULUCF-related policies.

Several environmental policies and measures are included in the *WM scenario.* The most relevant include:

Sector Industry:
- Amendment of generic emission requirements following the Environmental Activities Decree (in Dutch: Besluit Activiteiten Leefomgeving).

Sector Mobility:
- Roadmap and covenant clean and zero-emission construction (targeting non-road mobile machinery for construction)
- Temporary subsidy scheme for shore power for sea-borne vessels 2024–2026;
- Euro7 requirements for road transport;
- Restriction of EU CO_2 emission limit values for heavy-duty road transport beyond 2030;
- Subsidy Scheme for Limitation of energy use in the fishery sector (ENERGIEVIS);
- Sustainability scheme diesel traction for railways Zutphen-Oldenzaal and Almelo-Mariënberg.

Sector Agriculture:
- Regulation and buy-out schemes to terminate cattle farming (in Dutch: Lbv);
- Regulation and buy-out schemes to terminate cattle farming targeted at locations with emission peaks (relating to Natura2000 protected areas; in Dutch: Lbv-plus);
- Subsidy and switch-over schemes to implement sustainable agricultural practices;
- Regulation for provincial measures for permit holders, whose permits turn out to be non-viable due to nitrogen policies (in Dutch: Regeling provinciale maatregelen PAS-melders);

- Provincial acceleration measures for the National Programme Rural Areas (in Dutch: Versnelling NPLG);
- Diminution and expiration of the (manure) derogation for the Nitrates Directive (in Dutch: vervallen derogatie onder Nitraatrichtlijn).

Several environmental policies and measures are included in the *WAM scenario.* The most relevant include:

Sector Mobility:
- Expansion of subsidy scheme for sustainable inland shipping (in Dutch: SRVB);
- Temporary subsidy scheme for shore power for sea-borne vessels 2024–2026;
- CO_2 differentiation truck levies and backflow of these revenues to support sustainable freight traffic.

Sector Agriculture:
- Decrease of the amount of pig rights and poultry rights (this targets the maximum amount of animals that may be kept in livestock farming);
- Faster decrease of the amount of phosphate rights of dairy cattle upon trading these rights (this targets the maximum amount of cattle that may be kept in dairy cattle farming);
- Restriction of the emission limit values for particulate matter at poultry stables;
- Blending obligation of renewable (green) gas.

As mentioned before, a third scenario called proposed policies, includes policy plans and intentions that, by 1 May 2024, had been made public, but had not yet been worked out in sufficient detail. This is mainly relevant for the governmental plans at that time of the current Schoof Cabinet, but not restricted to these. This scenario includes some plans under the Clean Air Agreement (in Dutch: Schone Lucht Akkoord) and the revision of the Industrial Emissions Directive. But it also includes some intentions of the current cabinet, e.g. increasing the maximum speed on highways, the reintroduction of duty-free diesel for agriculture and the reintroduction of the original derogation under the Nitrates Directive. This projection has not been used for international reporting in this report. If policies will be worked out in more detail, these intentions will be included under the *WM* and *WAM scenarios* for the IIR publication in 2027.

Table 12.1 Results of NEC emissions for the WAM (With Additional Measures) scenario according to European definitions (i.e. NEC Directive) for 2030 and 2035

	2005	2022	Projection 2030	EU NEC target 2030	Projection 2035
NO_x	395	162	118 [109-129]	154	94.9
NH_3	155	121	101 [95.8-107]	122	97.6
$PM_{2.5}$	28.5	14.3	12.6 [11.1-14.0]	15.7	11.8
SO_x	67.9	19.6	16.7 [12.3-18.5]	31.9	15.2
NMVOC	204	154	153 [148-160]	173	148

The numbers within brackets represent the calculated uncertainty of this projection, which has only been determined for 2030. The NEC emissions for 2005 and 2022 are based on emissions inventories that have been used for the projections (statistics from the Dutch emission inventory as reported in February 2024). The target for 2030 has been calculated according to the NEC Directive and represents the maximum allowed emissions for the Netherlands. All numbers are expressed in Gg.

12.5 Projection totals for compliance checking NEC-targets 2030

In Table 12.1 the projection results for the *WAM scenario* are summarised according to European definitions. European definitions mean that calculations have been performed according to definitions as prescribed in the NEC Directive (Directive 2016/2284/EU) and not according to the definition for Dutch territory. This means, for example, that international maritime traffic is not taken into account (aircraft emissions beyond the landing and take-off cycle are not taken into account for either definition). Also, the emissions of NO_x and NMVOC from manure management and agricultural soils (NFR 3B and 3D; Sector Agriculture) are exempted from the compliance totals. Lastly, emissions from road transport are calculated on the basis of fuel sold; hence, not on the amount of driven kilometres. The EU NEC targets in Table 12.1 have been calculated using reduction percentages according to the NEC Directive (Directive 2016/2284/EU) and represent the maximum allowable emissions for the Netherlands.

The maximum emissions allowed (‘emission ceilings’) provided in Table 12.1 have been calculated on the basis of the statistics from the Dutch emission inventory as reported in February 2024. This has been done since projections are based on this inventory. It should be noted that projections given here for 2030 may not be compared to maximum allowed emissions in 2030 that are calculated on the basis of statistics from the Dutch emission inventory as reported in February 2025.

As can be seen in Table 12.1, the targets in place for 2030 and beyond are extremely likely to be met according to the *WAM scenario*.

12.6 Emissions uncertainty range for 2030

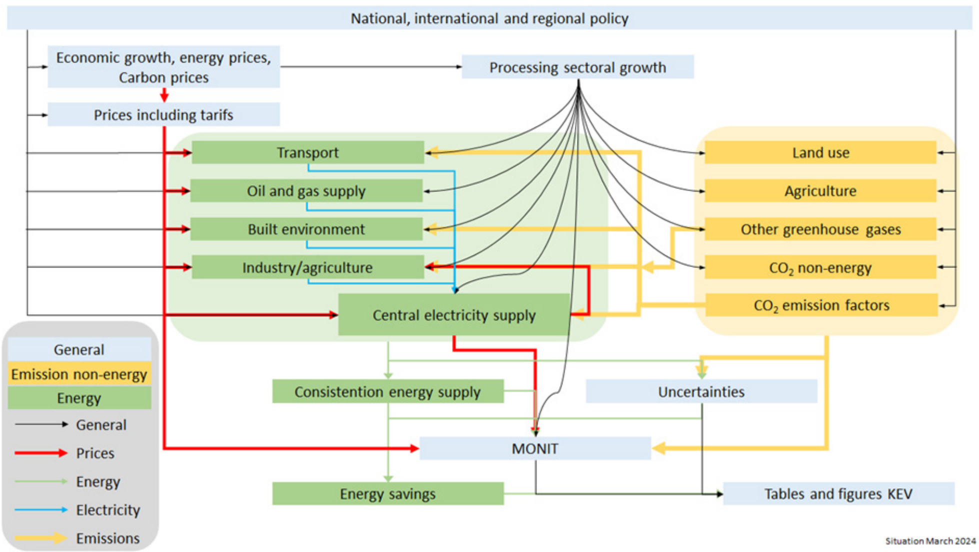
The projections are based on future expectations with respect to the development of various factors that determine the economy, energy system and emissions. These factors encompass developments of external factors, such as macro-economic developments, population growth and energy and CO_2 prices. The likely effectiveness of policy measures has also been estimated.

Uncertainties in relevant factors have been translated into consequences for emissions in 2030. For every factor and every pollutant, it has been estimated how much the emission could deviate (upwards and downwards) from the central projection, expressed as a point value. It has also been determined whether, how and to what extent one factor is interlinked with another factor. All this information has been brought together in a Monte Carlo uncertainty analysis. Separate analyses have been performed for the national NEC total and for the totals per KEV sector. The result is an uncertainty range with respect to the projected point values. The possibility of new policies coming in and/or the possibility that policies will stop have not been taken into account in the uncertainty analysis. The uncertainty range is calculated given the policies taken into account in the reported scenarios (WM and WAM). The uncertainty range only provides the uncertainty determined by external factors such as prices and economic developments and the uncertainty in the effectiveness for those measures that are included in the central projection. The uncertainty in the historical emissions of the emission inventory has been excluded from the uncertainty analysis.

12.7 Model descriptions

This section briefly describes the modelling system for projections of energy, greenhouse gas emissions and NEC emissions. In the Netherlands, a combination of modelling tools is used. The National Energy Outlook Modelling System (NEOMS) is the primary modelling suite, which has been developed for over twenty years by the Energy Research Centre of the Netherlands (ECN) and PBL Netherlands Environmental Assessment Agency for projections and policy evaluations. In 2018, the NEOMS was transferred to PBL.

National Energy Outlook Modelling System
NEOMS is a suite of models to simulate the various parts and sectors of the Dutch Energy System (PBL, 2025b). Some constituent models have been developed in spreadsheets (Excel) and Python, some are optimisation models developed in AIMMS or GAMS. While each model is unique, the general starting point is a detailed inventory of the existing portfolio of (economic) activities in all sectors, such as industrial production, transportation volumes, etcetera. The models translate the activity levels in an (projected) energy demand and supply, using assumptions on energy prices, policies and technologies. The models are calibrated using recent national statistics on energy demand and supply, investments, added value and data available from other sources (e.g. world market prices for oil, gas and coal from IEA and futures markets, monitoring of government programmes). Building on the drivers for developments in the energy system, such as economic growth, population growth, behavioural change and technological development – some as endogenous efforts, some defined exogenously – the models simulate the development of the system, activity levels and the uptake of alternative technologies therein, taking into account consumer preferences and market behaviours and the impact of policies thereupon. Combining expected technology deployment and the demand for various products and energy services results in projections of final and primary energy consumption, greenhouse gas emissions and air pollutants. Most energy demand and supply models provide data on investment costs and costs for operation and maintenance.



NEOMS enables the exchange of data between twelve energy models, producing consistent and detailed results. Detailed results include energy demand, supply, emissions, technology uptake, investments, costs, prices, policy impacts. The total system includes about twenty-two sub-sectors including all relevant technologies and fuels per sub-sector. Their CO_2 emissions are also calculated.

The NEOMS models currently cover the following sectors and their corresponding models:

- Energy demand
- Industry and agriculture (E2-Mission)
- Service sector (SAVE-Services)
- Households (Hestia and EVA)
- Transport (various models)
- Energy supply
- Combined heat and power (E2-Mission)
- Electricity supply (Competes)
- Refineries (SERUM)
- Renewables (RESolve-E and E2-Mission)
- Gas and oil supply

The outputs of the separate models are combined in a model of the total energy sector (SELPE) in which the validity and consistency of the energy system as a whole is verified. Ultimately, all the results feed into MONIT-Conversion, a tool that calculates the energy savings per sector and produces aggregated results for all kinds of analyses, for example for the presentation tool MONIT.

Energy demand
E2-Mision (industry, agriculture and CHP)
E2-Mission is a simulation model that calculates the energy demand of industry and agricultural sectors and the sectoral implementation of combined heat and power generation. The

future energy demand is calculated on the basis of the economic growth per subsector and the measures taken.

SAVE-Services (services sector)
SAVE-Services is a simulation model for the services sector. On the basis of the economic growth per subsector and the measures taken, the model calculates future gas and electricity demands.

Hestia (households)
Hestia models the energy efficiency of the housing stock and simulates the investment behaviour of home owners at the level of individual houses. The model calculates the development of the gas, electricity and heat consumption until 2050. Hestia is open source and open access.

EVA (households)
EVA uses a detailed stock database to calculate the national electricity use of household appliances. EVA offers a detailed view on the impact of changes in the penetration of appliances and autonomous or policy driven (mostly 'Ecodesign') changes in energy consumption.

Transport
The transport model is a tool to incorporate the results of the calculations of all kinds of models specific to the transport sector used at PBL into the databases of NEOMS. This enables the other models to use this data for their calculations.

Energy Supply
COMPETES (electricity supply)
COMPETES is used to calculate decisions in investments and operations for centralised electricity production in the EU. On the basis of the Dutch sectoral electricity demand, hourly electricity production from intermittent renewables and sectoral implementation of combined heat and power, the remaining demand is covered by COMPETES, taking into account the merit order of the supply curve of centralised electricity generators and electricity trade with neighbouring countries. COMPETES also provides the commodity prices for electricity.

SERUM (refineries and oil supply)
SERUM is an optimisation model for the Dutch oil refining sector. On the basis of expectations about the demand for oil products, environmental measures and crude properties, SERUM calculates the required crude intake, the required refining configuration and the energy use for the entire process. On the basis of energy use and energy carriers, emission developments are calculated.

RESolve-E (renewables)
The aim of the RESolve-E model is to provide data about renewable energy production, including biomass combustion in various types of (medium-sized) combustion installations. It is

noted here that, due to closure of coal-fired power plants in 2030 in the Netherlands, by 2030 biomass co-firing will no longer be eligible either.

For the renewable energy production that is eligible to receive a subsidy via the SDE subsidy scheme, the SDE budget constitutes a ceiling for the total production. Because renewable energy can contribute to realising the energy performance coefficient standards for new buildings, the renewable energy production of Hestia and SAVE-Services serve as input for RESolve-E. Many renewable energy technologies have been transferred from RESolve-E to E2-Mission, so RESolve-E does not cover heat production technologies anymore. Ultimately, RESolve-E will be fully incorporated into other models (e.g. E2-Mission, COMPETES).

Gas/oil production (gas and oil supply)
In this model, the supply of natural gas and crude oil is calculated on the basis of the availability of natural gas in the 'Groningen' gas field, and other onshore as well as offshore fields for gas and oil. Exogenous assumptions are made about the volume for gas storage, gas export and oil export. If demand exceeds this production, natural gas and oil will be imported. The model calculates the amount of energy needed for production, storage and transport as well as losses in the grid.

Other models and tools in NEOMS
Energy prices
The energy prices tool provides electricity and gas prices for the various sectors as defined in NEOMS. This data can be used by the NEOMS models.

SELPE (validity and consistency check)
SELPE is an optimisation model that is used to model the entire Dutch energy sector. Most of the constraints are set by the above-mentioned models. The aim of this model is to check the feasibility and consistency of the outcomes of the other models, for example verifying that the total electricity demand does not exceed the electricity supply.

MONIT
The output of the SELPE model is very detailed. MONIT-Conversion can aggregate its results into any format needed by the user. The output is made available to MONIT and can also be made available to external parties. Another function of this tool is to calculate the energy efficiency indicators. The tool is used to present the combined results of the models in such a way that they can be used in all kinds of reports, together with historical data.

NEC-emissions calculations relating to energy use
The NEC emissions, i.e. NO_x, NH_3, $PM_{2.5}$ (and PM_{10}), SO_x and NMVOC, relating to energy use, are calculated in line with the

results of all afore-mentioned models. Statistics of point sources, as well as inventories of installations and its characteristics, are combined with projected energy use, emission factors and the potential effect of policies, if deemed relevant. To that purpose, spreadsheet tools have been developed and are kept updated.

Non-energy models
The results from NEOMS are used and/or complemented with the modelling of non-CO_2 emissions and non-energy-related CO_2 emissions (LULUCF). This is achieved using sectoral models (agriculture and LULUCF) and spreadsheet tools (industry and other sectors).

Agriculture
For the calculation of the agricultural emission projections, the National Emission Model for Agriculture (NEMA) is used (Van der Zee et al., 2024). NEMA models CH_4, NH_3, N_2O, NO_x, PM_{10}, $PM_{2.5}$ and CO_2 emissions from agriculture using a methodology in compliance with the IPCC and EMEP Guidelines. Usually, the model runs with historical input data calculating the emissions for the National inventory report and the Informative inventory report. Input data for projections is based on the estimated effects of existing policies and expert judgement using other models, research and historical trends. Institutes involved in estimating input data are Wageningen Economic Research, Wageningen Environmental research, Wageningen Livestock Research and PBL.

12.8 Role of biomass in the projection

As mentioned before, biomass combustion in various types of (medium-sized) combustion installations is determined using the RESolve-E model. This is relevant because this type of renewable energy is mainly determined by the subsidy scheme SDE++. Since various categories, in particular the ones for solid biomass combustion in medium-sized combustion installations, have been closed in this subsidy scheme, biomass combustion does not have a significant role in the projections.

It is noted here that due to closure of coal-fired power plants in 2030 in the Netherlands, by 2030, biomass co-firing will no longer be eligible either.

Wood combustion in domestic dwellings is calculated and projected using a separate model. This model calculates the total amount of wood use on the basis of wood consumption per hour of each type of stove and the operating hours per year per stove. The input is updated on the basis of regular surveys made by Statistics Netherlands (CBS) (Jansen, 2016; Visschedijk & Dröge, 2020; Visschedijk & Dröge, 2024).

12.9 Role of waste in the projection

Waste processing has not been mentioned specifically in former model descriptions. In general, a large part of Dutch household waste, such as glass, paper, compostable waste and plastic waste, is collected separately to facilitate substantial recycling. Household residual waste is incinerated in dedicated waste incinerators, which need to meet strict emission requirements. These waste incinerators often produce power as well as heat for district heating. Waste incinerators, and their respective emissions, are incorporated into the afore-mentioned spreadsheet tools to calculate NEC emissions relating to energy use.

For historical reasons, the Netherlands had excess capacity of waste incinerators, which it used to incinerate foreign waste. The Dutch government regards this as detrimental and discourages this by putting a tax on imported waste. Due to this policy, the amount of imported waste has been declining since 2018. The outlook for inland supply of household waste will depend on developments and policies with respect to recycling and circularity, but its effects remain uncertain. Therefore, it is assumed for this outlook that waste supply will remain at its current level, which means that future waste incineration will remain stable. Since a decline of waste supply may also be anticipated, a future decrease in waste incineration has been adopted as part of the uncertainty analysis. As mentioned before, due to regulations, waste incineration in the Netherlands is a relatively small source of environmental emissions.

13 Adjustments and Compliance

13.1 Compliance with the emission reduction targets

In 2001, being an EU Member State, the Netherlands adopted the NECD (National Emission reductions Commitments Directive) 2001 (EU, 2001), which was replaced by the revised NECD 2016 (EU, 2016). In 2017, the Netherlands signed and ratified the amended text on the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (UNECE Gothenburg Protocol). Both the NECD and the Gothenburg Protocol commit the Netherlands to reducing its NO_x, SO_x, NMVOC, NH_3 and $PM_{2.5}$ emissions to the agreed national reduction targets for the years 2020–2029 and for 2030 and beyond, compared to the 2005 emissions.

Both for the Gothenburg Protocol and the NECD, the Netherlands has opted to calculate the compliance totals on the basis of fuel sold.

The emission reduction targets for both the NECD and the Gothenburg Protocol amount to the same percentage for each pollutant. However, for NO_x and NMVOC, there is a difference between the NECD and the Gothenburg Protocol regarding the calculation of the emission totals for compliance checking. Under the NECD, the emissions of NO_x and NMVOC from manure management and agricultural soils (NFR 3B and 3D; Agriculture Sector) are exempted from the compliance total, whereas these sources are included in the Gothenburg Protocol.

Under the NECD, the emissions of NO_x, NMVOC, NH_3, SO_x, and $PM_{2.5}$ comply with the 2020–2029 reduction targets (Table 13.1).

Table 13.1 Compliance under the NECD

	NECD emissions reduction targets, compliance total and achieved reductions									
	Target 2020-2029 (compared to 2005)	Compliance total (Gg)					Achieved reduction			
Pollutant		**2005**	**2020**	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	**2023**
NO_x	**-45%**	396.6	175.0	170.8	159.5	151.7	56%	57%	60%	62%
NMVOC	**-8%**	202.2	165.2	152.6	153.1	152.8	18%	25%	24%	24%
SO_x	**-28%**	67.8	19.6	20.9	19.6	17.5	71%	69%	71%	74%
NH_3	**-13%**	155.2	124.6	122.9	120.4	116.4	20%	21%	22%	25%
$PM_{2.5}$	**-37%**	28.4	14.2	14.4	14.1	13.8	50%	49%	50%	51%

Under the Gothenburg Protocol, the Netherlands did not comply with the NMVOC reduction target for the year 2020 (Table 13.2).

Table 13.2 Compliance under the Gothenburg Protocol

Gothenburg Protocol emissions reduction targets, compliance total and achieved reductions										
	Target 2020-2029	**Compliance total (Gg)**					**Achieved reduction**			
Pollutant	**(compared to 2005)**	**2005**	**2020**	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	**2023**
NO_x	**-45%**	432.3	209.0	204.0	191.6	183.8	52%	53%	56%	57%
NMVOC	**-8%**	268.1	252.9	239.6	240.1	238.4	6%	11%	10%	11%
SO_x	**-28%**	67.8	19.6	20.9	19.6	17.5	71%	69%	71%	74%
NH_3	**-13%**	155.2	124.6	122.9	120.4	116.4	20%	21%	22%	25%
$PM_{2.5}$	**-37%**	28.4	14.2	14.4	14.1	13.8	50%	49%	50%	51%

13.2 Adjustment under the Gothenburg Protocol

Decision 2012/3 (UNECE, 2012) of the Executive Body stated that as a flexibility mechanism adjustments can be made to the emissions inventory for demonstrating compliance with the emission reduction targets. Under specific circumstances, such adjustments allow a Party to report national emission estimates, which differ from their best science national emission estimates, for compliance purposes.

The 2013 EMEP/EEA Guidebook implemented a default methodology and default EFs for NMVOC from animal husbandry and manure management. In 2017, this resulted in the inclusion of the NMVOC emissions from agriculture into the emission inventory as best science estimate, as described in Chapter 6. Thus, the NMVOC emissions from these sources were not accounted for at the time when emission reduction commitments were set. For this reason, this new NMVOC source is eligible to be applied as an adjustment to the inventory for the purpose of demonstrating compliance to the reduction targets.

In the 2022 submission, the Netherlands applied for an adjustment for NMVOC emissions from source category 3B1a (Manure management – Dairy cattle) for the years 2005 and 2020. The adjustment was approved following review. For source explanation and methodology, we refer to Chapter 6 (Agriculture).

In this 2025 submission, an adjustment is again needed for 2020. The same adjustment is applied that was approved in 2022. The NMVOC emission from 3B1a differs slightly from the emission reported in the 2022 submission. This is due to recalculations that were introduced and explained in the 2023 and 2024 submissions. In the 2025 submission, no new recalculation for sector 3B1a has been introduced.

When the approved adjustment is applied to the inventory, compliance is achieved for the year 2020, as presented in Table 13.3.

