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

Informative *Inventory* Report 2019

Emissions of transboundary air pollutants in the Netherlands 1990–2017

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The emissions and activity data of the Netherlands' inventory were converted into the NFR source categories contained in the Nomenclature for Reporting (NRF) tables, which form a supplement to this report.

In addition to the authors, several people contributed to this report. Rianne Dröge and Jolien Huijstee worked on completing the Approach 2 uncertainty data and performed the Approach2 uncertainty analyses. Bart Jansen, Bas van Huet, Olaf Janmaat and Kees Baas provided information regarding the emission sources in Chapter 7 (Waste).

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Synopsis

Informative Inventory Report 2019
Emissions of transboundary air pollutants in the Netherlands 1990–2017

Increase in ammonia emissions; entire time series adjusted upwards
At 132.4 Gg in 2017, ammonia emissions increased by 3.9 Gg compared with 2016 and are 4.4 Gg above the maximum set by the European Union and the UNECE under the Gothenburg Protocol (both 128 Gg).

The increase in ammonia emissions in 2017 compared with 2016 is mainly due to the increased N excretion per dairy cow caused by a higher manure production (higher milk production and higher average weight) per animal and higher nitrogen content in the grass fed. The increase was also partly due to the addition of emission sources Residential combustion in woodstoves and fireplaces, Bonfires, Accidental building fires and Manure treatment. The entire time series for ammonia was adjusted upwards to allow for the added emission sources.

Increase in non-methane volatile organic compounds; the entire time series adjusted significantly upwards
Mainly as a result of the addition of new emission sources, emissions of non-methane volatile organic compounds increased to 254 Gg in 2017 – 69 Gg above the maximum set by the European Union (185 Gg) and 63 Gg above the UNECE maximum under the Gothenburg Protocol (191 Gg).

The entire time series for non-methane volatile organic compounds was significantly adjusted upwards to allow for the new sources. Under the source sector 3B Manure management, the emissions coming from the use of silage was added. Furthermore, under the source sector 3D Emissions from soils, the new emission sources Animal manure applied to soils, Farm-level agricultural operations including storage, handling and transport of agricultural products and Cultivated crops were added. Additionally, the emission factor from the use of cleaning products by consumers is significantly higher.

Applying for adjustments
The emissions ceilings of both the European Union and the UNECE were set on the basis of knowledge at the time. To promote the implementation of new scientific knowledge in the inventories of individual member states, a mechanism is adopted whereby emissions can be adjusted for compliance. For instance, where a member state exceeds the emission ceiling as result of the implementation of new emission sources, it can apply for an adjustment of the emissions used for checking compliance.
For both ammonia and non-methane volatile organic compounds the Netherlands requests adjustments of the emissions for compliance with the ceilings set by the European Union and the UNECE under the Gothenburg Protocol.

The Informative Inventory Report 2019 was drawn up by the RIVM and partner institutes, which collaborate to analyse and report emission data each year – an obligatory procedure for Member States. The analyses are used to support Dutch policy.

Keywords: emissions, transboundary air pollution, emission inventory

Publiekssamenvatting

Informative Inventory Report 2019

De uitstoot van ammoniak is in 2017 gestegen ten opzichte van 2016 en ligt met 132,4 kiloton boven het maximum van 128 kiloton dat vanuit Europa voor Nederland is bepaald. De toename wordt veroorzaakt doordat nieuwe bronnen die ammoniak uitstoten zijn toegevoegd aan de emissie-inventarisatie: sfeerverwarming (open haarden en allesbranders), vreugdevuren, woningbranden en mestverwerking. Ook komt het door ontwikkelingen in de landbouw, zoals een hogere mestproductie per melkkoe en een hoger gehalte aan stikstof in het gevoerde gras.

De emissie van vluchtige organische stoffen is in 2017 gestegen tot 254 kiloton en ligt daarmee boven het maximum van 185 kiloton dat vanuit Europa voor Nederland is bepaald. Ook hier komt dat vooral doordat nieuwe bronnen zijn toegevoegd, met als belangrijkste het gebruik van kuilvoer. Daarnaast blijkt door nieuwe inzichten dat consumenten er meer van uitstoten via het gebruik van schoonmaakmiddelen.