Table 13.3 Compliance under the Gothenburg Protocol with the inventory adjustment approved in 2020

NMVOC Compliance and adjustment under the Gothenburg Protocol						
Year	**Inventory total**	**Reduction Target**	**Unadjusted reduction**	**Adjustment NFR-3B1a**	**Adjusted Compliance total**	**Reduction with adjustment**
	(Gg)	**%**	**%**	**(Gg)**	**(Gg)**	**%**
2005	**268.1**	**-**	**-**	**24.2**	**243.8**	**-**
2020	252.9	8%	6%	43.6	209.3	14%
2021	239.6	8%	11%	-	-	-
2022	240.1	8%	10%	-	-	-
2023	238.4	8%	11%			

14 Spatial Distributions

14.1 Background for reporting

In 2025, the Netherlands reported geographically distributed emissions to the UNECE LRTAP Convention for the year 2022. The data delivered consists of two separate sets, one for Large Point Sources (LPS) and one dataset aggregated at NFR level and spatially distributed at the EMEP 0.1°x0.1° longitude-latitude grid. The NFR data also includes the LPS data. Substances reported are NO_x (as NO_2),NMVOC, SO_x (as SO_2),NH_3, $PM_{2.5}$, PM_{10}, Black Carbon (BC), CO, Pb, Cd, Hg, PCDD/PCDF (dioxins/ furans), PAHs, HCB and PCBs. Guidelines for reporting air emissions at grid level are provided in Spatial Mapping of emissions in the EMEP/EEA air pollutant emission inventory guidebook 2023 (EEA, 2023). Gridded emission data is used in integrated European air pollution models, e.g. GAINS and EMEP's chemical transport models. The aggregated sectors, 'gridded NFR' (GNFR), for reporting are defined in table I of annex IV to the Guidelines for reporting emission data under the Convention on Long-Range Transboundary Air Pollution (EEA, 2023).

The supplied LPS and NFR data originate from one and the same dataset, the dataset '1990-2022 definitive' of the Netherlands Emission Inventory. This means that the data is mutually consistent with each other; there are no differences between the emissions from the deliveries and the emissions as recorded for the relevant dataset in the emission inventory.

14.2 Methodology for disaggregation of emission data

Energy, Industrial Processes and Product Use
For energy and industrial processes, the vast majority of emissions (80-90%) can be directly linked to large companies with a reporting obligation. The remaining part of the emissions is distributed across the locations of smaller companies on the basis of the number of jobs.
The company locations are well known, but the data on the number of employees is sometimes outdated. In addition, the number of jobs is only partly representative of the company emissions. Therefore, this method is classified as Tier 1. See this link for the factsheet.

Transport
For inland shipping, recreational shipping and fishing, AIS (Automatic Identification System) data is used for the spatial distribution, which provides a direct picture of the position and speed of a ship.
By linking this data to data on ship types and derived emission factors, an accurate picture of the emission totals and the spatial distribution is created. Given their accuracy, these distributions can be considered Tier 3. More information can be found here.
For road traffic an advanced traffic model is used for spatial distribution, which is largely fed with navigation and mobile phone data. That is why this distribution method is also considered Tier 3.
For aviation, the data for Schiphol (which has by far the largest share in aviation emissions) is accurately recorded and is classified as Tier 3.

For railways, data on the number of trains per railway section is used. This data provides a good picture of the distribution, but is a few years old, hence Tier 2.

The distribution of emissions by mobile equipment is linked to agricultural land use for agriculture, and to business locations and jobs for industry. Since both distributions are less accurate, they are classified as Tier 1. For mobile equipment in construction, TNO has developed a specific method to be able to localise and quantify the use of this equipment. This distribution is estimated as Tier 2.

Agriculture
Within the agriculture category, the distribution of emissions from stables and storage uses animal numbers and emission factors per stable type from the Geographic Information System for Agricultural Businesses (GIAB). For emissions from the application of (artificial) fertiliser on the land, the results of the Initiator model are used. Both methods have been specifically developed to provide the most accurate possible picture of the spatial distribution and are classified as Tier 3. Emissions from tillage and harvesting are linked to agricultural land use files. Since this distribution is somewhat less specific, it is classified as Tier 2.

Waste Management
Waste incineration plants in the Netherlands have a reporting obligation, which means that both location and emissions are known. The same applies to sewage treatment plants. Emissions from landfills are distributed on the basis of data on released and flared landfill gas. This method is estimated as Tier 2, which also applies to the emissions from the processing of GFT, which is related to the amount of processed waste per location.

14.3 Method changes in spatial distribution

Since the last delivery in 2021 with spatially distributed data for 2018, there have been a number of method changes regarding the spatially distributed emission data. For road traffic, a new model has been used to map the distribution of traffic intensity on the roads in the Netherlands. A clear difference with the previous model is the use of 'real-time data' based on navigation and mobile phones to visualise the distribution. This means that the distribution is even more in line with the actual traffic intensity, especially on non-motorways. For inland shipping, the distribution of emissions was based on model calculations with the Inland Shipping Analysis System (BIVAS) of Rijkswaterstaat. However, for 2022, just like for sea shipping, AIS (Automatic Identification System) data is available, which means that the distribution can be based on the actual number of ships and the actual sailing speed and ship type. For the distribution of emissions at Amsterdam Airport Schiphol, new data from the Netherlands Aerospace Centre (NLR) was used for 2022. In addition to flying (emissions during flight, braking and taxiing), this also includes emissions from platform traffic and the use of generators. The emission distribution for fisheries and agriculture (stables and storage, use of artificial and animal manure) was recalculated on the basis of new data in combination with the most recent versions of the models used for this purpose.

14.4 Maps with geographically distributed emission data

The maps below are examples of the disaggregated emission data based on the latest reporting data (2022) from the Netherlands Pollutants Release and Transfer Register. They all result from allocating emissions to the grid using the methods described above. The selected air pollutants are ammonia (NH_3), sulphur oxides (SO_x), nitrogen oxides (NO_x) and fine particulates ($PM_{2.5}$). Figures 14.1–14.4 represent the geographically distributed emissions for these air pollutants.

On a national scale, the agricultural sector is the main contributor to NH_3 emissions (Figure 14.1). Emissions of NH_3 are mainly caused by livestock farming and particularly by the handling of manure. Therefore, they are related to the storage and spreading of manure, as well as to animal housing (Van Bruggen et al., 2021). The burning of fossil fuels also emits NH_3. Therefore, some inland shipping routes and fishing grounds are visible in the map. There are no other large surface water sources that contribute to the national ammonia emission. Compared to other sectors, however, the emission quantities from inland shipping and fisheries are small.

Both SO_x and NO_x are predominantly emitted by transport; therefore, cities, main roads, airports and shipping routes are clearly visible in the maps (Figures 14.2-14.3). On the SO_x map, inland shipping routes stand out from the rest because more reduction measures were taken in other sectors than in inland shipping.

On the map of fine particulate matter (Figure 14.4), cities, airports, agriculture, main roads and shipping routes can all be recognised due to the fact that residential heating, agricultural animal housing, traffic and shipping are main sources of PM emissions.

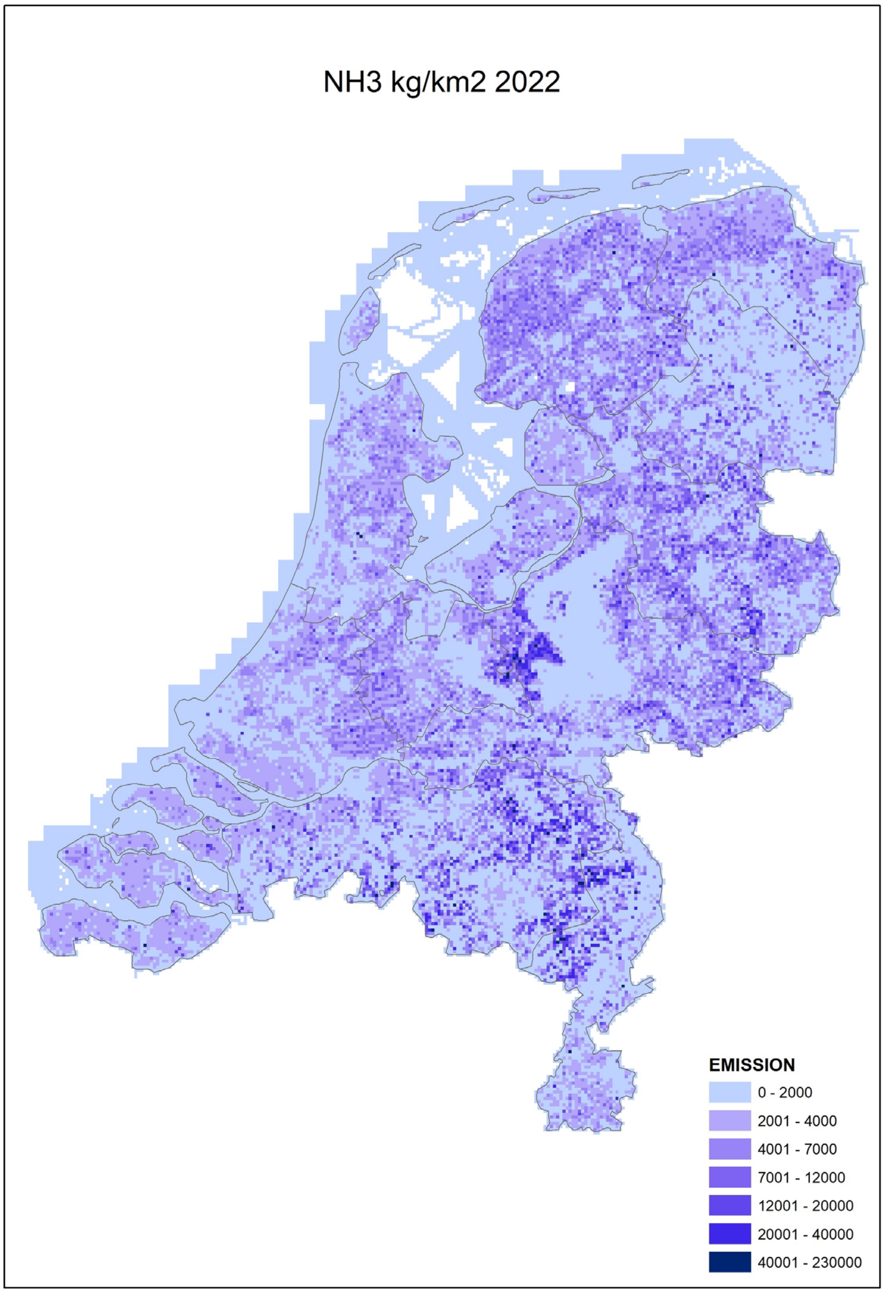


*Figure 14.*1 *Geographical distribution of NH_3 emissions in the Netherlands in 2022*

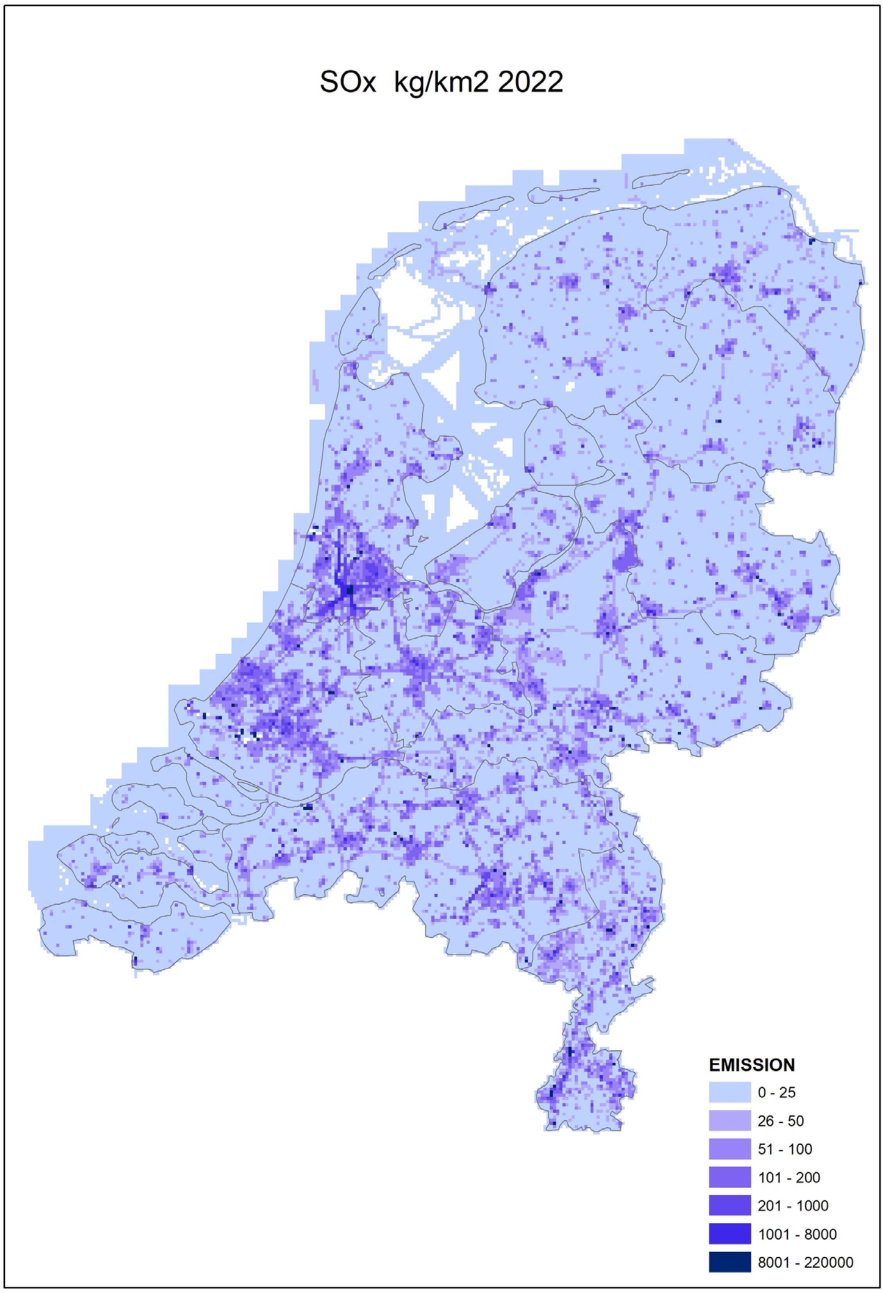


Figure 14.2 Geographical distribution of SOx emissions in the Netherlands in 2022

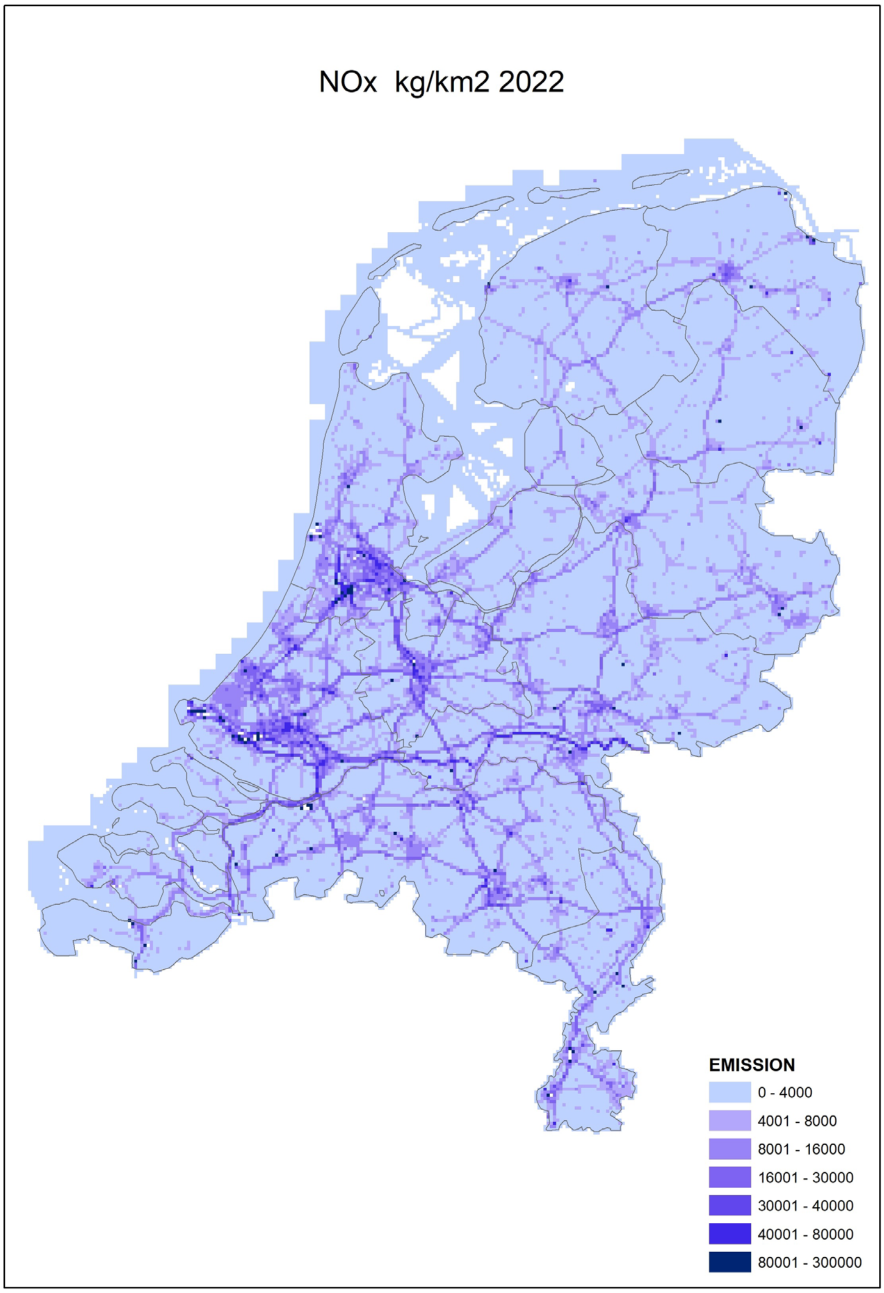


Figure 14.3 Geographical distribution of NOx emissions in the Netherlands in 2022

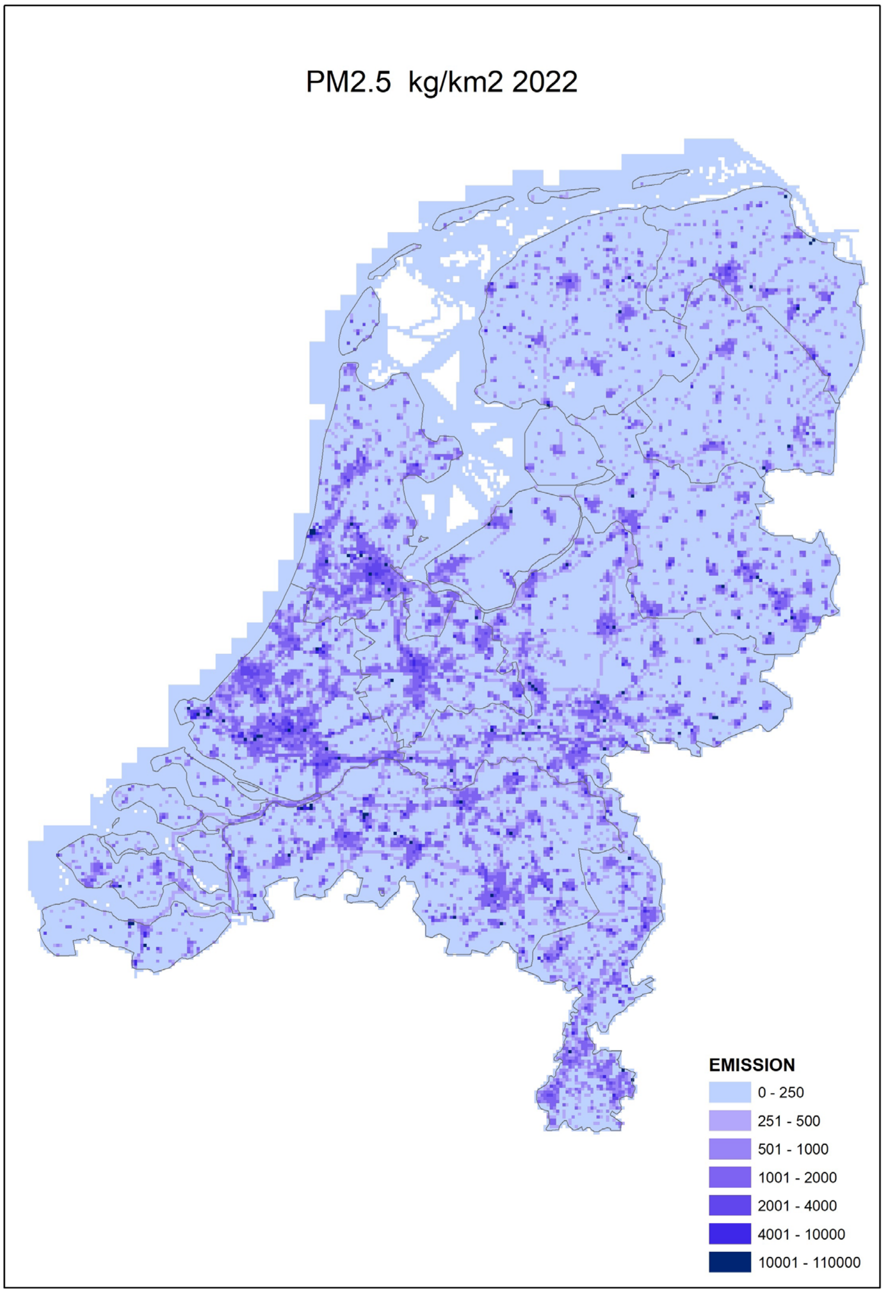


Figure 14.4 Geographical distribution of PM2.5 emissions in the Netherlands in 2022

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The emission and activity data of the Netherlands' inventory were converted into the NFR source categories contained in the Nomenclature for Reporting (NFR) tables, which form a supplement to this report. Also, the methodology reports are an integral part of the IIR report.

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Appendix 1 The use of notation keys 'IE' and 'NE'

Table A1.1 The Included Elsewhere (IE) notation key explained

NFR code	Substance(s)	Included in NFR code	Explanation
1A1c	All, except NO_x and SO_x	1A2a (all pollutants) and 1B2b (NMVOC)	The emissions from coke production are reported by the combined coke production and iron/steel production plant in the Netherlands. It is not possible to split the emissions into coke production and iron/steel production, and therefore the emissions of this source are reported in 1A2a. The emissions from the oil and gas industry are allocated to 1A1c (combustion emissions reported by gas companies using natural gas) and 1B2b (NMVOC fugitive emissions)
1A2a	NH_3, dioxin, PAH	2C1	Emissions are reported by the one iron and steel plant in the Netherlands. Distinction between combustion and process emissions is not always possible. When this is not possible, emissions of NH_3 are reported in 2C1.
1A2b	NH_3, dioxin, PAH	2C3, 2C5, 2C6, 2C7a	Emissions are reported by several non-ferrous plants in the Netherlands. Distinction between combustion and process emissions is not always possible.
1A2f	All	1A2gviii	Whether splitting these emission sources is possible is under evaluation by the specific task force.
1A3ei	All	1A2gviii, 1A4cii, 1B2b	Combustion and process emissions from pipeline transport cannot be split due to lack of detailed activity data.
1A5a	All	1A4ai	The emissions from military stationary combustion are included in 1A4ai.
1B1a	TSP, PM_{10}, $PM_{2.5}$	2H3	Only emissions from coal storage and handling occur. These cannot be separated from emissions of other storage and handling of dry bulk products, so are included in 2H3.
1B1b	All	1A2a	Emissions from coke production are reported by the combined coke production and iron/steel production plant in the Netherlands. It is not possible to split the emissions between coke production and iron/steel production, and therefore all emissions are reported in 1A2a.
1B2aiv	NO_x, SO_x, CO, TSP, PM_{10}, $PM_{2.5}$, BC, Dioxins and PAH	1A1b	Emissions are reported by the refineries in the Netherlands. Distinction between combustion and fugitive emissions is not always possible.

NFR code	Substance(s)	Included in NFR code	Explanation
1B2c	NO_x, NMVOC, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC, CO	NMVOC included in 1B2b; NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC and CO included in 1A1c	Combustion and process emissions cannot be split due to lack of detailed activity data.
2A2	All	2A6	Because of allocation problems, emissions from 2A2 are reported in the category Other mineral products (2A6).
2A5a	All	2A6	Because of allocation problems, emissions from 2A5a are reported in the categories 1A2gvii, 2A1, and 2H3.
2B1	All	2B10a	Because of allocation problems and for confidentiality reasons, emissions from 2B1 are included in Chemical industry: Other (2B10a).
2B2	All	2B10a	Because of allocation problems and for confidentiality reasons, emissions from 2B2 are included in Chemical industry: Other (2B10a).
2B5	All	2B10a	Because of allocation problems and for confidentiality reasons, emissions from Silicon carbide (2B5) are included in Chemical industry: Other (2B10a).
2B6	All	2B10a	Because of allocation problems and for confidentiality reasons, emissions from 2B6 are included in Chemical industry: Other (2B10a).
2B7	All	2B10a	Because of allocation problems and for confidentiality reasons, emissions from 2B7 are included in Chemical industry: Other (2B10a).
2B10a	NO_x, and SO_x	1A2c	Because it is not possible to split the SO_x and NO_x from chemical industry, all SO_x and NO_x emissions are reported in 1A2c.
2B10b	All	2D3i	Emissions from storage, handling and transport of chemical products are reported in 2D3i (other)
2C3	NO_x, and SO_x	1A2b	Because it is not possible to split the SO_x and NO_x from Aluminium production, all SO_x and NO_x emissions are reported in 1A2b.
2C4	All	2H3	For confidentiality reasons, emissions from 2C4 are included in 2H3.
2C7a	NO_x, and SO_x		The only Dutch copper producer does not report SO_x or PM emissions in its Annual Emission Reporting because they are below the EPRTR reporting threshold. These emissions are therefore not estimated (NE).

NFR code	Substance(s)	Included in NFR code	Explanation
2C7d	All	2H3	Because only emissions from the storage and handling of bulk products companies are available, emissions from 2C7d are reported in 2H3. The 2H3 subcategory in the Dutch PRTR includes, among others, emissions from the storage and handling of bulk products. Only companies that have the storage and handling of bulk products as their main activity are included in the 2H3 subcategory.
2D3g	NMVOC	2B10a	See IIR, Section 5.3.1.
2L	All	2H3	Because the 2016 Guidebook is not clear about which sources belong to 2L, 2L is included in 2H3 (Other industrial processes).
3B4a	all	3B1a and 3B1b	Little information is available for the years 1990-2015 on animal numbers and to create the most consistent time series emissions are included with cattle.
5A	BC	1A1a and 1A5a	Emissions from heat and power production are included in the sector Energy. See Chapter 7
5C1a	All	1A1a	All waste incinerators in the Netherlands produce heat and/or electricity. Emissions from heat and power production are included in the sector Energy.
5C1bi	All	1A1a	All waste incinerators in the Netherlands produce heat and/or electricity. Emissions from heat and power production are included in the sector Energy.
5C1bii	All	1A1a	All waste incinerators in the Netherlands produce heat and/or electricity. Emissions from heat and power production are included in the sector Energy.
5C1biii	All	1A1a	All waste incinerators in the Netherlands produce heat and/or electricity. Emissions from heat and power Production are included in the sector Energy.
5C1biv	All	1A1a	All waste incinerators in the Netherlands produce heat and/or electricity. Emissions from heat and power production are included in the sector Energy.
5C1bv	NO_x, SO_x, NH_3, BC and CO	1A1ai	The natural gas used for cremation cannot be split from the natural gas used for heating the crematoria buildings. Therefore, all emissions from natural gas combustion in this sector are allocated to 1A4ai.
5D1	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC and CO	1A4ai	Emissions from heat and power production are included in the sector Energy.
5D2	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC and CO	1A4ai	Emissions from heat and power production are included in the sector Energy.

Table A1.2 The Not Estimated (NE) notation key explained

NFR code	Substance(s)	Reason for non-estimation
1A1a, 1A1b, 1A2c, 1A2d, 1A2e	NH_3	Assumed negligible, no method available
1A1b, 1A2a, 1A3bi till 1A3biv, 2C1, 2C3	HCB	assumed negligible; no method available
2C5	PCBs	assumed negligible
1A2c, 1A2gvii, 1A3C, 1A3di(ii), 1A3dii, 1A4aii, 1A4bii, 1A4cii, 1A5b,	HCB and PCBs	assumed negligible
1A2d	Dioxins, PAHs, HCB and PCBs	assumed negligible
1A2e	Dioxins	assumed negligible
1A3ai(i)	NH_3 and Hg	assumed negligible
1A3aii(i)	NH_3, Cd, Hg, As, Cr, Cu, Ni, Se, Zn,	assumed negligible
1A3bv	Dioxins, PAHs and HCB	assumed negligible
1A3bvi	Hg, Dioxins and HCB	assumed negligible
1A3bvii	Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCB	assumed negligible
1B1a	NMVOC, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn	assumed negligible. For BC and metals no method available
1B2ai, 1B2av and 1B2b	SO_x, Dioxins	assumed negligible. No method available in the Guidebook
1B2c	Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs	assumed negligible. For PAH and dioxin, no method is available in the Guidebook
2C7a	Cd	assumed negligible
2D3b	NO_x, SO_x, NH_3, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs, HCB and PCBs	assumed negligible
2D3c	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs, HCB and PCBs	assumed negligible
3Da2a, 3Da2b, 3Da2c, 3Da3 and 3Da4	TSP, PM_{10} and $PM_{2.5}$	assumed negligible
3Db	NH_3, TSP, PM_{10} and $PM_{2.5}$	assumed negligible
3Dd	NMVOC	Assumed negligible

NFR code	Substance(s)	Reason for non-estimation
3De	NO_x, SO_x, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni and Se	assumed negligible
3Df	NO_x, NMVOC, SO_x, CO, NH_3, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn and Se	assumed negligible
3I	NO_x, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni and Se	assumed negligible
6A	SO_x, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs, PCB and HCB	assumed negligible

Appendix 2 Key category analysis results; Approach 1

Approach 1 method

The Approach 1 methodology presented in the EMEP/EEA emission inventory guidebook 2023 was used. Results from the key (source) category analysis have been calculated and sorted for every component. In addition to a 2023 and 1990 level assessment, a trend assessment was performed. In both approaches, key source categories are identified using a cumulative threshold of 80%.

For the key source analyses, the emissions were taken from the fuel-sold calculations.

SO_x key sources

Table A2.1.a SO_x key source categories identified by 2023 level assessment (emissions in Gg)

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
1A1b	Petroleum refining	8.0	45.5%	45.5%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	3.0	16.9%	62.4%
1A1a	Public electricity and heat production	1.8	10.4%	72.9%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	1.0	5.9%	78.8%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	1.0	5.6%	84.4%

Table A2.1.b SOx key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A1b	Petroleum refining	67.1	33.9%	33.9%
1A1a	Public electricity and heat production	48.5	24.5%	58.3%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	20.0	10.1%	68.4%
1A3biii	Road transport: Heavy duty vehicles and buses	9.5	4.8%	73.2%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	9.1	4.6%	77.8%
2A6	Other mineral products (please specify in the IIR)	5.5	2.8%	80.6%

Table A2.1.c SOx key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1b	Petroleum refining	0.327	33.1%	33.1%
1A1a	Public electricity and heat production	0.258	26.1%	59.2%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.105	10.6%	69.9%
1A3biii	Road transport: Heavy duty vehicles and buses	0.052	5.3%	75.1%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.034	3.5%	78.6%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.027	2.7%	81.3%

NO_x key sources

Table A2.2.a NOx key source categories identified by 2023 level assessment (emissions in Gg)

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy duty vehicles and buses	23.1	12.6%	12.6%
1A3bi	Road transport: Passenger cars	18.6	10.1%	22.7%
3Da2a	Animal manure applied to soils	14.8	8.1%	30.7%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	11.7	6.4%	37.1%
1A1a	Public electricity and heat production	10.5	5.7%	42.8%
1A3di(ii)	International inland waterways	10.5	5.7%	48.5%
1A3bii	Road transport: Light duty vehicles	10.3	5.6%	54.1%
3Da1	Inorganic N fertilisers (includes also urea application)	8.5	4.6%	58.7%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	8.1	4.4%	63.1%

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	7.5	4.1%	67.2%
1A3dii	National navigation (shipping)	7.1	3.8%	71.0%
1A4ciii	Agriculture/Forestry/Fishing: National fishing	5.0	2.7%	73.7%
1A4bi	Residential: Stationary	4.9	2.7%	76.4%
1A1b	Petroleum refining	4.7	2.6%	79.0%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	4.3	2.3%	81.3%

Table A2.2.b NOx key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	141.4	20.7%	20.7%
1A3biii	Road transport: Heavy duty vehicles and buses	131.9	19.3%	40.1%
1A1a	Public electricity and heat production	82.9	12.2%	52.2%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	35.9	5.3%	57.5%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	32.5	4.8%	62.2%
1A3di(ii)	International inland waterways	22.3	3.3%	65.5%
1A3bii	Road transport: Light duty vehicles	21.0	3.1%	68.6%
1A4ciii	Agriculture/Forestry/Fishing: National fishing	20.7	3.0%	71.6%
1A4bi	Residential: Stationary	20.6	3.0%	74.6%
3Da2a	Animal manure applied to soils	20.1	3.0%	77.6%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	19.6	2.9%	80.5%

Table A2.2.c NOx key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	0.246	24.3%	24.3%
1A3biii	Road transport: Heavy duty vehicles and buses	0.218	21.5%	45.8%
1A1a	Public electricity and heat production	0.145	14.3%	60.2%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.057	5.6%	65.8%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.042	4.1%	69.9%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.033	3.2%	73.1%
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.032	3.11%	76.23%
1A4bi	Residential: Stationary	0.031	3.10%	79.33%
1A1b	Petroleum refining	0.028	2.80%	82.13%

NH_3 key sources

Table A2.3.a NH3 key source categories identified by 2023 level assessment (emissions in Gg)

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	33.1	28%	28.4%
3B1a	Manure management - Dairy cattle	21.4	18%	46.8%
3B3	Manure management - Swine	11.1	10%	56.3%
3Da1	Inorganic N fertilisers (includes also urea application)	9.8	8%	64.7%
3B1b	Manure management - Non-dairy cattle	8.8	8%	72.3%
3B4gi	Manure management - Laying hens	8.1	7%	79.3%
6A	Other (included in national total for entire territory) (please specify in IIR)	3.4	3%	82.2%

Table A2.3.b NH3 key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	199.8	57.6%	57.6%
3B3	Manure management - Swine	49.2	14.2%	71.8%
3B1a	Manure management - Dairy cattle	22.3	6.4%	78.3%
3Da3	Urine and dung deposited by grazing animals	15.7	4.5%	82.8%

Table A2.3.c NH3 key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
3Da2a	Animal manure applied to soils	0.724	68.2%	68.2%
3B3	Manure management - Swine	0.166	15.6%	83.8%

NMVOC key sources

Table A2.4.a NMVOC key source categories identified by 2023 level assessment (emissions in Gg)

NFR14 Code	Long name	3Gg	Contribution	Cumulative contribution
2D3a	Domestic solvent use including fungicides	47.9	20.1%	20.1%
3B1a	Manure management - Dairy cattle	43.7	18.3%	38.4%
2D3i	Other solvent use (please specify in the IIR)	15.6	6.5%	45.0%
2D3d	Coating applications	13.9	5.8%	50.8%
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	11.4	4.8%	55.6%
3B1b	Manure management - Non-dairy cattle	10.8	5%	60.1%
2H3	Other industrial processes (please specify in the IIR)	10.3	4.3%	64.5%
1A3bi	Road transport: Passenger cars	9.4	3.9%	68.4%
3Da2a	Animal manure applied to soils	9.0	3.8%	72.2%
1A4bi	Residential: Stationary	8.2	3.4%	75.7%
2H2	Food and beverages industry	5.5	2.3%	78.0%
1A3biii	Road transport: Heavy duty vehicles and buses	4.90	2.1%	80.03%

Table A2.4.b NMVOC key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	99.3	16.5%	16.5%
2D3d	Coating applications	93.1	15.5%	32.0%
3Da2a	Animal manure applied to soils	48.2	8.0%	40.1%
1A3bv	Road transport: Gasoline evaporation	35.4	5.9%	46.0%
2B10a	Chemical industry: Other (please specify in the IIR)	33.4	5.6%	51.5%
2H3	Other industrial processes (please specify in the IIR)	25.3	4.2%	55.7%
2D3a	Domestic solvent use including fungicides	24.3	4.1%	59.8%
2D3i	Other solvent use (please specify in the IIR)	18.4	3.1%	62.8%
1A3biii	Road transport: Heavy duty vehicles and buses	17.5	2.9%	65.7%
1B2av	Distribution of oil products	16.9	2.8%	68.6%
3B1a	Manure management - Dairy cattle	15.3	2.5%	71.1%
1B2aiv	Fugitive emissions oil: Refining / storage	14.8	2.5%	73.6%
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	14.6	2.4%	76.0%
2D3h	Printing	14.4	2.4%	78.4%
3B1b	Manure management - Non-dairy cattle	14.1	2%	81%

Table A2.4.c NMVOC key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	0.248	18.6%	18.6%
2D3d	Coating applications	0.219	16.4%	35.0%
3Da2a	Animal manure applied to soils	0.108	8.1%	43.1%
1A3bv	Road transport: Gasoline evaporation	0.094	7.0%	50.1%
2B10a	Chemical industry: Other (please specify in the IIR)	0.083	6.2%	56.3%
3B1a	Manure management - Dairy cattle	0.078	5.9%	62.2%

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2D3a	Domestic solvent use including fungicides	0.065	4.9%	67.0%
2H3	Other industrial processes (please specify in the IIR)	0.041	3.1%	70.1%
1B2aiv	Fugitive emissions oil: Refining / storage	0.037	2.8%	72.9%
1B2av	Distribution of oil products	0.036	2.70%	75.58%
1A3biii	Road transport: Heavy duty vehicles and buses	0.035	2.6%	78.2%
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	0.034	2.54%	80.72%

CO key sources

Table A2.5.a CO key source categories identified by 2023 level assessment (emissions in Gg)

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	131.9	34.2%	34.2%
1A4bi	Residential: Stationary	59.2	15.3%	49.5%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	48.6	12.6%	62.1%
1A4bii	Residential: Household and gardening (mobile)	25.2	6.5%	68.6%
1A3biv	Road transport: Mopeds & motorcycles	20.5	5.3%	73.9%
1A5b	Other, Mobile (including military, land based and recreational boats)	12.5	3.2%	77.2%
1A4aii	Commercial/institutional: Mobile	11.3	2.9%	80.1%

Table A2.5.b CO key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	581.9	49.4%	49.4%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	187.7	15.9%	65.4%
1A4bi	Residential: Stationary	73.6	6.3%	71.6%
1A3bii	Road transport: Light duty vehicles	46.3	3.9%	75.6%

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A4bii	Residential: Household and gardening (mobile)	44.9	3.8%	79.4%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	37.41	3%	82.56%

Table A2.5.c CO key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	0.569	54.8%	54.8%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.176	16.9%	71.7%
1A3bii	Road transport: Light duty vehicles	0.053	5.1%	76.8%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.046	4.5%	81.3%

PM_{10} key sources

Table A2.6.a PM10 key source categories identified by 2023 level assessment (emissions in Gg)

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	4.5	17.0%	17.0%
3B4gi	Manure management - Laying hens	2.1	8.2%	25.2%
2G	Other product use (please specify in the IIR)	1.8	6.9%	32.1%
1A3bvi	Road transport: Automobile tyre and brake wear	1.6	6.0%	38.1%
2H2	Food and beverages industry	1.3	5.0%	43.1%
1A3bvii	Road transport: Automobile road abrasion	1.3	4.9%	48.0%
2A6	Other mineral products (please specify in the IIR)	1.3	4.8%	52.8%
2A5b	Construction and demolition	1.15	4.4%	57.2%
2C1	Iron and steel production	0.9	3.3%	60.5%
3B4gii	Manure management - Broilers	0.84	3.2%	63.7%
2A5c	Storage, handling and transport of mineral products	0.77	2.93%	66.61%
3De	Cultivated crops	0.76	2.9%	69.5%
3B3	Manure management - Swine	0.71	2.7%	72.2%

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
2B10a	Chemical industry: Other (please specify in the IIR)	0.67	2.5%	74.8%
2H3	Other industrial processes (please specify in the IIR)	0.59	2.3%	77.0%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.49	1.9%	78.9%
5E	Other waste (please specify in IIR)	0.48	1.8%	80.7%

Table A2.6.b PM_{10} key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
2C1	Iron and steel production	9.1	11.3%	11.3%
1A3biii	Road transport: Heavy duty vehicles and buses	7.8	9.7%	21.0%
1A4bi	Residential: Stationary	7.2	9.0%	30.0%
1A1b	Petroleum refining	6.4	7.9%	37.9%
1A3bi	Road transport: Passenger cars	5.6	6.9%	44.8%
2H2	Food and beverages industry	4.5	5.5%	50.3%
2B10a	Chemical industry: Other (please specify in the IIR)	4.1	5.1%	55.4%
1A3bii	Road transport: Light duty vehicles	3.8	4.7%	60.1%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	3.4	4.2%	64.4%
2H3	Other industrial processes (please specify in the IIR)	3.0	3.8%	68.2%
1A1a	Public electricity and heat production	2.2	2.7%	70.9%
2A6	Other mineral products (please specify in the IIR)	2.1	2.6%	73.5%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.7	2.1%	75.59%
3B3	Manure management - Swine	1.6	2.0%	77.5%
2A5c	Storage, handling and transport of mineral products	1.4	1.8%	79.3%
2G	Other product use (please specify in the IIR)	1.4	1.8%	81.1%

Table A2.6.c PM10 key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2C1	Iron and steel production	0.152	13.7%	13.7%
1A3biii	Road transport: Heavy duty vehicles and buses	0.138	12.5%	26.2%
1A1b	Petroleum refining	0.113	10.2%	36.5%
1A3bi	Road transport: Passenger cars	0.098	8.8%	45.3%
1A3bii	Road transport: Light duty vehicles	0.067	6.0%	51.3%
2B10a	Chemical industry: Other (please specify in the IIR)	0.063	5.7%	57.0%
2H2	Food and beverages industry	0.058	5%	62%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.054	4.9%	67.1%
1A4bi	Residential: Stationary	0.051	4.6%	71.6%
2H3	Other industrial processes (please specify in the IIR)	0.045	4.1%	75.7%
1A1a	Public electricity and heat production	0.038	3.5%	79.1%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.026	2.36%	81.51%

$PM_{2.5}$ key sources

Table A2.7.a PM2.5 key source categories identified by 2023 level assessment (emissions in Gg)

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	4.2	30.6%	30.6%
2G	Other product use (please specify in the IIR)	1.12	8.1%	38.8%
2A6	Other mineral products (please specify in the IIR)	1.1	8.0%	46.7%
2C1	Iron and steel production	0.49	3.6%	50.3%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.46	3.4%	53.7%
5E	Other waste (please specify in IIR)	0.44	3.2%	56.9%
2B10a	Chemical industry: Other (please specify in the IIR)	0.42	3.1%	60.0%
2A5b	Construction and demolition	0.38	2.8%	62.8%
1A3di(ii)	International inland waterways	0.34	2.5%	65.2%

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
1A3dii	National navigation (shipping)	0.30	2.2%	67.4%
1A4ai	Commercial/institutional: Stationary	0.29	2.13%	69.48%
1A3bvi	Road transport: Automobile tyre and brake wear	0.28	2.1%	72%
1A3biii	Road transport: Heavy duty vehicles and buses	0.28	2.0%	73.6%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.28	2.0%	75.6%
2H2	Food and beverages industry	0.27	2.0%	77.6%
1A3bi	Road transport: Passenger cars	0.24	1.8%	79.3%
1A5b	Other, Mobile (including military, land based and recreational boats)	0.22	1.6%	80.9%

Table A2.7.b PM2.5 key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy duty vehicles and buses	7.8	13.6%	13.6%
1A4bi	Residential: Stationary	6.8	11.9%	25.6%
2C1	Iron and steel production	5.9	10.4%	35.9%
1A3bi	Road transport: Passenger cars	5.6	9.7%	45.6%
1A1b	Petroleum refining	4.9	8.5%	54.1%
1A3bii	Road transport: Light duty vehicles	3.8	6.6%	60.8%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	3.3	5.7%	66.4%
2B10a	Chemical industry: Other (please specify in the IIR)	2.6	4.5%	70.9%
1A1a	Public electricity and heat production	1.8	3.2%	74.1%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.6	3%	76.9%
2A6	Other mineral products (please specify in the IIR)	1.6	3%	79.7%
2G	Other product use (please specify in the IIR)	1.2	2.1%	81.8%

Table A2.7.c PM2.5 key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3biii	Road transport: Heavy duty vehicles and buses	0.173	17.0%	17.0%
2C1	Iron and steel production	0.125	12.2%	29.2%
1A3bi	Road transport: Passenger cars	0.122	12.0%	41.1%
1A1b	Petroleum refining	0.108	10.6%	51.7%
1A3bii	Road transport: Light duty vehicles	0.083	8.1%	59.9%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.064	6.3%	66.1%
1A4bi	Residential: Stationary	0.060	5.9%	72.0%
2B10a	Chemical industry: Other (please specify in the IIR)	0.049	4.8%	76.82%
1A1a	Public electricity and heat production	0.039	3.8%	80.7%