De door Europa vastgestelde maxima zijn gebaseerd op de situatie in 2000. Bronnen die daarna zijn toegevoegd, hoeven voor de toetsing aan de vastgestelde maxima niet mee te tellen. Nederland heeft daartoe een verzoek opgenomen in dit rapport. Voor ammoniak zijn dat de bronnen afrijping van gewassen, gewasresten in de bodem en mestverwerking. Voor vluchtige organische stoffen zijn dat de uitstoot uit landbouwbodems en het gebruik van kuilvoer.

Dit blijkt uit het Informative Inventory Report (IIR) 2019. Het RIVM analyseert en rapporteert hierin jaarlijks met diverse partnerinstituten de uitstoot van stoffen. Lidstaten van de Europese Unie zijn hiertoe verplicht. Nederland gebruikt de analyses om beleid te onderbouwen.

Kernwoorden: emissies, grootschalige luchtverontreiniging, emissieregistratie

Contents

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. The European Community subsequently adopted the Revised National Emission Ceiling Directive (NECD) in 2016 to set national emission-reduction commitments for EU Member States.

Parties to the CLRTAP and European Member States are obligated to report their emission data annually. Under the CLRTAP, these data are 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 Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution 2014 (UNECE, 2014).

The Informative Inventory Report 2019 (IIR 2019) comprises the national emissions 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 (PM10, 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 (POP).

The Netherlands' IIR 2019 is based on data from the national Pollutant Release and Transfer Register (PRTR). The IIR contains information on the Netherlands' emission inventories for the years 1990 to 2017, including descriptions of methods, data sources and QA/QC activities carried out and a trend analysis. The inventory covers all anthropogenic emissions covered by the Nomenclature for Reporting (NFR), including individual polycyclic aromatic hydrocarbons (PAHs), which are to be reported under persistent organic pollutants (POP) in Annex IV.

1.1 National inventory background

Emission estimates in the Netherlands are registered in the PRTR, which is the national database for the sectoral monitoring of emissions to air, water and soil of pollutants and greenhouse gases. The database was set up to support national environmental policy, as well as to meet the requirements of the National Emission Ceilings (EU), the CLRTAP, the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (National System). This policy covers the constant updating of the PRTR, the process of data collection, processing and registration, and the reporting of emission data for some 350 compounds. Emission data (for the most significant pollutants) and documentation can be found at www.prtr.nl.

Instead of using the defaults from the EMEP/EEA air pollutant emission inventory guidebook 2016 (EMEP/EEA, 2016), the Netherlands often applies country-specific methods, with associated activity data and emission factors. 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 emission factors 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 CLRTAP and NECD. A Pollutant Release and Transfer Register (PRTR) system has been in operation in the Netherlands since 1974. Since 2010, the Ministry of Infrastructure and Water Management (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 produce annually 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 are produced in annual (project) cycles. In addition to the 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 (RWS):
    - Centre for Water Management (RWS-WD);
    - Centre for Transport and Navigation (RWS-DVS);
    - Water, Traffic and Environment (RWS-WVL);
    - Human Environment and Transport Inspectorate (RWS-ILT).
- Deltares;
- Wageningen Environmental Research;
- Wageningen UR Livestock Research;
- Wageningen Economic Research;
- Fugro, which coordinates annual environmental reporting (AER) by companies.

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 the RIVM and in the annual project plan (RIVM, 2018).

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 lead to changes in methods and to the recalculation of historical emissions. The following task forces are recognized (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.

Every year, after the emission data have been collected, several quality control checks are performed by the task forces during a yearly 'trend analysis' workshop. After being approved by participating institutes, emission data are released for publication (www.prtr.nl). Subsequently, these data are disaggregated to regional emission data for national use (e.g. 1 x 1 km grid, municipality scale, provincial scale and water authority scale).

Point-source emissions

As of 1 January 2010, the legal obligated companies can only submit their emissions electronically as a part of an Annual Environmental Report (AER). All these companies have emission monitoring and registration systems 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 the RIVM and remains the property of the companies involved.