Black Carbon key sources

Table A2.8.a Black carbon key source categories identified by 2023 level assessment (emissions in Gg)

NFR14 Code	Long name	2023 Gg	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	0.51	24.0%	24.0%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.23	11.0%	35.1%
1A3di(ii)	International inland waterways	0.15	7.3%	42.4%
1A3biii	Road transport: Heavy duty vehicles and buses	0.14	6.7%	49.1%
1A3dii	National navigation (shipping)	0.14	6.4%	55.6%
1A3bii	Road transport: Light duty vehicles	0.13	6.3%	61.8%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.13	6.1%	67.9%
5E	Other waste (please specify in IIR)	0.11	5.2%	73.1%
1A5b	Other, Mobile (including military, land based and recreational boats)	0.09	4.30%	77.45%
1A3bi	Road transport: Passenger cars	0.09	4.2%	81.7%

Table A2.8.b Black carbon key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy duty vehicles and buses	3.9	27.6%	27.6%
1A3bi	Road transport: Passenger cars	2.5	17.8%	45.4%
1A3bii	Road transport: Light duty vehicles	2.1	14.5%	59.9%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	1.7	11.7%	71.6%
1A4bi	Residential: Stationary	0.9	6.2%	77.8%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.8	5.6%	83.4%

Table A2.8.c Black carbon key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3biii	Road transport: Heavy duty vehicles and buses	0.313	30.7%	30.7%
1A3bi	Road transport: Passenger cars	0.202	19.8%	50.5%
1A3bii	Road transport: Light duty vehicles	0.159	15.6%	66.2%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.118	11.57%	77.76%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.055	5.45%	83.21%
1A4bi	Residential: Stationary	0.031	3.0%	86.3%

Pb key sources

Table A2.9.a Pb key source categories identified by 2023 level assessment (emissions in Mg)

NFR14 Code	Long name	2023 Mg	Contribution	Cumulative contribution
1A3aii(i)	Domestic aviation LTO (civil)	0.73	18.2%	18.2%
2C1	Iron and steel production	0.56	14.0%	32.1%
1A3bi	Road transport: Passenger cars	0.51	12.7%	44.8%
2A3	Glass production	0.36	9.0%	53.9%
1A3c	Railways	0.34	8.5%	62%
1A3bvi	Road transport: Automobile tyre and brake wear	0.33	8.3%	70.7%

NFR14 Code	Long name	2023 Mg	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	0.18	4.59%	75.27%
2B10a	Chemical industry: Other (please specify in the IIR)	0.17	4.2%	79.5%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.16	4.10%	83.60%

Table A2.9.b Pb key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	230.1	68.6%	68.6%
2C1	Iron and steel production	55.7	16.6%	85.2%

Table A2.9.c Pb key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	0.692	69.2%	69.2%
2C1	Iron and steel production	0.166	16.6%	85.8%

Hg key sources

Table A2.10.a Hg key source categories identified by 2023 level assessment (emissions in Mg)

NFR14 Code	Long name	2023 Mg	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	0.12	27.7%	27.7%
2A6	Other mineral products (please specify in the IIR)	0.08	18.3%	46.0%
1A3bi	Road transport: Passenger cars	0.06	14.6%	60.6%
2C1	Iron and steel production	0.04	8.9%	69.5%
1A4bi	Residential: Stationary	0.04	8.4%	77.9%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.04	8.3%	86.2%

Table A2.10.b Hg key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	1.9	52.7%	52.7%
2B10a	Chemical industry: Other (please specify in the IIR)	0.7	19.1%	71.8%
2C1	Iron and steel production	0.4	10.6%	82.4%

Table A2.10.c Hg key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	0.560	53.8%	53.8%
2B10a	Chemical industry: Other (please specify in the IIR)	0.217	20.8%	74.6%
2C1	Iron and steel production	0.108	10.4%	85.0%

Cd key sources

Table A2.11.a Cd key source categories identified by 2023 level assessment (emissions in Mg)

NFR14 Code	Long name	2023 Mg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	0.11	22.5%	22.5%
2B10a	Chemical industry: Other (please specify in the IIR)	0.08	16.7%	39.2%
2G	Other product use (please specify in the IIR)	0.08	16.1%	55.2%
1A4bi	Residential: Stationary	0.06	12.0%	67.3%
1A1a	Public electricity and heat production	0.03	7.24%	74.49%
2C6	Zinc production	0.03	5.4%	79.9%
5E	Other waste (please specify in IIR)	0.02	4.80%	84.71%

Table A2.11.b Cd key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
2C6	Zinc production	1.8	43.7%	43.7%
1A1a	Public electricity and heat production	0.9	23.3%	67.0%
2C1	Iron and steel production	0.7	16.9%	83.8%

Table A2.11.c Cd key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2C6	Zinc production	0.487	46.9%	46.9%
1A1a	Public electricity and heat production	0.254	24.5%	71.4%
2C1	Iron and steel production	0.185	17.9%	89.3%

Dioxin key sources

Table A2.12.a Dioxin key source categories identified by 2023 level assessment (emissions in g I-Teq)

NFR14 Code	Long name	2023 g I-Teq	Contribution	Cumulative contribution
5E	Other waste (please specify in IIR)	16.5	38.4%	38.4%
1A1a	Public electricity and heat production	14.3	33.2%	71.6%
1A4bi	Residential: Stationary	6.2	14.3%	85.9%

Table A2.12.b Dioxin key source categories identified by 1990 level assessment (emissions in g I-Teq)

NFR14 Code	Long name	1990 g I-Teq	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	582.6	78.2%	78.2%
1A4ai	Commercial/institutional: Stationary	100.0	13.4%	91.6%

Table A2.12.c Dioxin key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	0.810	80.1%	80.1%

PAH key sources

Table A2.13.a PAH key source categories identified by 2023 level assessment (emissions in Mg)

NFR14 Code	Long name	2023 Mg	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	3.0	59.8%	59.8%
5E	Other waste (please specify in IIR)	0.61	11.9%	71.8%
2A6	Other mineral products (please specify in the IIR)	0.53	10.38%	82%

Table A2.13.b PAH key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
2C3	Aluminium production	6.9	32.2%	32.2%
1A4bi	Residential: Stationary	3.5	16.4%	48.6%
2D3d	Coating applications	2.4	11.3%	59.9%
2C1	Iron and steel production	1.6	7.7%	67.5%
2H3	Other industrial processes (please specify in the IIR)	1.4	6.4%	73.9%
1A3bi	Road transport: Passenger cars	0.8	3.8%	77.7%
1A1c	Manufacture of solid fuels and other energy industries	0.7	3.2%	81.0%

Table A2.13.c PAH key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2C3	Aluminium production	0.422	57.8%	57.8%
2C1	Iron and steel production	0.094	12.9%	70.72%
1A3bi	Road transport: Passenger cars	0.043	5.88%	76.61%
2B10a	Chemical industry: Other (please specify in the IIR)	0.039	5.4%	81.99%

HCB key sources

Table A2.13.a HCB key source categories identified by 2023 level assessment (emissions in Mg)

NFR14 Code	Long name	2023 Mg	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	3.0	94.2%	94.2%

Table A2.13.b HCB key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	45.2	68.1%	68.1%
3Df	Use of pesticides	21.1	31.8%	99.9%

Table A2.13.c HCB key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	0.667	66.6%	66.6%
3Df	Use of pesticides	0.333	33.3%	99.9%

PCB key sources

Table A2.13.a PCB key source categories identified by 2023 level assessment (emissions in Mg)

NFR14 Code	Long name	2023 Mg	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	0.05	40.1%	40.1%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.04	35.4%	75.5%
1A1c	Manufacture of solid fuels and other energy industries	0.01	11.0%	86.5%

Table A2.13.b PCB key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
2C1	Iron and steel production	19.2	49.9%	49.9%
1A1a	Public electricity and heat production	12.1	31.5%	81.4%

Table A2.13.c PCB key source categories identified by 1990–2023 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2C1	Iron and steel production	0.500	50.8%	50.8%
1A1a	Public electricity and heat production	0.315	32.0%	82.8%

Appendix 3 Key category analysis results; Approach 2

Approach 2 method

The Approach 2 method requires uncertainty estimates for the source categories to identify the key categories. The uncertainty estimates are applied as weights to each of the source categories and incorporated in the level and trend assessment before ordering the list of shares.
As recommended by the IPCC guidelines, the uncertainty estimates are based on an Approach 2 (Monte Carlo) uncertainty analysis. In Section 1.5, the details of the Monte Carlo analyses are described.

SO_x Key sources

Table A3.1 Key source ranking using IPCC Approach 2 ***level*** *assessment for 2023* ***SO_x*** *emissions*

GNFR	2023 Gg	Share	Uncertainty estimate	Level * Uncertainty	Share L * U	Cumulative Share L * U
B_Industry	**14.4**	**82.4%**	**30.3%**	**25.0%**	**77.3%**	**77.3%**
A_PublicPower	**1.8**	**10.4%**	**42.2%**	**4.4%**	**13.7%**	**91.0%**
C_OtherStationaryComb	0.5	2.7%	41.6%	1.1%	3.5%	94.4%
H_Aviation	0.2	1.4%	48.7%	0.7%	2.1%	96.6%
I_Offroad	0.3	1.5%	30.7%	0.5%	1.4%	98.0%
E_Solvents	0.0	0.2%	115.6%	0.3%	0.9%	98.8%
J_Waste	0.1	0.3%	73.5%	0.3%	0.8%	99.6%
F_RoadTransport	0.2	1.0%	11.6%	0.1%	0.3%	100.0%
G_Shipping	0.0	0.1%	17.1%	0.0%	0.0%	100.0%

*Table A3.2 Key source ranking using IPCC Approach 2 **trend** assessment for 2023 **SO_x** emissions compared to the base year*

GNFR	1990 Gg	2023 Gg	Level assessment latest year	Uncertainty estimate	Trend	Trend * uncertainty	Contribution to trend	Cumulative contribution
H_Aviation	**0.1**	**0.2**	**1.4%**	**48.7%**	**3.2%**	**1.6%**	**37.2%**	**37.2%**
E_Solvents	**0.0**	**0.0**	**0.2%**	**115.6%**	**0.8%**	**0.9%**	**21.5%**	**58.7%**
B_Industry	**120.0**	**14.4**	**82.4%**	**30.3%**	**2.6%**	**0.8%**	**18.8%**	**77.5%**
J_Waste	**0.0**	**0.1**	**0.3%**	**73.5%**	**0.7%**	**0.5%**	**13.0%**	**90.4%**
A_PublicPower	48.5	1.8	10.4%	42.2%	0.5%	0.2%	5.3%	95.7%
C_OtherStationaryComb	2.2	0.5	2.7%	41.6%	0.3%	0.1%	3.4%	99.1%
I_Offroad	9.5	0.3	1.5%	30.7%	0.1%	0.0%	0.7%	99.8%
F_RoadTransport	16.0	0.2	1.0%	11.6%	0.1%	0.0%	0.2%	100.0%
G_Shipping	1.8	0.0	0.1%	17.1%	0.0%	0.0%	0.0%	100.0%

NO_x Key sources

*Table A3.3 Key source ranking using IPCC Approach 2 **level** assessment for 2023 **NO_x** emissions*

GNFR	2023 Gg	Share	Uncertainty estimate	Level * Uncertainty	Share L * U	Cumulative Share L * U
L_AgriOther	**28.5**	**15.5%**	**123.3%**	**19.1%**	**45.6%**	**45.6%**
I_Offroad	**32.1**	**17.5%**	**53.7%**	**9.4%**	**22.3%**	**67.9%**
F_RoadTransport	**52.6**	**28.6%**	**11.5%**	**3.3%**	**7.8%**	**75.7%**
B_Industry	**24.0**	**13.0%**	**21.2%**	**2.8%**	**6.6%**	**82.3%**
A_PublicPower	10.5	5.7%	37.2%	2.1%	5.1%	87.4%
G_Shipping	17.5	9.5%	21.4%	2.0%	4.9%	92.3%
C_OtherStationaryComb	11.2	6.1%	28.5%	1.7%	4.1%	96.4%
H_Aviation	3.5	1.9%	35.2%	0.7%	1.6%	98.0%
K_AgriLivestock	3.5	1.9%	34.3%	0.7%	1.6%	99.6%
J_Waste	0.4	0.2%	69.4%	0.2%	0.4%	100.0%
E_Solvents	0.0	0.0%	79.5%	0.0%	0.0%	100.0%

*Table A3.4 Key source ranking using IPCC Approach 2 **trend** assessment for 2023 **NO_x** emissions compared to the base year*

GNFR	1990 Gg	2023 Gg	Level assessment latest year	Uncertainty estimate	Trend	Trend * uncertainty	Contribution to trend	Cumulative contribution
L_AgriOther	**47.1**	**28.5**	**15.5%**	**123.3%**	**5.22%**	**6.44%**	**54.4%**	**54.4%**
H_Aviation	**1.2**	**3.5**	**1.9%**	**35.2%**	**4.92%**	**1.73%**	**14.7%**	**69.1%**
I_Offroad	**76.7**	**32.1**	**17.5%**	**53.7%**	**2.60%**	**1.39%**	**11.8%**	**80.9%**
G_Shipping	28.8	17.5	9.5%	21.4%	3.23%	0.69%	5.9%	86.8%
K_AgriLivestock	3.9	3.5	1.9%	34.3%	1.24%	0.42%	3.6%	90.4%
J_Waste	0.2	0.4	0.2%	69.4%	0.60%	0.41%	3.5%	93.9%
A_PublicPower	82.9	10.5	5.7%	37.2%	0.82%	0.30%	2.6%	96.4%
F_RoadTransport	294.7	52.6	28.6%	11.5%	2.60%	0.30%	2.5%	99.0%
B_Industry	105.7	24.0	13.0%	21.2%	0.56%	0.12%	1.0%	100.0%
C_OtherStationaryComb	41.1	11.2	6.1%	28.5%	0.01%	0.00%	0.0%	100.0%
E_Solvents	0.1	0.0	0.0%	79.5%	0.00%	0.00%	0.0%	100.0%

NH_3 Key sources

*Table A3.5 Key source ranking using IPCC Approach 2 **level** assessment for 2023 **NH_3** emissions*

GNFR	2023 Gg	Share	Uncertainty estimate	Level * Uncertainty	Share L * U	Cumulative Share L * U
L_AgriOther	**49.4**	**42.4%**	**32.2%**	**13.6%**	**32.2%**	**32.2%**
K_AgriLivestock	**55.6**	**47.8%**	**27.0%**	**12.9%**	**30.4%**	**62.6%**
M_Other	**3.4**	**2.9%**	**277.0%**	**8.1%**	**19.1%**	**81.7%**
F_RoadTransport	3.8	3.2%	153.0%	4.9%	11.7%	93.4%
J_Waste	1.4	1.2%	70.3%	0.8%	2.0%	95.4%
E_Solvents	1.1	1.0%	67.6%	0.7%	1.6%	96.9%
B_Industry	1.1	1.0%	68.0%	0.7%	1.6%	98.5%
C_OtherStationaryComb	0.4	0.3%	133.0%	0.4%	1.0%	99.4%
I_Offroad	0.2	0.1%	122.2%	0.2%	0.4%	99.8%
A_PublicPower	0.1	0.1%	76.4%	0.1%	0.1%	100.0%
G_Shipping	0.0	0.0%	254.7%	0.0%	0.0%	100.0%
D_Fugitive	0.0	0.0%	99.2%	0.0%	0.0%	100.0%

Table A3.6 Key source ranking using IPCC Approach 2 ***trend*** *assessment for 2023* ***NH_3*** *emissions compared to the base year*

GNFR	1990 Gg	2023 Gg	Level assessment latest year	Uncertainty estimate	Trend	Trend * uncertainty	Contribution to trend	Cumulative contribution
F_RoadTransport	**0.9**	**3.8**	**3.2%**	**153.0%**	**11.9%**	**18.1%**	**46.4%**	**46.4%**
M_Other	**2.7**	**3.4**	**2.9%**	**277.0%**	**2.7%**	**7.6%**	**19.5%**	**65.9%**
J_Waste	**0.2**	**1.4**	**1.2%**	**70.3%**	**10.3%**	**7.2%**	**18.5%**	**84.3%**
K_AgriLivestock	99.7	55.6	47.8%	27.0%	10.6%	2.9%	7.3%	91.7%
L_AgriOther	236.9	49.4	42.4%	32.2%	5.4%	1.7%	4.4%	96.1%
I_Offroad	0.0	0.2	0.1%	122.2%	0.6%	0.7%	1.9%	98.0%
E_Solvents	1.1	1.1	1.0%	67.6%	0.7%	0.5%	1.2%	99.1%
C_OtherStationaryComb	0.3	0.4	0.3%	133.0%	0.2%	0.3%	0.7%	99.8%
B_Industry	4.7	1.1	1.0%	68.0%	0.1%	0.1%	0.2%	100.0%
G_Shipping	0.0	0.0	0.0%	254.7%	0.0%	0.0%	0.0%	100.0%
D_Fugitive	0.0	0.0	0.0%	99.2%	0.0%	0.0%	0.0%	100.0%

NMVOC Key sources

Table A3.7 Key source ranking using IPCC Approach 2 level assessment for 2023 NMVOC emissions

GNFR	2023 Gg	Share	Uncertainty estimate	Level * Uncertainty	Share L * U	Cumulative Share L * U
K_AgriLivestock	**63.5**	**26.6%**	**175.1%**	**46.7%**	**51.5%**	**51.5%**
E_Solvents	**83.5**	**35.0%**	**31.8%**	**11.1%**	**12.3%**	**63.7%**
L_AgriOther	**22.2**	**9.3%**	**104.6%**	**9.7%**	**10.7%**	**74.4%**
F_RoadTransport	**19.4**	**8.2%**	**90.7%**	**7.4%**	**8.2%**	**82.6%**
B_Industry	22.0	9.2%	72.2%	6.7%	7.3%	89.9%
I_Offroad	6.3	2.7%	151.2%	4.0%	4.4%	94.4%
C_OtherStationaryComb	10.6	4.4%	54.1%	2.4%	2.7%	97.0%
D_Fugitive	7.5	3.2%	34.1%	1.1%	1.2%	98.2%
J_Waste	1.3	0.6%	154.3%	0.9%	1.0%	99.2%
G_Shipping	1.1	0.4%	68.6%	0.3%	0.3%	99.5%
H_Aviation	0.3	0.1%	187.8%	0.3%	0.3%	99.8%
A_PublicPower	0.7	0.3%	60.7%	0.2%	0.2%	100.0%

Table A3.8 Key source ranking using IPCC Approach 2 trend assessment for 2023 NMVOC emissions compared to the base year

GNFR	1990 Gg	2023 Gg	Level assessment latest year	Uncertainty estimate	Trend	Trend* uncertainty	Contribution to trend	Cumulative contribution
K_AgriLivestock	**41.7**	**63.5**	**26.6%**	**175.1%**	**30.0%**	**52.5%**	**89.2%**	**89.2%**
F_RoadTransport	175.9	19.4	8.2%	90.7%	2.3%	2.1%	3.6%	92.8%
E_Solvents	158.8	83.5	35.0%	31.8%	4.5%	1.4%	2.4%	95.3%
C_OtherStationaryComb	13.3	10.6	4.4%	54.1%	1.8%	1.0%	1.6%	96.9%
B_Industry	80.5	22.0	9.2%	72.2%	1.1%	0.8%	1.4%	98.3%
I_Offroad	21.2	6.3	2.7%	151.2%	0.3%	0.4%	0.7%	99.0%
D_Fugitive	47.8	7.5	3.2%	34.1%	0.8%	0.3%	0.4%	99.4%
J_Waste	2.4	1.3	0.6%	154.3%	0.1%	0.1%	0.2%	99.6%
H_Aviation	0.4	0.3	0.1%	187.8%	0.1%	0.1%	0.2%	99.8%
A_PublicPower	0.9	0.7	0.3%	60.7%	0.1%	0.1%	0.1%	99.9%
G_Shipping	2.0	1.1	0.4%	68.6%	0.1%	0.0%	0.1%	100.0%
L_AgriOther	55.8	22.2	9.3%	104.6%	0.0%	0.0%	0.0%	100.0%

PM_{10} Key sources

Table A3.9 Key source ranking using IPCC Approach 2 ***level*** *assessment for 2023* ***PM_{10}*** *emissions*

GNFR	2023 Gg	Share	Uncertainty estimate	Level * Uncertainty	Share L * U	Cumulative Share L * U
C_OtherStationaryComb	**4.8**	**18.5%**	**120.0%**	**22.1%**	**32.6%**	**32.6%**
B_Industry	**7.8**	**29.9%**	**41.4%**	**12.4%**	**18.3%**	**50.9%**
F_RoadTransport	**3.6**	**13.7%**	**55.4%**	**7.6%**	**11.2%**	**62.1%**
L_AgriOther	**1.1**	**4.1%**	**158.0%**	**6.5%**	**9.6%**	**71.7%**
E_Solvents	**1.8**	**6.9%**	**92.8%**	**6.4%**	**9.4%**	**81.1%**
K_AgriLivestock	4.2	16.0%	24.9%	4.0%	5.9%	87.0%
I_Offroad	1.4	5.5%	67.6%	3.7%	5.5%	92.4%
J_Waste	0.6	2.1%	170.1%	3.6%	5.3%	97.8%
G_Shipping	0.7	2.6%	41.5%	1.1%	1.6%	99.3%
A_PublicPower	0.1	0.5%	59.2%	0.3%	0.4%	99.8%
H_Aviation	0.0	0.1%	109.1%	0.2%	0.2%	100.0%
D_Fugitive	0.0	0.0%	99.1%	0.0%	0.0%	100.0%

*Table A3.10 Key source ranking using IPCC Approach 2 **trend** assessment for 2023 **PM_{10}** emissions compared to the base year*

GNFR	1990 Gg	2023 Gg	Level assessment latest year	Uncertainty estimate	Trend	Trend * uncertainty	Contribution to trend	Cumulative contribution
C_OtherStationaryComb	**7.6**	**4.8**	**18.5%**	**120.0%**	**5.8%**	**7.0%**	**27.2%**	**27.2%**
E_Solvents	**1.4**	**1.8**	**6.9%**	**92.8%**	**6.5%**	**6.1%**	**23.6%**	**50.8%**
L_AgriOther	**1.2**	**1.1**	**4.1%**	**158.0%**	**2.5%**	**3.9%**	**15.1%**	**65.9%**
K_AgriLivestock	**4.1**	**4.2**	**16.0%**	**24.9%**	**11.3%**	**2.8%**	**10.9%**	**76.7%**
J_Waste	**0.5**	**0.6**	**2.1%**	**170.1%**	**1.6%**	**2.7%**	**10.6%**	**87.3%**
B_Industry	35.4	7.8	29.9%	41.4%	3.1%	1.3%	5.0%	92.3%
F_RoadTransport	19.4	3.6	13.7%	55.4%	1.9%	1.1%	4.1%	96.5%
I_Offroad	7.2	1.4	5.5%	67.6%	0.7%	0.5%	1.8%	98.3%
G_Shipping	1.3	0.7	2.6%	41.5%	0.5%	0.2%	0.8%	99.1%
H_Aviation	0.0	0.0	0.1%	109.1%	0.1%	0.2%	0.6%	99.7%
A_PublicPower	2.2	0.1	0.5%	59.2%	0.1%	0.1%	0.3%	100.0%
D_Fugitive	0.2	0.0	0.0%	99.1%	0.0%	0.0%	0.0%	100.0%

$PM_{2.5}$ Key sources

*Table A3.11 Key source ranking using IPCC Approach 2 **level** assessment for 2023 **$PM_{2.5}$** emissions*

GNFR	2023 Gg	Share	Uncertainty estimate	Level * Uncertainty	Share L * U	Cumulative Share L * U
C_OtherStationaryComb	**4.6**	**33.3%**	**120.1%**	**40.0%**	**46.4%**	**46.4%**
B_Industry	**3.7**	**27.0%**	**63.5%**	**17.1%**	**19.9%**	**66.3%**
I_Offroad	**1.4**	**9.8%**	**68.1%**	**6.7%**	**7.7%**	**74.0%**
E_Solvents	**1.1**	**8.1%**	**81.4%**	**6.6%**	**7.7%**	**81.7%**
J_Waste	0.5	3.7%	174.5%	6.4%	7.5%	89.2%
F_RoadTransport	1.2	8.9%	55.7%	4.9%	5.7%	94.9%
G_Shipping	0.6	4.6%	40.1%	1.8%	2.1%	97.0%
K_AgriLivestock	0.4	2.9%	35.3%	1.0%	1.2%	98.2%
L_AgriOther	0.1	0.8%	100.0%	0.8%	0.9%	99.1%
A_PublicPower	0.1	0.8%	59.5%	0.5%	0.5%	99.6%
H_Aviation	0.0	0.2%	145.4%	0.3%	0.3%	100.0%
D_Fugitive	0.0	0.0%	99.5%	0.0%	0.0%	100.0%

*Table A3.12 Key source ranking using IPCC Approach 2 **trend** assessment for 2023 **$PM_{2.5}$** emissions compared to the base year*

GNFR	1990 Gg	2023 Gg	Level assessment latest year	Uncertainty estimate	Trend	Trend * uncertainty	Contribution to trend	Cumulative contribution
C_OtherStationaryComb	**7.1**	**4.6**	**33.3%**	**120.1%**	**13.3%**	**16.0%**	**53.3%**	**53.3%**
J_Waste	**0.5**	**0.5**	**3.7%**	**174.5%**	**3.1%**	**5.3%**	**17.8%**	**71.1%**
E_Solvents	**1.2**	**1.1**	**8.1%**	**81.4%**	**5.6%**	**4.5%**	**15.1%**	**86.2%**
B_Industry	20.1	3.7	27.0%	63.5%	1.5%	1.0%	3.2%	89.4%
F_RoadTransport	17.7	1.2	8.9%	55.7%	1.5%	0.8%	2.8%	92.2%
K_AgriLivestock	0.5	0.4	2.9%	35.3%	1.8%	0.6%	2.2%	94.4%
L_AgriOther	0.1	0.1	0.8%	100.0%	0.6%	0.6%	1.9%	96.2%
G_Shipping	1.2	0.6	4.6%	40.1%	1.2%	0.5%	1.6%	97.9%
I_Offroad	6.8	1.4	9.8%	68.1%	0.4%	0.3%	1.0%	98.9%
H_Aviation	0.0	0.0	0.2%	145.4%	0.2%	0.3%	0.9%	99.7%
A_PublicPower	1.8	0.1	0.8%	59.5%	0.1%	0.1%	0.3%	100.0%
D_Fugitive	0.1	0.0	0.0%	99.5%	0.0%	0.0%	0.0%	100.0%

Appendix 4 NECD and EMEP review 2024; Status on implementation of recommendations

This appendix contains 5 tables:

- Table A4.1 provides an overview of the status of implementation of recommendations from the NECD-2024 inventory review;
- Table A4.2 provides an overview of the status of implementation of recommendations from the EMEP-2024 inventory review
- Table A4.3 provides an overview of the status of implementation of recommendations from the NECD-2021 LPS review;
- Table A4.4 provides an overview of the status of implementation of recommendations from the NECD-2021 Gridded data review;
- Table A4.5 provides an overview of the status of implementation of recommendations from the NECD-2023 Projections review.

Overall assessment by the NECD review team of the quality of the 2024 inventory submission

- The Netherlands is compliant with all emission reduction commitments and therefore no pollutants were subject to an in-depth review in 2024.
- Based on the review of the 2024 inventory submission and the 2024 IIR, the TERT considers that there is no indication that the overall assessment of the quality of the submission made in the 2023 NECD inventory review has changed. In 2023, the TERT considered the inventory submission to be of very good quality in terms of completeness and accuracy. The IIR submitted in 2023 described the methods transparently. A full detailed review for all pollutants with accompanying quality assessment will be conducted in the 2025 NECD inventory review.
- The TERT acknowledges that the following previous findings for improving the quality of the submissions were implemented by the Netherlands:
  - calculate missing emissions for sources even if the emissions are expected to be small and even for memo items, e.g. recommendation NL-1A3aii(ii)-2023-0001.
- The TERT emphasises the following findings for improving the quality of the submissions from the Netherlands:
  - implement previously raised recommendations (e.g. NL-2A5a-2022-0002, NL-2D3c-2022-0001, NL-2B-2022-0001, NL-1B1a-2022-0001, NL-1A2a-2022-0002);

   - estimate and report $PM_{2.5}$ and PM_{10} emissions in the industry and solvent sectors (e.g. NL-2C5-2023-0001, NL-2C7a-2023-0001);
   - improve completeness by calculating missing emissions for sources even if the emissions are expected to be small or are memo items, e.g., recommendation NL-2D3c-2022-0001.
- The TERT considers that it received responses from the Netherlands that were sufficient in order to undertake the 2024 NECD inventory review

Table A4.1 Overview of the implementation of actions from the ***2024 NECD inventory review***

EMRT-NECD Observation	**Recommendation**	**Reference to IIR or improvement status**
NL-1A2a-2022-0002	Assessment of the implementation of the initial recommendation: For category 1A2a Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel, pollutant SO2, years 2005 and 2020, the TERT noted that there is a lack of transparency regarding reporting of fuel consumption data and large variations in the SO2 implied emission factors (IEF). This was raised during the 2022 NECD inventory review. The TERT notes that the issue does not relate to an over- or under-estimate of emissions. The TERT notes that the IIR states that the issue has been included in the list of improvements. **The TERT reiterates the recommendation that the Netherlands include in the NFR tables the complete fuel consumption, and in the IIR explain the methodology and any assumptions made to tackle the allocation differences between NFR/Annual Emissions Reports (AERs) and CRF/energy statistics in the 2025 submission.**	The NFR tables contain the activity data, as reported by the individual companies and the energy statistics data that is used for the emission calculation of the non-reporting companies. For 1A2a, this is not correct, as not all of the fuels are included in the reporting. Also a comparison to the CRF activity data is not possible, as the CRF emission calculation is based on a mass balance. In response to recommendation NL-1A2a-2022-0002, we have now included a description in Section 3.3.4, explaining what the activity data is based on. Also, a graph is included with the fuel consumption in the iron/steel sector and the coke plants (as the emissions from the integrated coke plant / iron and steel plant are reported in 1A2a and 2C1)

EMRT-NECD Observation	Recommendation	Reference to IIR or improvement status
NL-1A3bii-2023-0002	Assessment of the implementation of the initial recommendation: For category 1A3bii Road Transport: Light Duty Vehicles, NOX, years 2021 and 2022, the TERT notes that the IEF for NOX are lower than those for other Member States. This was raised during the 2023 NECD review, and the TERT recommended that the reference for the source of the NOX emission factor be added in the 2024 IIR, or in the Appendix 5. The TERT noted that neither the 2024 IIR, nor Appendix 5, include such reference. In response to a question raised during the review, the Netherlands states that the reference was overlooked as the text does not mention the study used. **The TERT recommends that Netherlands include the reason for the lower NOX IEF, along with the reference, in the next submission to improve transparency.**	The reference will be included in the Transport methodology report (Witt et al., 2025a) for the 2025 submission. A detailed explanation on how the NO_x IEF for road transport were calculated is given in Section 3.4.1. of this report.
NL-1A3biii-2024-0001	Assessment of the implementation of the initial recommendation: For category 1A3biii Road Transport: Heavy Duty Vehicles and Buses, pollutant NMVOC, years 2005 and 2021, the TERT notes that there is a lack of transparency regarding significant applied recalculations (>10% change). This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Netherlands explained that the reason for the recalculations is the use of new IEF for NMVOC, which solved a previously identified discrepancy between NMVOC emissions from fuel sales and fuel used. **The TERT recommends that the Netherlands include a description of any recalculations for category 1A3biii Road transport: Heavy duty vehicles and buses in the next IIR submission.**	Recalculations for 1A3biii and Road transport in general are explained in paragraph 4.3.8 of the IIR.

EMRT-NECD Observation	Recommendation	Reference to IIR or improvement status
NL-1A3bvi-2023-0001	Assessment of the implementation of the initial recommendation: For 1A3bvi Road Transport: Automobile Tyre and Brake Wear, PM2.5, PM10, all years, the TERT notes that the ratio PM10/PM2.5 is significantly higher than for most other Member States and the EU27 average (5.5 vs. 1.9). A similar issue exists for 1A3bvii Road Transport: Automobile Road Abrasion, i.e., the ratio of the Netherlands is 6.7 vs. 1.9 in other countries. This was raised in the 2023 NECD review. The 2024 IIR states 'Due to limited resources the issue was not solved in the 2024 submission, but is added to the list of improvements for the IIR 2025 submission.' **The TERT reiterates the recommendation that the Netherlands engage with the Dutch PRTR-Task Force for Transportation to address the ratio of PM10/PM2.5 for 1A3bvi for all years, and the Netherlands provide information in the next IIR submission.**	The Task Force for Transportation discussed this topic and carried out literature research. It was found that both ratios used by the Netherlands as well as the recommendation from the guidebook rely on the same very old measurements from the last century, which were aggregated differently (Ten Broeke et al., 2008). As there is an ongoing project to measure country-specific $PM_{10}/PM_{2.5}$ ratios, the decision was made to wait for these results to update the ratios, instead of having a recalculations in subsequent years. This information was included in the source description in Section 4.3.3 and as a source-specific planned improvement in Section 4.3.9.
NL-1A3di(ii)-2024-0001	Assessment of the implementation of the initial recommendation: For category 1A3di(ii) International Inland Waterways, pollutant NOX, and year 2021, the TERT notes that there is a lack of transparency regarding significant applied recalculations (>10% change). This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, the Netherlands explained that the reason for the significant recalculations is the use of more accurate activity data based on AIS signals. The Netherlands also added that the description of the methodology is part of ongoing work. **The TERT recommends that the Netherlands include a description of the new activity data for category 1A3di(ii) and description of any recalculations in the next IIR submission.**	Implemented. A detailed description of the activity data can be found in the method report by Witt et al. (2025a) section 5.2.

EMRT-NECD Observation	Recommendation	Reference to IIR or improvement status
NL-1A4bi-2024-0001	Assessment of the implementation of the initial recommendation: For 1A4bi Residential: Stationary, NOX, years 2005, 2020-2022 the TERT notes that there is a lack of transparency regarding reported fuel consumption activity data in the NFR tables which makes validation of reported emissions impossible. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, the Netherlands explained that activity data were not correctly reported and provided corrected fuel consumption data. **The TERT recommends that the Netherlands correct activity data for 1A4bi Residential: Stationary in the next submission.**	In response to NECD recommendation NL-1A4bi-2024-0001, the activity data for 1A4bi has been corrected. In the previous submission, the activity data of some of the underlying emission sources had been included in the NFR 1A4bi category twice. Because of this error, the AD was almost doubled for gaseous fuels and a bit higher for solid fuels. In the current submission, the double counting in activity data has been removed. This correction only affects activity data, and does not influence emissions.
NL-1B1a-2022-0001	Assessment of the implementation of the initial recommendation: For category 1B1a, pollutants PM2.5 and PM10, years 1990-2020, the TERT notes that there is a lack of transparency regarding reporting of PM emissions from storage and handling of coal. This was raised during the 2022 NECD inventory review. The TERT notes that the issue is below the threshold of significance for a technical correction. The TERT notes that the IIR states that the issue has been included in the list of improvements. **The TERT reiterates the recommendation that the Netherlands investigate further if emissions from storage and handling of coal are included in the Annual Emissions Reports (AERs) for the relevant companies, and include estimates for companies that do not include the emissions in their AERs, and include a description in the IIR in the 2025 submission.**	This improvement is not yet implemented, but it is included in the list of improvements for the year 2025. We will report on the progress in the IIR of 2026.

EMRT-NECD Observation	Recommendation	Reference to IIR or improvement status
NL-2A5a-2022-0002	Assessment of the implementation of the initial recommendation; For 2A5a Quarrying and mining of minerals other than oal, PM10, PM2.5, 1990-2022 the TERT notes that the previous recommendation NL-2A5a-2022-0002 has not yet been implemented. This was raised during the 2022 and 2023 NECD inventory review. The TERT notes that it is mainly an issue of comparability and transparency, but also partially completeness as the Netherlands in previous reviews acknowledged that a small-scale operation was not included. The TERT considers that the effect will be below the threshold of significance. The TERT notes that the IIR states that the issue has been included in the list of improvements and that the recommendation will be addressed in the next submission (IIR p. 127). **The TERT reiterates the recommendation that the Netherlands provide further clarification on whether the identified small missing source has been addressed, that the contribution of these PM emissions actually belongs to 2A5a and also to what extent emissions from 2A5a are reported at all and reports on the findings in the next IIR.**	Unfortunately this action has not been performed for this submission. We still will investigate if it is possible to disaggregate reported emissions between mining/quarrying emissions and other emissions.
NL-2B-2022-0001	Assessment of the implementation of the initial recommendation: For 2B Chemical industry for SO2, NOX, NH3, NMVOC, PM2.5, PM10 and for years 1990-2022 the TERT notes that there is a lack of transparency as all emissions are assigned to NFR 2B10a Other chemical industry, which is a key category for PM2.5 and PM10. This does not relate to an over- or under-estimate of emissions. This was raised during the 2022 and 2023 NECD inventory review. In response to a question raised during the review, the Netherlands explained that due to unforeseen circumstances (limited capacity due to prolonged illness) the correct allocation of emissions has not been possible. **The TERT recommends the Netherlands disaggregate emissions into the different NFR categories in the next submission and provide sufficient explanation in the IIR**	We intended to perform this task for the 2025 submission, however due to unforeseen circumstances (limited capacity due to prolonged illness) this has not been possible. It is now our intention to perform this task for the 2026 submission.

EMRT-NECD Observation	Recommendation	Reference to IIR or improvement status
NL-2C5-2023-0001	Assessment of the implementation of the initial recommendation: For 2C5 Lead Production for PM2.5 and PM10 for 1999, 2000, 2010, 2011, 2020-2022 the TERT notes that no emissions are reported. This was raised during the 2023 NECD inventory review. The TERT notes that the issue is below the threshold of significance for a technical correction. The TERT notes that the IIR states that the issue has been included in the list of improvements (IIR page 287 Table 4.1) and that the recommendation will be addressed in future submission. **The TERT reiterates the recommendation that the Netherlands include the missing emission estimates in the next submission.**	There are two lead producers in the Netherlands, that publish their AER. Both companies do not report PM, however, they did for some years. From this it appears that for the other years the emission levels are the PRTR reporting threshold. These AERs are validated by the competent authority that's also involved in licensing, permit monitoring and enforcement.
NL-2C7a-2023-0001	Assessment of the implementation of the initial recommendation: For 2C7a Copper Production for SO2 (1990-2022); PM2.5 (1999, 2000, 2009-2022); PM10 (1999, 2000, 2009-2022) the TERT notes that no emissions are reported. This was raised during the 2023 NECD inventory review. The TERT notes that the issue is below the threshold of significance for a technical correction. The TERT notes that the IIR states that the issue has been included in the list of improvements (IIR page 288 Table 4.1) and that the recommendation will be addressed in future submission. **The TERT reiterates the recommendation that the Netherlands include the missing emission estimates in the next submission.**	There is one copper producing operator in the Netherland. This company does not report SO_2 and PM emissions in its AER, apparently because they are below EPRTR reporting threshold. As such, the process-emissions are assumed to be very low. The now used notation key should therefore be "NE" and explanation will be added to the IIR in the next submission.

EMRT-NECD Observation	Recommendation	Reference to IIR or improvement status
NL-2D3c-2022-0001	Assessment of the implementation of the initial recommendation: For 2D3c Asphalt Roofing, NMVOC, PM10, PM2.5, 1990-2021, the TERT notes that the notation key 'NE' (not estimated) is used whilst a Tier 1 method is available in the 2023 EMEP/EEA Guidebook. This was raised during the 2022 NECD inventory review. The TERT notes that the issue is below the threshold of significance for a technical correction. The TERT notes that the IIR states that the issue has been included in the list of improvements (IIR p.288) as 'Still no activity data available, see section 5.5.1'. **The TERT reiterates the recommendation that the Netherlands include these estimates in the next NFR and IIR submission.**	As stated in the IIR: Emissions from Asphalt roofing (2D3c) were not estimated because no activity data were available. We have been searching for activity data, without results. Without this data, Tier1 cannot be applied. There are no producers where the production of asphalt roofing is the main economic activity. As such inventorying the producers in the Netherlands is a problem and secondly we need them to report their activity data to the PRTR (without having a legal obligation for this). In addition we note that the producers that have as a secondary economic activity the production of asphalt roofing, report their emissions in the AERs and that our general methodology for estimating industrial emissions that we use also provides an estimate on top of the emissions for non-reporting companies/producers (that are not required to report their emission in an EAR). The issue is added to our long list of improvements.

EMRT-NECD Observation	**Recommendation**	**Reference to IIR or improvement status**
NL-3Df-2023-0001	For category 3Df Use of pesticides for NMVOC and years 2005 and 2010-2021, the TERT noted that there is a lack of transparency in the IIR concerning the reporting of NMVOC emissions from this category. The TERT notes that there is no method for estimating NMVOC emissions from pesticide application in the 2019 EMEP/EEA Guidebook, and the TERT cannot find a description of a country-specific method in the IIR (page 172 states that NMVOC emissions are allocated to category 3Da2a, 3Da3, 3Dc and 3De). Therefore, the TERT would not expect emissions of NMVOC to be reported under 3Df Use of pesticides. In response to a question raised during the review, the Netherlands explained that emissions from individual pesticides in the agriculture sector are calculated using statistics on sales. Emissions are calculated with the NMI4-model. The factsheet Bestrijdingsmiddelengebruik bij landbouwkundige toepassingen (https://www.emissieregistratie.nl/documenten/bestrijdingsmiddelengebruik-bij-landbouwkundige-toepassingen) explains the methodology and activity data. The individual pesticides are then reported to the PRTR, which sums the pesticides based on volatility (from the NMVOC scope) to total NMVOC for this source. This is done automatically in the Netherlands' database using the relations from the so-called ER-rekenfactoren. Additionally, the information was provided that in the Netherlands mineral oil is also often used as crop protection agents and thus added as a pesticide to the NMVOC total. The TERT notes that this issue does not relate to an over- or under-estimate of emissions. **The TERT recommends that in the 2024 IIR the Netherlands include an explanation of the country-specific method to calculate NMVOC emissions from use of pesticides and also update the text on page 172 to include 3Df Use of pesticides in the list of categories for which NMVOC emissions are estimated.**	An explanation has been included in Section 6.3.4. 3df has been included in the list of categories in Section 6.3.1.

EMRT-NECD Observation	Recommendation	Reference to IIR or improvement status
NL-5A-2023-0001	For 5A Biological treatment of waste - Solid waste disposal on land, $PM_{2.5}$ and PM_{10}, all years, the TERT notes that there is a lack of transparency regarding the activity data used for calculation, in particular whether mineral waste is included. In response to a question raised during the review, the Netherlands indicated that the total amount of waste landfilled, as also used for GHG reporting, is considered for the calculation of PM. **The TERT recommends that the Netherlands investigate whether the 'Annual waste at the SWDS' - as covered in the CRF GHG reporting on 5A Biological treatment of waste - includes the total waste landfilled or only landfilled wastes with organic carbon (as relevant for GHG reporting), and include information on this result in the next submission.**	Section 7.1 explains that the amount of annual waste to SWDS includes also the mineral fraction.
NL-5C2-2023-0002	For 5C2 Open burning of waste, SO_x, NO_x, NH_3, NMVOC, $PM_{2.5}$ and PM_{10} and all years, the TERT notes that there is a lack of transparency regarding relevance of open burning of agricultural waste, i.e. orchard crops and forest residues, in the Netherlands. This was raised during the 2022 NECD inventory review. In the IIR 2023, text was added, section 7.5.2, explaining that a ban on open waste burning was imposed and that these emission sources are thus considered not to occur in the Netherlands. In response to a question raised during the review, the Netherlands provided a more comprehensive explanation about the ban on open burning (at the beginning of the 1980s). **The TERT recommends that the Netherlands include this explanation in its next IIR 2024.**	The complete detailed explanation is added to Section 7.5.