Data on point-source emissions in the AER database are checked for consistency by the ENINA task force. The result is a selection of validated data on point-source emissions and activities (ER-I), which are then stored in the PRTR database (Peek *et al.*, 2019).

As a result of the Dutch implementation of the EU Directive on the European Pollutant Release and Transfer Register (E-PRTR), since 2011 about 1,000 facilities have been legally obligated to submit data on their emissions of air pollutants when they exceed a certain threshold. To compensate for emissions from facilities in a particular subsector that do not exceed the threshold (small and medium-sized enterprises - SMEs), a supplementary estimate is added to the emissions inventory. For these supplementary estimates known emission factors from research (for instance for NO_x from Van Soest-Vercammen *et al.,* 2002) and implied factors from the reported emissions and production are used, as well as statistical information such as production indexes and sold fuels. The methods for these supplementary estimates are explained in detail in chapters 3 and 5.
To safeguard that the supplementary estimates do not add to the uncertainty of the subsectors total emission, the Dutch implementation of the E-PRTR directive (VROM, 2008) has set lower thresholds for major pollutants, so that a minimum of approximately 80% of the total subsector emissions is covered by facility emission reports.

1.3.2 Data storage

In cooperation with the contributing research institutes, all emission data are collected and stored in the PRTR database managed by the RIVM.