EMRT-NECD Observation	Recommendation	Reference to IIR or improvement status
NL-5D-2023-0001	For 5D Wastewater handling, NMVOC, all years, the TERT notes that there is a lack of transparency regarding activity data used for calculation. Neither the IIR (section 7.6) nor the NFR tables provide data on the wastewater volume considered. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, the Netherlands referred to Appendix 5 to the IIR, where in section 3.4.3.4.2 a link is included to Statline to retrieve data on domestic wastewater volumes. Regarding industrial wastewater Appendix 5 explains that volumes of waste water treatment are compiled from a database of Statistics Netherlands for the years 1993-2016 as well as from data from the AER's on volumes of waste water; and that data for 2017-2021 are a copy of the 2016 values. **To increase transparency of reporting the TERT recommends that the Netherlands include activity data, in particular of industrial wastewater volumes, including a reference and information on any gap filling, in its next IIR and NFR.**	See Section 7.6

*Table A4.2 Overview of the implementation of actions from the **2024 EMEP inventory review***

EMEP Observation	Recommendation	Reference to IIR or improvement status
NL-2024-2D3a-1	ERT noted in relation to IIR 2024, 2D3 for industrial processes, that total category and subcategory emissions consist of the sum of data from individual facilities, supplemented by estimated emissions from non-published (small and medium-sized) facilities (p. 122, chapter 5.1.2 IIR 2024. In IIR 2024, page 123, it is explained that since 2000, due to the lack of data on production and emissions at individual facilities, total emissions by category and subcategories are calculated differently and details are given in the IIR. Use of this method in category 2D3d coating applications (with a focus on industrial activities), 2D3e degreasing, 2D3f dry cleaning, 2D3g chemical products, 2D3h printing and 2D3i other solvent uses not described in more detail in the 2024 IIR. During the review process, the Netherlands explained that as an exception, the methodology for calculating emissions from industrial coatings is described in another methodological report. On page 172, 'Group 5: NMVOC emissions from industrial coating applications'. Information on secondary techniques was obtained from the 2010 Paint Industry NMVOC Reduction Plan, which does not contain specific information on oxidizers or absorbers. For subsequent submissions, investigations will be conducted on this topic. **The ERT recommends that the Netherlands include a more precise explanation of the origin of NMVOC emissions for category 2D3a in the Solvent sector in the next submission to increase transparency of the inventory.** **The ERT encourages the Netherlands, although the explanation was given during the review process, to make the IIR as transparent as possible, so include information in the next submission on whether the ESIG data for hand sanitizers were used for calculation or just to check the results, include information on how the use of the agents was assessed for disinfection for 2022 as well.**	A detailed description was added to the previous (2024) submission.

EMEP Observation	Recommendation	Reference to IIR or improvement status
NL-2024-2D-1	ERT noted in relation to IIR 2024, 2D3 for industrial processes, that total category and subcategory emissions consist of the sum of data from individual facilities, supplemented by estimated emissions from non-published (small and medium-sized) facilities (p. 122, chapter 5.1.2 IIR 2024. In IIR 2024, page 123, it is explained that since 2000, due to the lack of data on production and emissions at individual facilities, total emissions by category and subcategories are calculated differently and details are given in the IIR. Use of this method in category 2D3d coating applications (with a focus on industrial activities), 2D3e degreasing, 2D3f dry cleaning, 2D3g chemical products, 2D3h printing and 2D3i other solvent uses not described in more detail in the 2024 IIR. During the review process, the Netherlands explained that as an exception, the methodology for calculating emissions from industrial coatings is described in another methodological report. On page 172, 'Group 5: NMVOC emissions from industrial coating applications'. Information on secondary techniques was obtained from the 2010 Paint Industry NMVOC Reduction Plan, which does not contain specific information on oxidizers or absorbers. For subsequent submissions, investigations will be conducted on this topic. **The ERT recommends the Netherlands, for the sake of better transparency of the IIR, to include in the next submission an explanation of the methodology for calculating emissions from industrial coatings, which is described in the second methodological report.** **The ERT also recommends the Netherlands to include information on planned investigations into secondary techniques in the next submission.**	The description can be found here in the ENINA methodology report 2024. Please refer to page 172, 'Group 5: NMVOC emissions from industrial coating application'. Methodology reports should be considered as a part of the IIR. Information about secondary techniques was obtained from a paint industry NMVOC reduction plan dating from 2010, not containing specific information about oxidators or adsorbers. For next submissions, investigations will be made on this subject.

EMEP Observation	Recommendation	Reference to IIR or improvement status
NL-2024-2D3a-2	The ERT noted with reference to the IIR 2024, category 2D3a uses of domestic products including fungicides, page 136, that a report is cited in reference for explanations of methods used for VOC emissions: For a detailed description of the methodology of the emission sources, see Visschedijk et al. (2024) (Visschedijk, A.J.H., J.A.J. Meesters, M.M. Nijkamp, W.W.R. Koch, B.I. Jansen & R. Dröge, (2024). RIVM Report 2024-0016. This report was not found on the Web by the ERT. During the review process, the Netherlands explained that the Visschedijk et al (2024) report should have been submitted together with the IIR, as it contains a complete description of the emission assessment for product use. Chapter 3 shows a list of NFR codes and emission sources in that NFR category. This table also shows a chapter that describes the emission source in more detail. **The ERT recommends the Netherlands to include in the next submission an explanation of the complete description of the emission assessment as well as the methodology described in a separate report by Visschedijk et al (2024), because for the sake of better transparency it is necessary to explain all the necessary information about the method of emission calculation in the IIR.**	Methodology reports should be considered as a part of the IIR.
NL-2024-2D-2	The ERT noted with reference to IIR 2024, categories 2D3e degreasing, 2D3f dry cleaning, 2D3g chemical products, 2D3h printing, pollutant NMVOC, all the years that the Netherlands reports NMVOC emissions from these categories in the NFR 2024 tables, but does not describe them in the IIR 2024, chapter 5.5. During the review process, the Netherlands briefly listed other sectors, but it would be good to describe other sectors as well. They are 2D3e: degreasing in the metallurgical industry - the production index of this sector is used, 2D3f: NACE 96.012: washing and (dry) cleaning and painting, described in chapter 3, 32 and 33 Visschedijk at al, 2D3g is included in 2B10a, 2D3h: emissions from printing are calculated from annual ink sales statistics, provided by the Dutch Paint and Ink Manufacturers Association (VVVF). **The ERT recommends the Netherlands to include information on non-key categories in the next submission to make the IIR as transparent as possible and to avoid confusion that certain activities do not take place if they are not described.**	Description is added the IIR.

EMEP Observation	Recommendation	Reference to IIR or improvement status
Gridding	With reference to IIR 2024, the ERT noted that the information on the grid parameters and LPS data used is only sparsely described, but a link to further information has been included. **The ETR encourages the Netherlands to provide information in more detail. e.g. NFR Aggregation for Gridding and LPS (GNFR) NFR Code Long name NFR Description (e.g. Distribution up to district level) and Tier-Level 3 / 2 / 1. As an overview and for completeness to the reader.**	A more elaborate description of the disaggregation methodology per sector has now been included in Chapter 14, including information on the tier level of the methods for each sector.

Table A4.3 Overview of the implementation of actions from the ***2021 NECD LPS review***

EMRT-NECD Observation	Recommendation	Reference into IIR
NL-LPS-GEN-2021-0001	The TERT noted that in 2019, the coordinates provided for the following LPSs are more than 10 km away from those reported in the Industrial Reporting database (v4) for the corresponding E-PRTR facility (matching facility ID and distance given in parentheses): Dow Benelux BV .Hoek. .4592. (51104; 13 km), Afvalstoffendienst gemeente Hertogenbosch (203707; 34 km). In response to a question raised during the review, the Netherlands explained that LPS-coordinates have their origin in the operators Annual Environmental Reports (AERs), and that there may have been an error in these coordinates. **The TERT agrees with the approach suggested by the Netherlands of asking operators to correct their reporting in the AER and recommends that the Netherlands upload a corrected version of the 2019 LPS data (Annex VI file) to the CDR as corrected coordinates for these plants are available, as well as ensuring that this issue does not reoccur in the 2023 LPS data submission in 2025.**	The errors are corrected and the correct data will be in the 2025 LPS-submission.

Table A4.4 Overview of the implementation of actions from the ***2021 NECD Gridded data review***

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-GRID-GEN-2020-0003	The TERT notes with reference to gridded emissions submitted in the GNFR tables for NO_X, $PM_{2.5}$, PM_{10}, NMVOC and CO that there may be an under-estimate (for NO_X, $PM_{2.5}$, PM_{10}) or over-estimate (for CO and NMVOC) of emissions. The gridded emissions reported for these pollutants are not consistent with the emissions reported in the national totals (NFR tables). In the cases of NO_X, $PM_{2.5}$, CO the differences are significant in the national totals reported. In the cases of NMVOC, PM_{10} the differences are related to the emissions for F_RoadTransport. The issue will be flagged as a priority recommendation. In response to a question raised in the review the Netherlands acknowledges that there is an error in the data and informed the TERT that it will be corrected and resubmitted. **The TERT recommends that Netherlands resubmits the corrected data and ensures that gridded emissions are consistent with national totals in the next submission.**	The error was corrected.

Table A4.5 Overview of the implementation of actions from the ***2023 NECD Projections review***

EMRT-NECD Observation	**Recommendation**	**Reference to IIR or status**
NL-0A-2023-0002	The TRT noted that the value zero (0) or a blank cell is reported for one or more categories for NMVOC in 2025 and 2030 and for the scenario With Measures (WM). In response to a question raised during the review, the Netherlands explained that small emission values similar to those reported in the WAM scenario should have been reported. The TRT notes that this issue relates to an underestimate and **recommends that the Netherlands ensures that emission values are reported where relevant in the next submission**.	The issue is corrected in the 2025 submission.
NL-NATIONAL TOTAL-2019-0004	The TRT notes that the Netherlands only has a short summary of the background and methodology to its projections in its IIR, which does not provide sufficient detail to support the review. This was raised during the 2021 Projections review. The Netherlands refers to background reports only available in Dutch. Furthermore, the TRT noted that activity data were not provided on a consistent basis in the Annex IV template. In response, the Netherlands explained that the activity data format requested in the Annex IV template did not in all cases match the data used in the projections and further that there were no plans to translate the more detailed projections methodological descriptions. The TRT notes that it is very difficult to review the projections with so little information on the methodologies, activity data and projected emission factors being available in the IIR. **The TRT recommends that the Netherlands provides more details on the methods, data sources and assumptions behind its projections in its IIR to enable the international and European community to understand the details of its estimated projections.**	As indicated before, the national emission projections for air pollutants for the Netherlands are prepared as part of the national emission projections for greenhouse gases in one and the same project called the Netherlands Climate and Energy Outlook. Various country-specific models are used in the Outlook underpinning the projections. The information in Chapter 12 has been extended and a more elaborate description of these models and data sources is now included in the chapter. This description fulfils requirements with respect to international reporting on greenhouse gases and energy, for which methodology descriptions have been made available in the references. Furthermore, an effort has been made to fill the Annex IV with more projected activity data. References are included in Chapter 12 to the reports that contain more detailed descriptions of the methodologies. The fact remains that due to resource constraints it is not possible to translate these reports.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-1A1a 2023-0001	For category 1A1a Public Electricity and Heat Production, SO2, PM2.5, NMVOC, NH3 and NOX for 2025, 2030, 2035, and 2040, the TRT noted that there is a lack of transparency regarding the trend of the fuel consumption of biomass. In response to a question raised during the review, the Netherlands explained that the decrease in biomass consumption is due to the closing of coal fired power plants, as mentioned in the KEV22 report, as most biomass is used for co-firing. The TRT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands include a description of the reason for the trend in the next IIR.**	Detailed explanations of the trends in the projections, per pollutant and sector, are given in the PBL report 'Emissieramingen luchtverontreinigende stoffen 2025' ('Emission projections for air pollutants 2025'). The full reference is included in Chapter 12. The report is only available in Dutch; there are no plans to publish an English version. The role of biomass in the current projections has been addressed separately under Section 12.7.
NL-1A1c 2023-0001	For category 1A1c Manufacture of Solid Fuels and Other Energy Industries and NOX for 2025, 2030, 2035, and 2040, the TRT noted that there is a lack of transparency regarding the emissions estimates and the trend. In response to a question raised during the review, the Netherlands explained that emissions are predominantly from gas production onshore and offshore, which, have decreased in the historical years. Furthermore new emission standards have led to a decrease of offshore emission factors in 2016-2019. The TRT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands include a description of the basis for the projection in the next IIR, i.e. information about activity data, emission factors and relevant policies and technological improvements taken into account in projected data.**	As indicated before, the national emission projections for air pollutants for the Netherlands are prepared as part of the national emission projections for greenhouse gases in the Netherlands Climate and Energy Outlook. Chapter 12 has been extended and a more elaborate description of the models and data sources used in the Outlook is now included in the chapter. Furthermore, an effort has been made to fill the Annex IV with more projected activity data. References are included in Chapter 12 to the reports that contain more detailed descriptions of the methodologies. The fact remains that due to resource constraints it is not possible to translate these reports.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-1A2a 2023-0001	For category 1A2a Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel, SO2 and NOX for 2025, 2030, 2035, and 2040, the TRT noted that there is a lack of transparency regarding the basis of the projection. In response to a question raised during the review, the Netherlands explained that the decreasing emissions mainly owe to action plans of Tata steel, e.g. denox installation and “DRI” installations. The TRT notes that, as explained by the Netherlands, a number of relevant policies are listed in the IIR, but that the effect for the relevant sectors regarding activity data and emission factors are not included. The TRT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands expands the description in the IIR projection chapter to include more details about the relevant policies and related assumptions, and the expected effect on the activity data and emission factors.**	As indicated before, the national emission projections for air pollutants for the Netherlands are prepared as part of the national emission projections for greenhouse gases in the Netherlands Climate and Energy Outlook. The information in Chapter 12 has been extended and a more elaborate description of the models and data sources used in the Outlook is now included in the chapter. Furthermore, an effort has been made to fill the Annex IV with more projected activity data. References are included in Chapter 12 to the reports that contain more detailed descriptions of the methodologies. The fact remains that due to resource constraints it is not possible to translate these reports. Relevant policies for this sector have been addressed in Chapter 12.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-1A2b 2023-0001	For category 1A2b Stationary Combustion in Manufacturing Industries and Construction: Non-Ferrous Metals and SO2 for 2025, 2030, 2035, and 2040, the TRT noted that there is a lack of transparency regarding the emissions estimates and the trend, and that no activity data are included in the Annex IV tables. In response to a question raised during the review, the Netherlands explained that the trend is mainly influenced by two individual aluminium factories, of which one shut down and was demolished in 2005-2013, and the other has suffered bankruptcies and various shut-downs and (partial) re-starts over the past few years. The TRT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands include an explanation of the drivers for the fluctuating trend and how this is handled in the projection, and information about the activity data and emission factors used in the IIR projection chapter in the next submission.**	As indicated before, the national emission projections for air pollutants for the Netherlands are prepared as part of the national emission projections for greenhouse gases in the Netherlands Climate and Energy Outlook. Chapter 12 has been extended and a more elaborate description of the models and data sources used in the Outlook is now included in the chapter. Furthermore, an effort has been made to fill the Annex IV with more projected activity data. References are included in Chapter 12 to the reports that contain more detailed descriptions of the methodologies. The fact remains that due to resource constraints it is not possible to translate these reports.
NL-1A2gviii 2023-0001	For category 1A2gviii Stationary combustion in manufacturing industries and construction: Other, SO2, NOX and PM2.5 for 2025, 2030, 2035, and 2040, the TRT noted that there is a lack of transparency regarding the emissions estimates and the trend and that no activity data are included in the Annex IV tables. In response to a question raised during the review, the Netherlands explained that emissions originate from building materials production, metal processing, other industries, recycling and construction, which all show declining fuel consumption 2020-2040. The Netherlands provided information about the shares for NOX, SO2 and PM, but it is unclear to the TRT what these refers to. The TRT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands includes a description of the sources, activity data, emission factors, and assumptions behind the trends in the projection years in the IIR and to report activity data in the Annex IV tables in the next submission.**	As indicated before, the national emission projections for air pollutants for the Netherlands are prepared as part of the national emission projections for greenhouse gases in the Netherlands Climate and Energy Outlook. The information in Chapter 12 has been extended and a more elaborate description of the models and data sources used in the Outlook is now included in the chapter. Furthermore, an effort has been made to fill the Annex IV with more projected activity data. References are included in Chapter 12 to the reports that contain more detailed descriptions of the methodologies. The fact remains that due to resource constraints it is not possible to translate these reports.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-1B2aiv 2023-0001	For category 1B2aiv Fugitive Emissions Oil: Refining and Storage and NMVOC for 2025, 2030, 2035, and 2040, the TRT noted that there is a lack of transparency regarding the emissions estimates and the trend, and that no activity data are reported in the Annex IV tables. In response to a question raised during the review, the Netherlands explained that emissions from refining and storage are reported by the operators in their AERs and that production data are not included. The Netherlands explained that measures taken into account in the growth scenario are almost fully implemented, hence few new reductions can be expected. The TRT notes that this issue does not relate to an over- or under-estimate and **recommends the Netherlands makes efforts to get the production data from the operators, which is used in the growth scenario and include this information in Annex IV in the next submission, if this is not possible, information should be included in the IIR including a description of the assumptions behind the projected emissions.**	As indicated before, the national emission projections for air pollutants for the Netherlands are prepared as part of the national emission projections for greenhouse gases in the Netherlands Climate and Energy Outlook. The information in Chapter 12 has been extended and a more elaborate description of the models and data sources used in the Outlook is now included in the chapter. References are included in Chapter 12 to the reports that contain more detailed descriptions of the methodologies. The fact remains that due to resource constraints it is not possible to translate these reports.
NL-2D3a 2023-0001	For NFR 2D3a Domestic Solvent Use Including Fungicides and NMVOC for 2025-2030, the TRT noted that the projected trends of emissions (important decrease between 2020 and 2025, then increase until 2030) could not be understood and no explanation was given in the IIR. In response to a question raised during the review, the Netherlands explained the methodologies used for the projected activity data of the major emission sources of this sector. The TRT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands adds the information about projected methodologies applied in the projections, given in answer to the question raised, in the IIR projection chapter, for the next submission.**	As indicated before, the national emission projections for air pollutants for the Netherlands are prepared as part of the national emission projections for greenhouse gases in the Netherlands Climate and Energy Outlook. The information in Chapter 12 has been extended and a more elaborate description of the models and data sources used in the Outlook is now included in the chapter. References are included in Chapter 12 to the reports that contain more detailed descriptions of the methodologies. The fact remains that due to resource constraints it is not possible to translate these reports.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-3B-2023-0001	For category 3B Manure management for base year 2020, 2025 and 2030, the TRT noted that there is a lack of transparency regarding the number of animals for both the scenario WM and WAM for following animal categories; 3B4d Goats, 3B4e Horses, 3Bf Mules/Asses, 3Bgii Broilers, 3B4giii Turkeys, 3BgiV Other poultry and 3B4h Other animals. Lack of activity data makes it difficult to conduct a proper review. In response to a question raised during the review, the Netherlands explained that activity data for the animal categories mentioned above can be found in a report in Dutch provided by Wageningen University and referred to relevant tables. The TRT notes that this issue does not relate to an over- or under-estimate. **The TRT recommends that the Netherlands includes activity data for 3B4d, 3B4e, 3Bf, 3Bgii, 3B4giii, 3BgiV and 3B4h in Annex IV or in the IIR in the next submission.**	An effort has been made to include more activity data in Annex IV. However, it should be noted that this is challenging, since the classification used for the Dutch emission projections (GCN codes) differs from the NFR classification.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-3B3-2023-0001	For category 3B3 Swine, the TRT noted that there is a lack of transparency regarding the expected decrease of NH3 emission from the projection base year to projection year 2030 for both the WM and WAM scenario. The number of swine decreases by 9% from 2021 to 2030, while the NH3 emission decreases by 35%. No information is given in the IIR, but low emission technology is mentioned in a background report written in Dutch (Geraamde ontwikkelingen in nationale emissies van luchtverontreinigende stoffen 2023). In response to a question raised during the review, the Netherlands explained that developments in housing systems and emission reducing technology can be found in a background report from Wageningen University written in Dutch ((https://research.wur.nl/en/publications/raming-van-luchtemissiesuit-de-landbouw-tot-2030-met-doorkijk-na). The TRT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands includes data regarding the projected use of NH3 reducing technology in housing and storage systems for 3B3 Swine in the next IIR submission to allow readers to understand the trend in projected emissions.**	Detailed explanations of the trends in the projections, per pollutant and sector, are given in the PBL report 'Emissieramingen luchtverontreinigende stoffen 2025' ('Emission projections for air pollutants 2025'). The full reference is included in Chapter 12. The report is only available in Dutch; there are no plans to publish an English version.
NL-3B4e 2023-0001	For category 3B4e Horses, the TRT noted that no emissions are reported for pollutants: NMVOC and PM2.5 for years 2025, 2030 for both the WM and WAM scenario. Emissions reporting for NMVOC and PM2.5 is expected because emissions for this category are reported for NH3 and NOx. In response to a question raised during the review, the Netherlands explained that NMVOC and PM projections for 3B4e have been included in 3b4f Mules and Asses. The TRT notes that this issue does not relate to an over- or underestimate. To ensure the consistency, the TRT recommends that the Netherlands uses the same structure in the **projections as in the inventory thus report emission from horses in category 3B4e and emission for mules and asses on category 3B4f. If this is not possible, the notation key should be corrected to “IE” and an explanation included in the IIR.**	This has been corrected in the 2025 submission.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-3B4e2023-0002	For category 3B4e Horses, the TRT noted that no emissions are reported for pollutants: NOx, NMVOC, NH3 or PM2.5 for base year 2020 in Annex IV for both the scenario WAM and WM. However, the emission for 3B4e Horses is reported in the historical inventory (Annex I). In response to a question raised during the review, the Netherlands explained that emissions from horses are included in 3B4f Mules and Asses, but also explained that the emission for 3B4f was incorrect and should be higher; 0,049 kt, NMVOC 0,054 kt, PM2.5 0,014 kt and NH3 0,397 kt. The TRT notes that this issue does relate to an under-estimate and **recommends that the Netherlands ensures correct emissions being reported for the base year in the next submission. The TRT also recommends that the Netherlands uses the same structure in the projection reporting as in the inventory and thus report emission from horses in category 3B4e and emission for mules and asses on category 3B4f.**	This has been corrected in the 2025 submission.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-3B4gi 2023-0001	For category 3B4gi Laying hens and NH3 for all years, the TRT noted that there is a lack of transparency regarding the trend from 2021 to 2030 for both the WM and the WAM scenario. The number of laying hens decreases by 2 %, while the emission for the same period decreases by 20 %. No information is provided in the IIR but low emission technology is mentioned in a background report written in Dutch (Geraamde ontwikkelingen in nationale emissies van luchtverontreinigende stoffen 2023). In response to a question raised during the review, the Netherlands explained that development in housing system and emission reducing technology can be found in a background report from Wageningen University written in Dutch (https://research.wur.nl/en/publications/raming-van-luchtemissies-uit-de-landbouw-tot-2030-met-doorkijk-na). The TRT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands includes data regarding use of NH3 reducing technology in the next IIR submission in a form which make it possible to understand the reason for the decreasing trend in NH3 emissions.**	Detailed explanations of the trends in the projections, per pollutant and sector, are given in the PBL report 'Emissieramingen luchtverontreinigende stoffen 2025’ ('Emission projections for air pollutants 2025'). The full reference is included in Chapter 12. The report is only available in Dutch; there are no plans to publish an English version.
NL-3Da1-2023-0002	For category 3Da1 Inorganic N-fertilizers (includes also urea application), the TRT noted that there is a lack of transparency regarding the trend for N applied. The activity data provided in Annex IV shows a significant decrease from 2020 to 2030 for both activity data (24%) and NH3 emission (27%), however no explanations for this expected decrease is mentioned in the IIR. In response to a question raised during the review, the Netherlands mentioned three reasons for decrease in use inorganic fertilisers; fall in agricultural area, high fertilizer prices and a special technique (SAFEMANURE), which can improve the N-utilization in animal manure. The TRT notes that this issue does not relate to an over- or under-estimate. **The TRT recommends that the Netherlands includes explanations for the expected trend in the use of inorganic fertiliser in the IIR in the next submission.**	Detailed explanations of the trends in the projections, per pollutant and sector, are given in the PBL report 'Emissieramingen luchtverontreinigende stoffen 2025’ ('Emission projections for air pollutants 2025'). The full reference is included in Chapter 12. The report is only available in Dutch; there are no plans to publish an English version.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-3De-2023-0001	For category 3Da2a Animal Manure Applied to Soils and NH3 for 2030, the TRT noted that there is a lack of transparency regarding the total N applied to soils and the emission trend. The trend for the most important livestock production is decreasing from 2021-2030, while the NH3 emission increases by 7%. No information is included in the IIR. In response to a question raised during the review, the Netherlands explained that the NH3 emission for 2020 is updated due to new insight for use of low emission application technics, which will result a higher NH3 emission for 2020 by 2.7 kt NH3. However, this change does not affect the projected emission and thus a slight decrease of NH3 emission is projected from 2020 to 2030. The TRT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands ensures that correct NH3 emissions are reported for the base year for the next submission. The TRT also recommends the Netherlands includes data on nitrogen applied to soils in the IIR for the next submission and an explanation for the trend.**	In the 2025 submission, it is ensured that emissions in the base year 2022 are in line with projected emissions.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-3De-2023-0001	For category 3De Cultivated Crops and NMVOC, the TRT noted that there is a lack of transparency regarding the trend from the base year of 2021 until projected year 2030. The emissions of NMVOC are expected to decrease from 2021 to 2030, while emissions of PM2.5 and NH3 are projected to remain at the same level. No information regarding the cultivated area or division of crop types is given in the IIR. In response to a question raised during the review, the Netherlands explained that information regarding the crop land area can be found in underlying report written in Dutch (https://research.wur.nl/en/publications/raming-van-luchtemissies-uit-de-landbouw-tot-2030-met-doorkijk-na). The TRT notes that this issue does not relate to an over- or under-estimate. **The TRT recommends that the Netherlands includes data regarding the cultivated area in Annex IV and/or the IIR in the next submission and includes explanation in the IIR, wherever the emission trend does not follow the trend of the activity data. More information included directly in IIR could improve the transparency significant.**	Detailed explanations of the trends in the projections, per pollutant and sector, are given in the PBL report 'Emissieramingen luchtverontreinigende stoffen 2025' ('Emission projections for air pollutants 2025'). The full reference is included in Chapter 12. The report is only available in Dutch; there are no plans to publish an English version.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-5A-2023-0001	For 5A Biological Treatment of Waste - Solid Waste Disposal On Land, NMVOC, years 2020, 2025 and 2030, the TRT noted that emissions are projected to increase between 2021 and 2025 (19% increase) whereas NMVOC emissions constantly declined from 2005 to 2021. There is no information in the IIR about activity data or emission factors used. In response to a question raised during the review, the Netherlands provided unclear information, explaining that this emission is estimated as 3% of the total waste sector emissions and these sector-emissions show a slight increase because of the increase in biological treatment of organic wastes. The TRT notes that this issue relates to an over- or under-estimate and **recommends that the Netherlands provides more information to explain why emissions increase by 19% between 2021 and 2025 whereas emissions decreased during the period 2005 - 2021 providing the methodology used in the IIR in the next submission.**	Detailed explanations of the trends in the projections, per pollutant and sector, are given in the PBL report 'Emissieramingen luchtverontreinigende stoffen 2025' ('Emission projections for air pollutants 2025'). The full reference is included in Chapter 12. The report is only available in Dutch; there are no plans to publish an English version.
NL-5B1-2023-0001	For 5B1 Biological treatment of waste - composting, NH3 and years 2005 and 2020, the TRT noted an inconsistency between emissions for 2005 and 2020 reported in the inventory (Annex I) and projections (Annex IV). This difference is important, approximately by a factor 3 and data reported in Annex IV are lower than inventory estimates. In response to a question raised during the review, the Netherlands provided unclear information, explaining that this emission is estimated as 47 % of the total waste sector emissions and these sector-emissions show a increase from 2005 because of an increase of treatment of organic wastes. The TRT notes that this issue relates to a possible over- or under-estimate and **recommends that the Netherlands provides more information to explain the difference between historical estimates and projections (all years) providing the methodology used in the IIR in the next submission.**	This inconsistency between inventory emissions and projected emissions has been corrected in the 2025 submission.