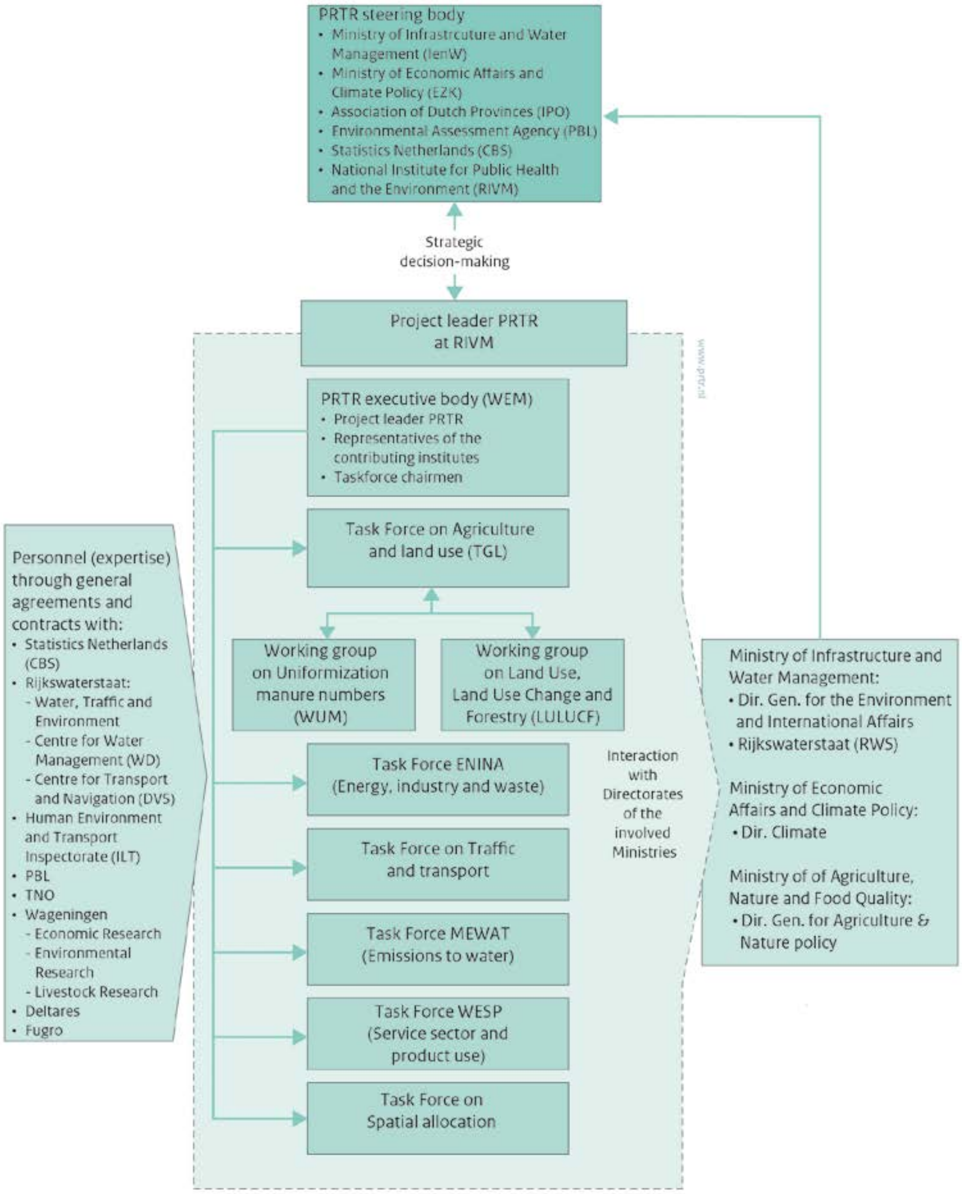

Figure 1.1 The organisational structure of the Netherlands Pollutant Release and Transfer Register (PRTR)

Emission data from the ER-I database and from collectively estimated industrial and non-industrial sources are 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 industrial subsector, separate information on process and combustion emissions, and the relevant environmental compartment and location. These emission sources can be selectively aggregated per NFR category.

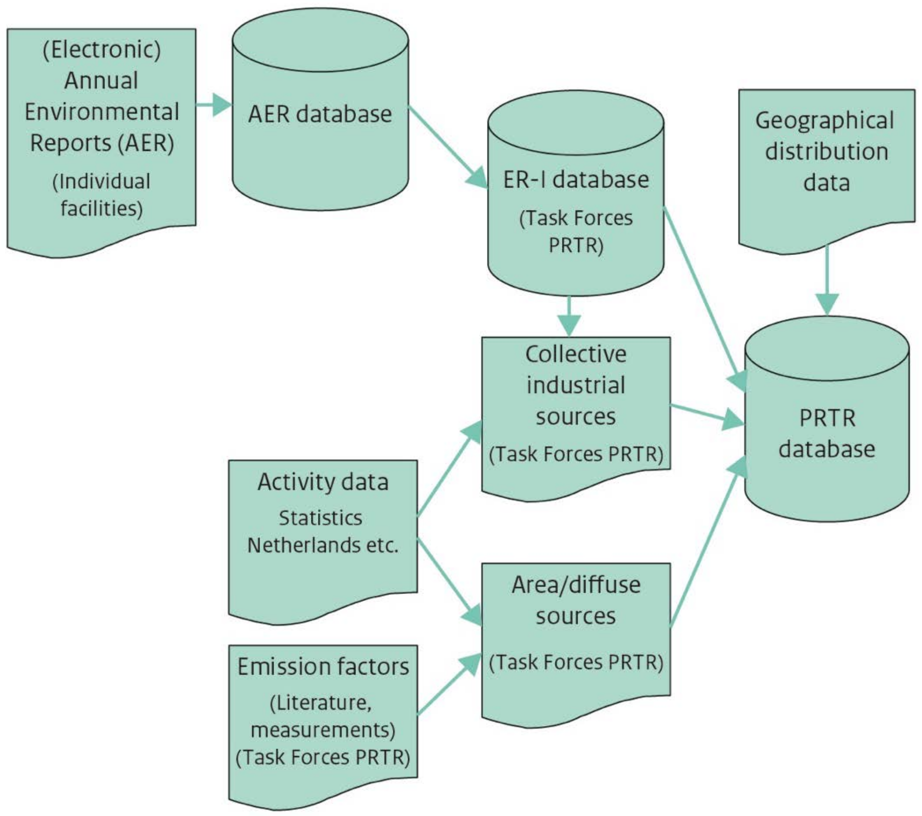

Figure 1.2 The data flow in the Netherlands Pollutant Release and Transfer Register (PRTR)

1.4 Methods and data sources

Methods used in the Netherlands are annually documented in several reports and protocols, and in meta-data files available from www.prtr.nl. All methodology reports are in English. However, some background reports are only available in Dutch.

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 emission factors from sectoral emission inventory studies in the Netherlands (e.g. SPIN documents produced by the 'Cooperation project on industrial emissions').

In addition, these assumptions are important to consider:

- Condensable emissions are only included in transport emissions, not in emissions from domestic wood burning or industrial emissions.

- Road transport emissions have been calculated using ‘on-road’ measured emission factors, so emission data are insensitive to ‘the diesel scandal’.

1.5 Key source analysis

A trend assessment was carried out for the emission inventory of all components, in addition to a level assessment, in order to identify key source categories. In both approaches, key source categories were identified using a cumulative threshold of 80%. Key categories are those which, when summed together in descending order of magnitude, add up to more than 80% of the total level (EMEP/EEA, 2016). The level assessments were performed for both the latest inventory year (2017) and the base year of the inventory (1990). The trend assessments aim to identify categories for which the trend is significantly different from that of the overall inventory. See Appendix 2 for the actual analysis.

1.6 Reporting, QA/QC and archiving

1.6.1 Reporting

The Informative Inventory Report is prepared by the inventory-compiling team at the RIVM, with contributions made by experts from the PRTR task forces.

1.6.2 QA/QC

The RIVM has an ISO 9001:2015 QA/QC system in place. PRTR quality management is fully in line with the RIVM QA/QC system. Part of the work for the PRTR is done by external agencies (other institutes). QA/QC arrangements and procedures for the contributing institutes are described in an annual project plan (RIVM, 2018). The general QA/QC activities meet the international inventory QA/QC requirements described in Part A, Chapter 6 of the EMEP inventory guidebook (EMEP/EEA, 2016).

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 calculation in the PRTR is based mainly on AERs made 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 Data and the Environment (DMO) 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 (for results, 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. The general QC for the inventory is largely performed within the PRTR as an integrated part of the working processes. For the 2019 inventory, the PRTR task forces filled in a standard-format database with emission data from 1990 to 2017. After an automated first check of the emission files by the data exchange module (DEX) for internal and external consistency, the data were 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 and they are provided by the ER team with comparable information on trends and time series. Several weeks before a final data set is fixed, a trend verification workshop is organised by the RIVM (see Text box 1.1). The results of this workshop, including actions to be taken by the task forces to resolve the identified clarification issues, are documented by the RIVM. Required changes to the database are then made by the task forces.

Table 1.1 Key items of the verification actions on data processing 2017 and NFR/IIR 2019

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
Input of outstanding issues for this inventory	4-07-2018	RIVM-PRTR	List of remaining issues/actions from last inventory	Actiepunten voorlopige cijfers 2017 v4 juli 2018. xls
Input for checking allocations from the PRTR database to the NFR tables	20-11-2018	RIVM-NIC	List of allocations	NFR-ER-Koppellijst-2018-03-08-dtt54_DW.xlsx
Comparison sheets with final data	19-11-2018	RIVM	Input for data checking	Verschiltabel_LuchtActueel_19-11-2018.xls
Input for trend analysis	27-11-2018	RIVM-PRTR	Updated list of required actions	Actiepunten definitieve cijfers v 27 november 2018.xls
Comparison sheets with final data	27-11-2018	RIVM	Input for trend analyses	Verschiltabel_LuchtActueel_27-11-2018.xls
Trend analysis workshops	06-12-2018	Sector specialists, RIVM-PRTR	Explanations for observed trends and actions to resolve before finalising the PRTR dataset	– Emissies uit de landbouw 1990–2017.pptx; – ENINA TrendAnalysedag reeks 1990–2017_v3.pptx; – Trendanalyse verkeer 2018.pptx; – WESP trendanalyse 6-12-2018 defintief.pptx; – Grootschalige luchtverontreiniging irt plafondsTrendanalysedag 2018 v1.pptx.