EMRT-NECD Observation	Recommendation	Reference to IIR or status
NL-5C1bv 2023-0001	For sector 5C1bv Cremation, SOX, NOx and NMVOC for 2025, 2030 and 2040, the TRT noted that emissions are reported as 'IE' in Annex IV whereas emissions are estimated in Annex I for 1990 – 2021 period. In response to a question raised during the review, the Netherlands explained that emissions from cremations in the projection were included 94% in 1A4Ai and 6% in 6A NFR code. **The TRT recommends that the Netherlands report consistently in the projection and the inventory. If this is not possible this should be explained in the IIR and the allocation of emissions should be transparently presented.**	This has been corrected in the 2025 submission.
NL-5E-2023-0001	For 5E Other waste, pollutants SO2, NOX, NMVOC, PM2.5 and NH3, years 2020, 2025 and 2030, the TRT noted trend inconsistencies according to the pollutant considered. Indeed, the emissions increase between 2020 and 2030 for PM2.5 and NH3, emissions are stable for SO2, and emissions decrease for NMVOC. There is no information in the IIR about activity data or emission factors used. In response to a question raised during the review, the Netherlands explained that it is because these compounds are emitted from different sources and are estimated differently because activity data statistics for these processes are not available. Indeed, NMVOC and PM are estimated as a percentage of the household and waste sector emissions, whereas the other pollutants are a percentage of only household emissions (here PM, NOX and SO2 mainly originate from (bon)fires and fireworks, NH3 from private animal husbandry, and NMVOC mainly from solvent use). The T.RT notes that this issue does not relate to an over- or under-estimate and **recommends that the Netherlands provides more information in the next IIR submission on the individual sources an the methodologies and data used to project emissions**	A more elaborate description of models and data sources used for projection calculations is now given in Chapter 12 of the IIR. References are included in Chapter 12 to reports that contain detailed explanations of the trends in the projections. As stated before, due to resource constraints it is not possible to provide translations of these reports.

Appendix 5 Additional information to be considered as part of the IIR submission

List A5.1 contains the list of methodology reports that have been submitted to the EU and UNECE as part of the submission of 15 March 2025. These reports are to be considered an integrated part of this IIR 2025.

A5.1 List of methodology reports

ENINA (Energy, IP, 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 and O.R. van Hunnik

Transport:
Methods 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 and M. Kosterman
This report includes a separate Excel document with activity data and emission factures: Methodology report transport ER 1990–2023 tables.xlsx

Product Use and Service sectors:
Methodology for the calculation of emissions from product usage by consumers, construction and services
RIVM report 2025-0004
A. Visschedijk, J.A.J. Meesters, M.M. Nijkamp, W.W.R Koch, B.I. Jansen, and R. Dröge

Agriculture:
Methodology for the calculation of emissions from agriculture - 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)
RIVM report 2025-0003
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 and G.L. Velthof

These reports are also available at the website http://rivm.nl

Appendix 6 Combined NFR source category KCA uncertainty analysis

The Approach 2 (Monte Carlo) uncertainty analysis, as described in Section 1.5, makes use of uncertainty information at the level of emission source and also produces results at that level. The level of detail is comparable to the SNAP reporting codes and is more specific than the NFR and GNFR sectors. By using the uncertainty estimates at the emission source level, the identification of key sources is more specific and precise.

The results of the uncertainty analyses at the emission source level are presented in the graphs below. For each substance, the uncertainty estimates (95% confidence level) of the emission sources are plotted against their share of the national total emission. For clarity, the plotted emission sources are classified by GNFR sector. The graphs visualise the emission sources that have a relatively large contribution to the national total and also have a high uncertainty. The addition of the uncertainty as a weight factor provides extra detail to the ranking of the key sources. This information can be helpful in the process of prioritising inventory improvements.

Details of the key sources are provided in the accompanying tables. The emission sources that have a relatively large contribution to the national total and/or also have a high uncertainty are labelled. The tables give a summary of these labelled key sources.

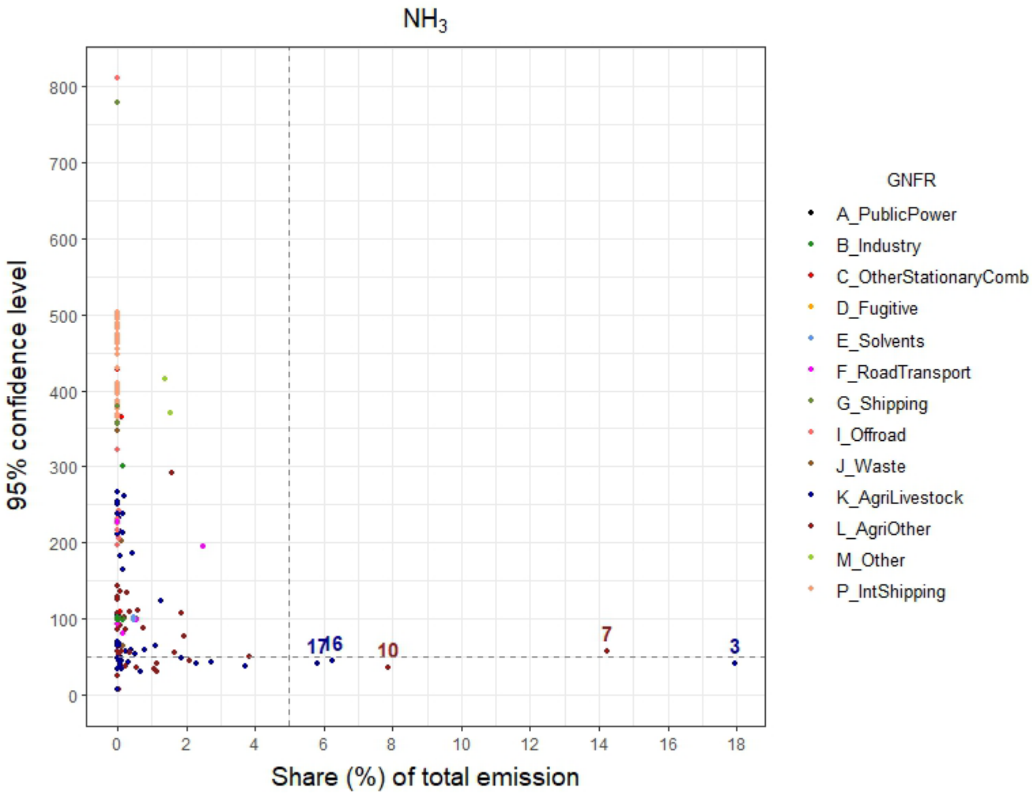

*Table A6.1 Emission sources of **NH_3** with a relative high uncertainty and contribution to the national total emission (numbers correspond with labels in graph)*

#	NFR Code	Long Name	Emission source	Share	Uncertainty estimate
3	3B1a	Manure management - Dairy cattle	Mature dairy cattle, manure in housing	17.9%	41%
7	3Da2a	Animal manure applied to soils	Mature dairy cattle, manure application	14.2%	57%
10	3Da1	Inorganic N fertilisers (includes also urea application)	Fertiliser application	7.9%	37%
16	3B3	Manure management - Swine	Fattening pigs, manure in housing	6.3%	45%
17	3B4gi	Manure management - Laying hens	Laying-hens, manure in housing	5.8%	41%

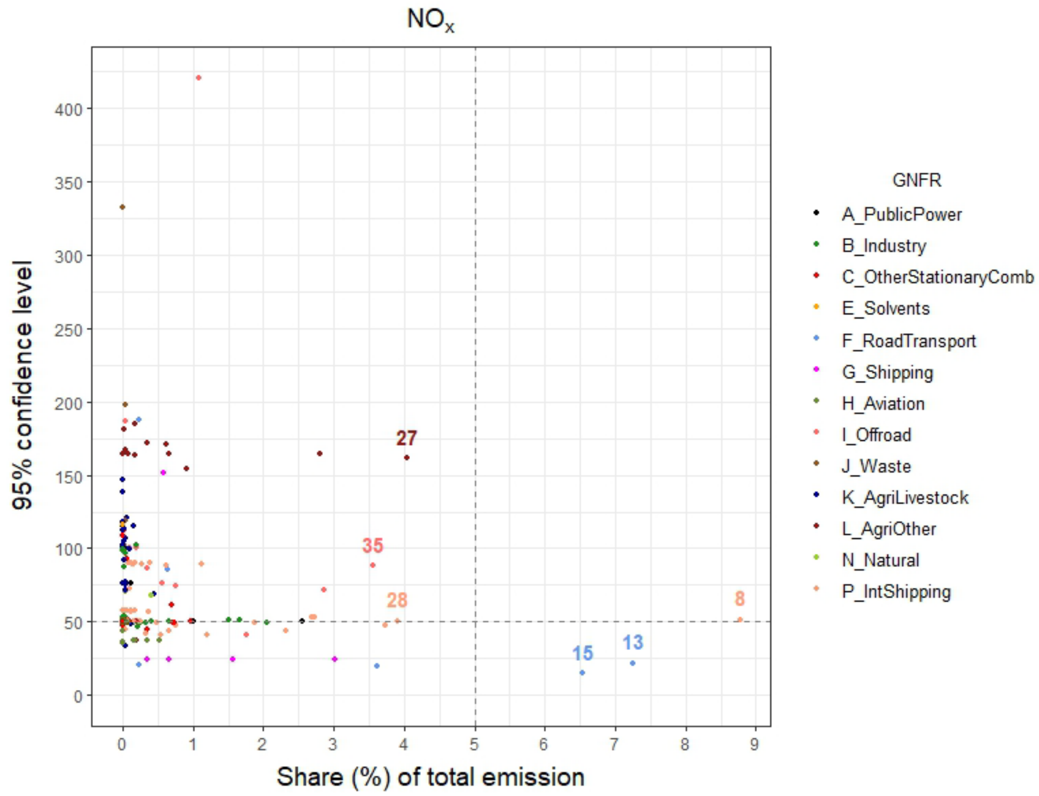

Table A6.2 Emission sources of ***NO_x*** *with a relative high uncertainty and contribution to the national total emission (numbers correspond with labels in graph)*

#	NFR Code	Long Name	Emission source	Share	Uncertainty estimate
8	1A3di(i)	International maritime navigation	Sailing, NCP, Container ships	8.7%	52%
13	1A3biii	Road transport: Heavy duty vehicles and buses	Exhaust gas, heavy vehicles	7.2%	22%
15	1A3bi	Road transport: Passenger cars	Exhaust gas, passenger cars	6.5%	15%
27	3Da2a	Animal manure applied to soils	Manure application	4%	161%
28	1A3di(i)	International maritime navigation	Sailing, NCP, Roro cargo/Car ships	3.9%	51%
35	1A3di(i)	International maritime navigation	Sailing, NCP, Chemicals/Gas tanker	3.7%	48%

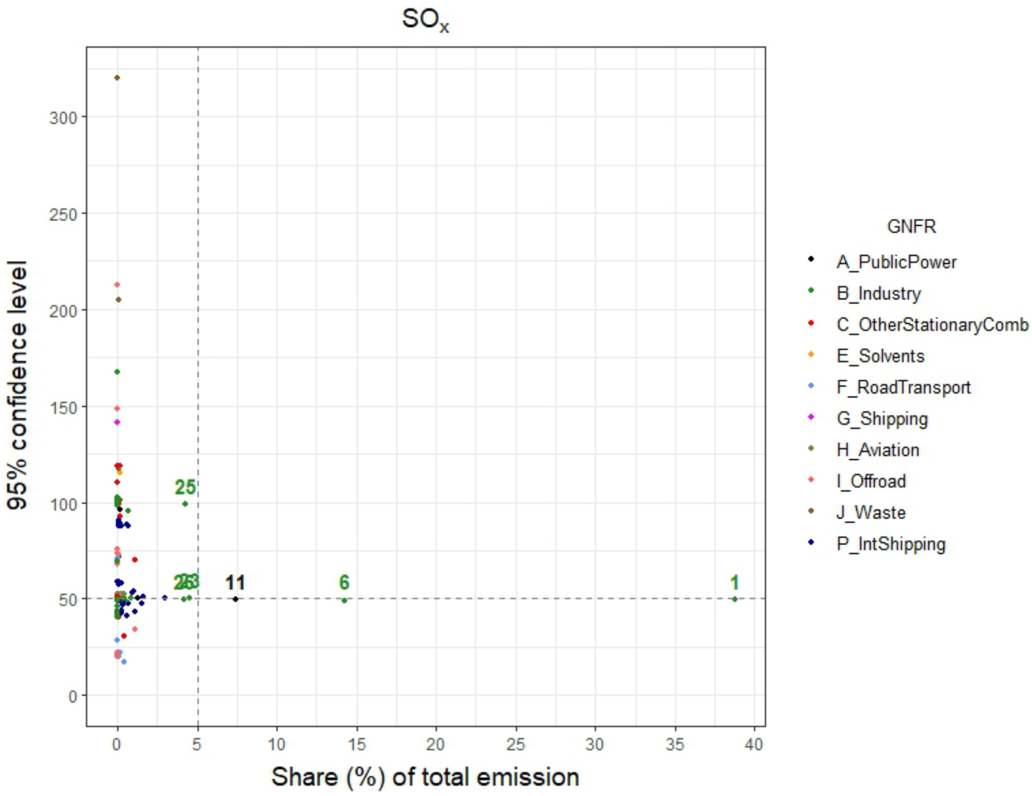

*Table A6.3 Emission sources of **SO_x** with a relative high uncertainty and contribution to the national total emission (numbers correspond with labels in graph)*

#	NFR Code	Long Name	Emission source	Share	Uncertainty estimate
1	1A1b	Petroleum refining	Facilities NACE 19.201: manufacture of refined petroleum products	38.7%	50%
6	1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	Facilities NACE 24.1-24.3 base metal industry, processing and manufacture of iron and steel	14.3%	49%
11	1A1a	Public electricity and heat production	Facilities NACE 35: production and distribution of electricity and gas	7.4%	50%
23	1A2gviii	Stationary combustion in manufacturing industries and construction: Other	Facilities NACE 23: construction material and glass industry	4.5%	50%
25	2A6	Other mineral products	NACE 23.32: manufacture of bricks and tiles	4.3%	99%
26	1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	Facilities NACE 20.1:manufacture of basic chemicals	4.2%	50%

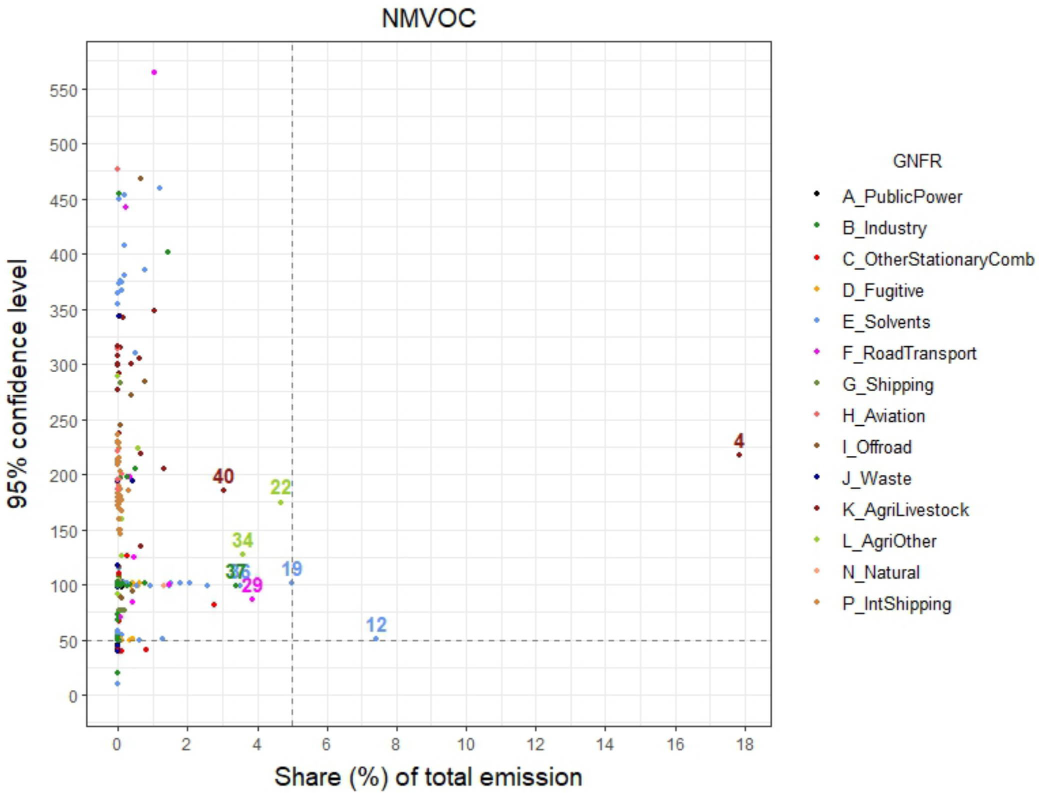

*Table A6.4 Emission sources of **NMVOC** with a relative high uncertainty and contribution to the national total emission (numbers correspond with labels in graph)*

#	NFR Code	Long Name	Emission source	Share	Uncertainty estimate
4	3B1a	Manure management - Dairy cattle	Mature dairy cattle, manure in housing + storage	17.9%	217%
12	2D3a	Domestic solvent use including fungicides	Solvent and other product use: hand sanitisers	7.4%	50%
19	2D3a	Domestic solvent use including fungicides	Solvent and other product use: cosmetics	5%	101%
22	3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	Silage storage	5%	175%
29	1A3bi	Road transport: Passenger cars	Exhaust gas, passenger cars	3.9%	87%
34	3Da2a	Animal manure applied to soils	Manure application	3.6%	127%
36	2D3a	Domestic solvent use including fungicides	Solvent and other product use: car products	3.5%	99%
37	2H3	Other industrial processes	NACE 52.10/52.24: cargo handling and storage	3.4%	99%
40	3B1b	Manure management - Non-dairy cattle	Young cattle breeding, manure in housing + storage	3%	185%

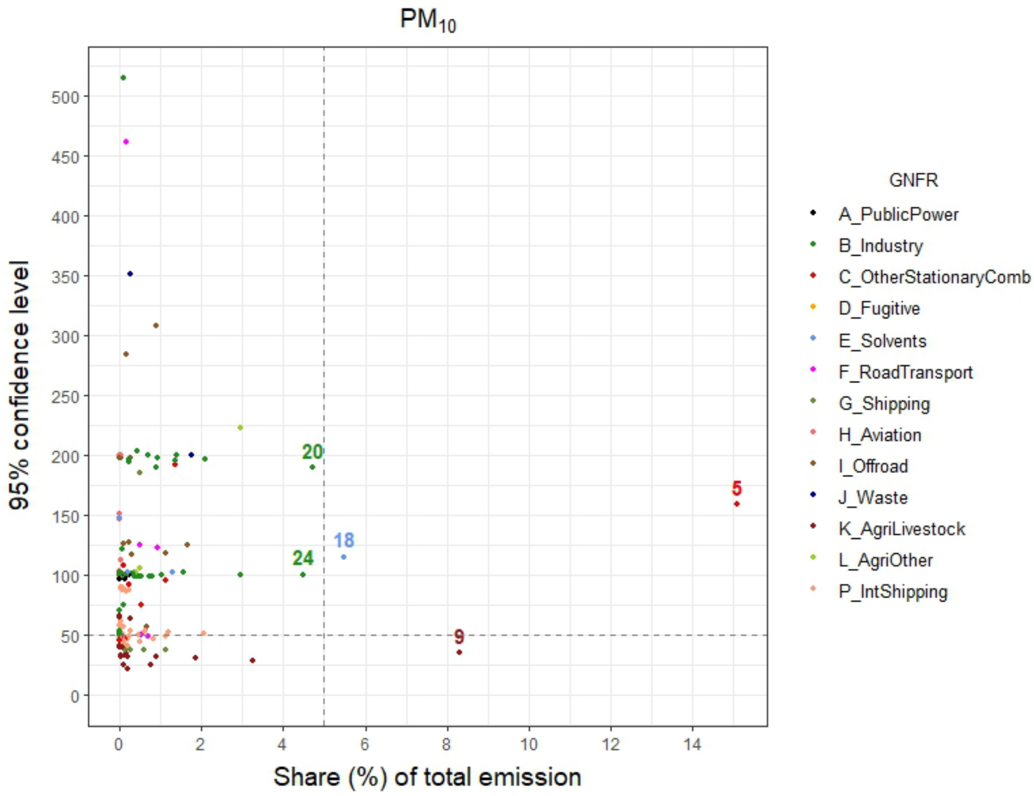

Table A6.5 Emission sources of ***PM_{10}*** *with a relative high uncertainty and contribution to the national total emission (numbers correspond with labels in graph)*

#	NFR Code	Long Name	Emission source	Share	Uncertainty estimate
5	1A4bi	Residential: Stationary	Residential combustion, wood stoves and fire places	15.1%	159%
9	3B4gi	Manure management - Laying hens	Laying-hens, manure in housing + storage	8.3%	35%
18	2G	Other product use	Fireworks at new year	5.5%	115%
20	2A6	Other mineral products	NACE 23: construction material and glass industry, diffuse	4.7%	190%
24	2A5b	Construction and demolition	Building and construction sites	4.5%	101%

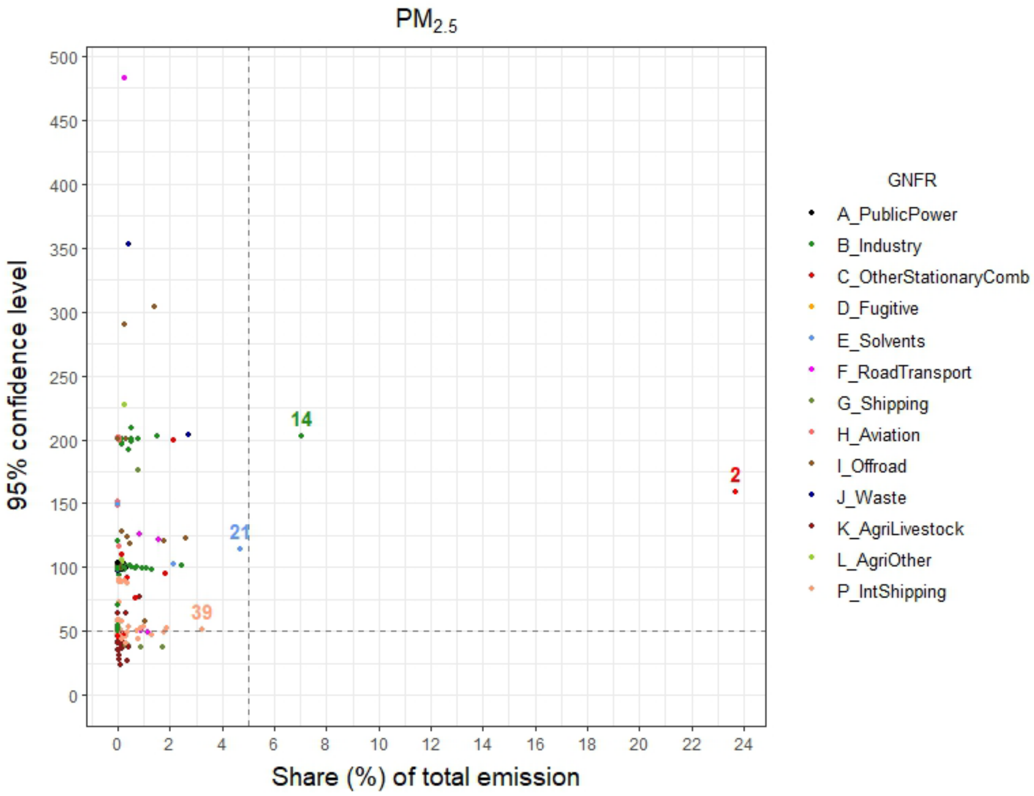

*Table A6.6 Emission sources of **$PM_{2.5}$** with a relative high uncertainty and contribution to the national total emission (numbers correspond with labels in graph)*

#	NFR Code	Long Name	Emission source	Share	Uncertainty estimate
2	1A4bi	Residential: Stationary	Residential combustion, wood stoves and fire places	23.7%	158%
14	2A6	Other mineral products	NACE 23: construction material and glass industry, diffuse	7%	202%
21	2G	Other product use	Fireworks at new year	4.7%	114%
39	1A3di(i)	International maritime navigation	Sailing, NCP, Container ships	3.2%	52%

Appendix 7 Data applied for the NMVOC adjustment 3B1a

Table A7.1 Quantification of approved ERC Adjustment Applications

NL_2025	**NMVOC**	
	3B1a: Manure management Dairy cattle	
	2005	**2020**
Activity data (1000 head)	1,433.202	1,593.071
Adjusted activity data	1,433.202	1,593.071
AD Revision (%)	0%	0%
EF (Gg/1000 head)	0.016915827	0.027380637
Adjusted EF	0	0
EF Revision (%)	-/-100%	-/-100%
Emissions (Gg)	24.24	43.62
Adjusted emissions (Gg)	0	0
Adjustment (Gg)	24.24	43.62

Appendix 8 Reconciliation of reported nitrogen oxides and ammonia emissions with satellite observations

In this annex, reported Dutch emissions of air pollutants are compared to emission estimates derived from satellite 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. Satellite emission estimates were kindly provided by the Royal Netherlands Meteorological Institute (KNMI) and produced with the DECSO algorithm. This annex is a first attempt at this analysis and covers nitrogen oxides (NO_x) and ammonia (NH_3) emissions from 2019/2020 until 2023. Going forward, our ambition is to expand it to more gases and more inversion systems and to be able to answer the questions raised by this first analysis.

Summary

This annex contains a comparison of emission estimates based on satellite observations with reported emissions for nitrogen oxides and ammonia. 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.

While the satellite observations yield lower nitrogen oxides emissions than the reported emissions, satellite-based ammonia emissions were higher than the reported emissions. By comparing the spatial distribution of satellite observations and reported emissions, it was found that satellite observations for nitrogen oxides appear to underestimate large point emitters. On the other hand, the deviation for ammonia seemed to be concentrated on few provinces, which might potentially help to decipher the origin of these deviations.

Data sources and processing

Emission estimates from atmospheric observations were produced and kindly provided by the Royal Netherlands Meteorological Institute (KNMI). Gratitude is extended to Ronald van der A and Jieying Ding (KNMI) for sharing and discussing the data and for critical reading of this annex. A detailed description of the used data and the algorithm can be found in Van der A et al. (2024) and Ding et al. (2024). In brief, atmospheric concentrations of NO_x were derived from the Tropomi instrument on board of the Sentinel-5P satellite, while NH_3 concentrations were derived from the CrIS instruments on board of the SNPP and NOAA-20 satellites.

To calculate emission estimates from these concentration measurements the DECSO algorithm (Mijling and Van der A, 2012) with the CHIMERE chemical transport model was used. DECSO does not require prior emissions as an input, as it uses the emissions of each day as the prior emissions of the subsequent day. The domain for the NO_x inversion was centred on the Netherlands and reached from 50° N to 54° N and from 2° E to 9° E. Two versions were used, one for the years from 2019 to 2023 at a resolution of 0.1° and one for only 2019 at a higher resolution of 0.05°. The domain for the NH_3 inversion was larger and reached from 35° N to 55° N and from 10° W to 30° E at a resolution of 0.2°.

Since this domain for which emissions were calculated does not completely include the Dutch part of the North Sea, it was excluded from the analysis on the basis of the spatial distribution of reported emissions. Since the spatial distribution of reported Dutch emissions for 2023 has not yet been published, in order to calculate the emissions for the Dutch mainland for 2023, the spatial distribution of 2022 with the emission total of 2023 was used.

To allow a fair comparison, the reported emissions used here are not calculated strictly following the NEC directive, for example shipping emissions are included and traffic emissions are calculated on the basis of *Fuel Used* rather than *Fuel Sold*.

To calculate the national Dutch emissions from the satellite data, pixels within the Netherlands, excluding the Dutch part of the North Sea, were selected. For pixels partially in the Netherlands, the emissions were distributed on the basis of the share of the pixel within the Netherlands. Error bars indicate 95% confidence intervals.

Nitrogen oxides

A map of NO_x emissions produced by the DECSO algorithm from satellite observations is shown in Figure A8.1. Due to the high resolution of 0.05°x0.05°, one can immediately recognise a range of known emission hot spots. In the Netherlands, one can for example clearly identify the Rotterdam area, as well as Amsterdam and various industrial complexes. Outside of the Netherlands, Antwerp, the Ruhr area and German lignite powerplants can be recognised. How well the spatial distribution and location of emission sources is captured in this dataset is further emphasised by comparing it to spatially distributed inventory emissions. While the inventory still has a better resolution at 1 km^2, the two maps show a clear correlation, which becomes even more apparent when the reported emissions are resampled to the resolution of the satellite observations.

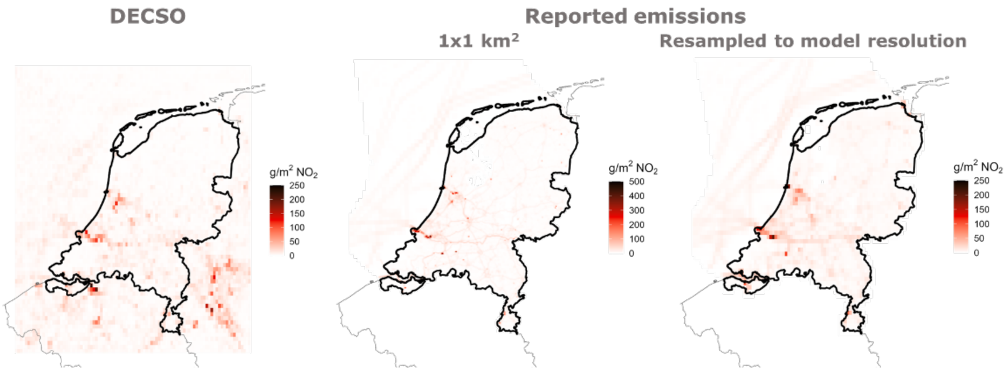

Figure A8.1 Map of Dutch NO_x emissions in 2019 according to satellite observations and as reported (in native resolution and resampled to the resolution of the satellite observations); this figure uses the 0.05° dataset

Next, the total national emissions based on satellite observations were compared to reported emissions as shown in Figure A8.2. There is a significant difference between the reported emissions and the satellite observations, with the satellite emissions being much lower than the reported emissions. Reported emissions decreased from 252 kt (as NO_2) in 2019 to 205 kt in 2023. Satellite observations, on the other hand, reported emissions of 187 kt in 2019 and 160 kt in 2023 (a relative difference of 26% and 22%, respectively). The emission trend of a slight decrease seems to agree between the two datasets, although the satellite observations show a marked dip in 2020 and 2021, the two years most strongly affected by the COVID19 pandemic, which is absent in the reported emissions.

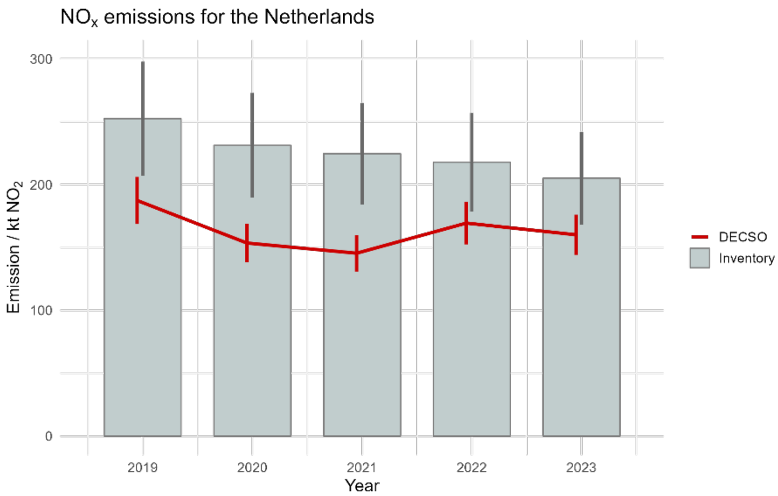

Figure A8.2 Comparison of the reported Dutch NO_x emissions with emission estimates derived from satellite observations using the DECSO algorithm; this figure uses the 0.1° dataset

To get a better understanding of the origin of these deviations, the spatial distribution of emissions was further analysed by comparing the emissions for 2019 per province and per municipality (Figure A8.3). At the province level, the satellite observations result for each province (Dutch *provincie*) in lower emissions than reported, similar to the national emissions. Zooming in further on the level of municipalities (Dutch *gemeente*) revealed a more complex relation. While both emission estimates agree well for municipalities with low emissions, they deviate very strongly for several municipalities with high emissions, where satellite observations yield much lower emissions than reported.

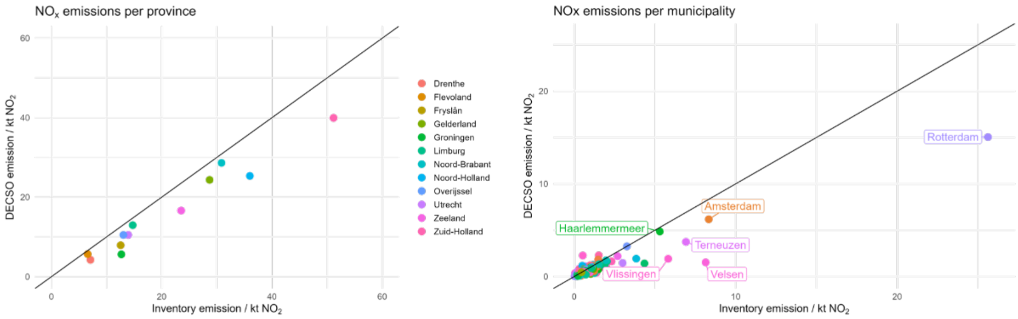

Figure A8.3 Comparison of the reported Dutch NO_x emissions with emission estimates derived from satellite observations using the DECSO algorithm per province and per municipality; this figure uses the 0.05° dataset

Some of this deviation might be explained by point sources with very high emissions blending into neighbouring pixels in the satellite observations. However, this should lead to overestimation of the emissions in neighbouring municipalities, which we do not observe here. On the other hand, for reported emissions these hotspots usually relate to large industrial point sources, where emission uncertainties are low. Therefore, it seems unlikely that this deviation can be explained on the basis of shortcomings of the emission inventory. Taken together, this suggests that emission estimates generated with the DECSO algorithm from satellite observations might underestimate some large point sources of NO_x in the Netherlands, which in turn leads to an underestimation of the total national emissions. However, so far it is not clear why this effect seems to take place for some large point sources while others are accurately captured (Van der A et al., 2024)). It will be interesting to work together with KNMI to fully understand and hopefully mitigate this effect.

Ammonia

A map of NH_3 emissions produced by the DECSO algorithm from satellite observations is shown in Figure A8.4. Although the resolution of 0.2° is much lower, one can still recognise the area of higher emissions in the centre of the Netherlands, that is also visible in the inventory emission map. Besides that, the emission map shows a rather homogeneous distribution of emissions, which also agrees with the spatial distribution of reported emissions. This becomes especially apparent when the reported emissions are resampled to the resolution of the satellite observations.

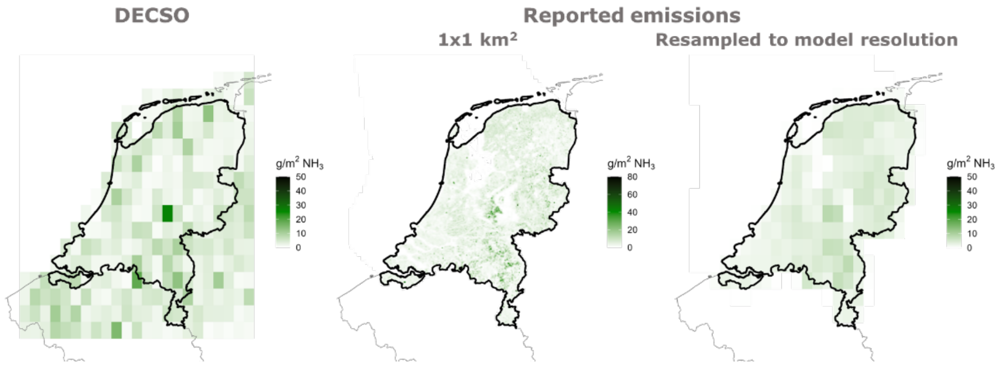

Figure A8.4 Map of Dutch NH_3 emissions in 2020 according to satellite observations and as reported (in native resolution and resampled to the resolution of the satellite observations)

A comparison of the total national emissions is shown in Figure A8.5. Here, the satellite observations report somewhat higher emissions than reported. However, the confidence intervals are overlapping which indicates lower levels of significance. Interestingly, while the reported emissions are almost constant with only a slight drop from 125 kt in 2020 to 116 kt in 2023, emissions based on satellite observations show quite some interannual variability between 146 kt and 166 kt. This most likely is related to the temperature dependence of most sources of NH_3 emissions, like emissions from livestock manure, whereas the inventory emissions are calculated on the basis of average meteorology.

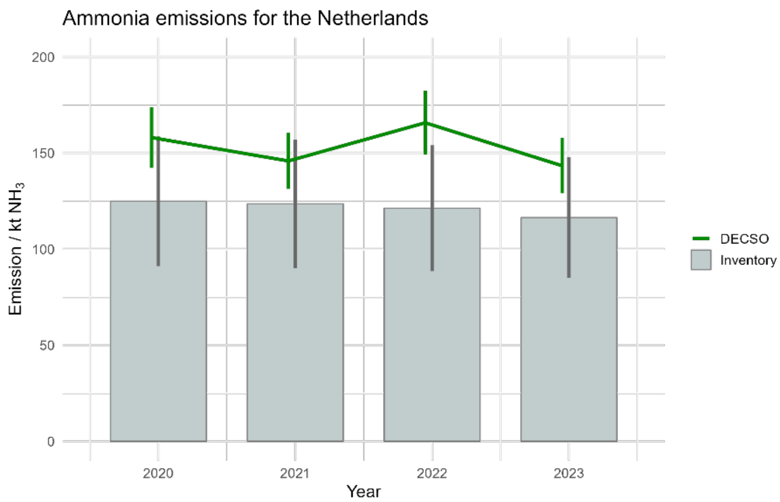

Figure A8.5 Comparison of the reported Dutch ammonia emissions with emission estimates derived from satellite observations using the DECSO algorithm

Since NH_3 emissions from satellite observations have a lower resolution, local emissions were only compared on the scale of provinces as shown in Figure A8.6 and not down to municipality level. This comparison revealed that for most provinces emissions derived from satellite observations and reported emissions agree very well (points close to the unity line). Most of the deviation is related to two provinces, North Holland and Friesland, where satellite emissions are much higher than reported emissions and which are both located in the North-West of the Netherlands. It will be interesting to further explore this regional pattern of where the satellite based emissions deviate most from the reported emissions in order to understand the origin of the difference.

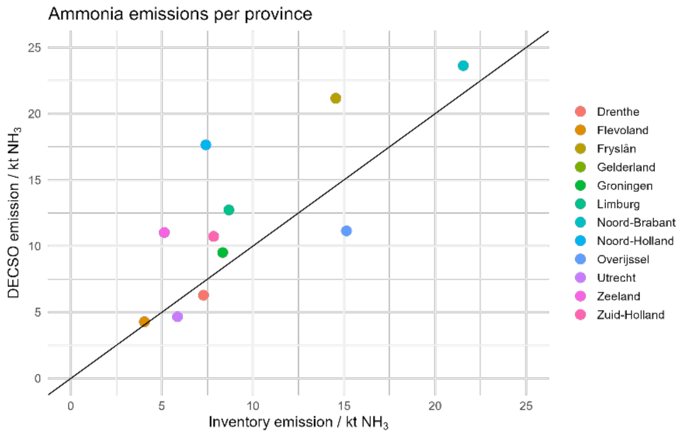

Figure A8.6 Comparison of the reported Dutch ammonia emissions with emission estimates derived from satellite observations using the DECSO algorithm per province

Outlook

This annex only represents a starting point to more verification activities for emissions of various pollutants. The results presented here illustrate the potential and challenges of these methods. While emission trends and spatial emission patterns seemed to fit quite nicely between reported emissions and satellite-based emissions, the absolute level of emissions on a national scale posed a larger challenge. It will be very interesting to further understand these differences and reconcile these two independent emission estimates.

Besides attempting to answer the questions raised in these first analyses, it will also be of great interest to further explore the effect of various transport models and inverse modelling algorithms on the resulting emissions. Finally, an aim will be to extend this analysis to more, and different, pollutants.

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