QC item / action	Date	Who	Result	Documentation*
Input for resolving the final actions before finalising the PRTR dataset	8-12-2018	RIVM-PRTR	Updated action list	Actiepunten Definitieve cijfers 1990–2017 v 7 december 2018.xls
Request to the individual task force chairs to approve the data produced by the task force.	16-1-2019	RIVM-PRTR	Updated action list	Actiepunten Definitieve cijfers 1990–2017 v 16 januari 2019.xls
Request to the contributing institutes to approve the PRTR database	18-01-2019	PRTR project secretary, representatives of the contributing institutes	Reactions of the contributing institutes to the PRTR project leader	– Email (18-1-2019 01:23) with the request to endorse the PRTR database; – Actiepunten definitieve cijfers v 16 januari 2018.xls; Emails with consent from PBL, Deltares and CBS (CBS 18-1-2019 15:11; PBL 18-1-2019 17:34; Deltares 18-1-2019 14:48).
Input for compiling the NEC report (in NFR format)	15-1-2019	RIVM-NIC	List of allocations for compiling from the PRTR database to the NFR tables	NFR-ER-Koppellijst-2018-12-03-dtt56 DW.xlsx
List of allocations for compiling from the PRTR database to the NFR tables	6-2-2019	RIVM	Input for compiling the EMEP/LRTAP report (NFR format)	NFR-ER-Koppellijst-2019-01-25-dtt56-BL-DW.xlsx

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

Text box 1.1 Trend verification workshops

About a week in advance of a trend analysis meeting, a snapshot of the database is made available by the RIVM in a web-based application (Emission Explorer, EmEx) for checks by the institutes involved, the sector and other experts (PRTR task forces) and the RIVM PRTR team. In this way, 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 totals for the sectors are then compared with the previous year's data set. Where significant differences are found, the task forces check the emission data in greater 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 for the individual subsectors. The task forces examine these time series. During the trend analysis for this inventory, the emission data were checked in two ways: (1) emissions from 1990 to 2017 from the new time series were compared with the time series of last year's inventory; and (2) the data for 2017 were compared with the trend development for each gas since 1990. The checks of outliers are performed on a more detailed level of the subsources in all sector background tables:

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

Exceptional trend changes and observed outliers are noted and discussed at the trend analysis workshop, resulting in an action list. Items on this list have to be processed within two weeks or dealt with in next year's inventory.

Archiving and documentation

Internal procedures are agreed on (e.g. in the PRTR work plan) for general data collection and the storage of fixed data sets 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, etc.) on a central server at the RIVM. These documents then become available through a limited-access website. The updating of monitoring protocols for substances under the 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 Annual Environmental Reports), as well as emission reports such as the National Inventory Report (UNFCCC) and the Informative Inventory Report (CLRTAP), are made available on the website of the PRTR: www.prtr.nl.

1.6.3 *Quantitative uncertainty*

Approach2 method

Uncertainty estimates of total national emissions are calculated using an Approach2 method (Monte Carlo analysis). Most uncertainty estimates were based on the judgement of emission experts from the ENINA, TgL, V&V and WESP task forces. For agriculture, the judgement of experts was combined with an Approach1 uncertainty calculation. In the Approach1 uncertainty calculation of agriculture, it was assumed that emissions from manure management and manure application were completely correlated with each other.

The expert elicitation was set up following the expert elicitation guidance in the IPCC 2006 Guidelines (motivating, structuring, conditioning, encoding and verification). Expert judgements were made for activity data and emission factors separately at the level of emission sources (which is more detailed than the NFR categories). Correlations between the activity data and emission factors of different emission sources have been included in the Monte Carlo analysis. These correlations are included for the following type of data:

- Activity data:
    - The energy statistics[1] are known better on an aggregated level (e.g. for industry) than they are on a detailed level (e.g. for the industrial sectors separately). This type of correlation is also used for several transport sectors (shipping and aviation);
    - The numbers of animals in animal subcategories that make up one emission source (e.g. non-dairy cattle, pigs, etc.) are correlated.
- Emission factor:
    - The uncertainty of an emission factor from stationary combustion is assumed to be equal for all of the emission sources in the stationary combustion sector. This type of correlation is also used for several transport sectors (shipping and aviation);
    - Emission factors for the different animal categories are assumed to be partly correlated, because part of the input data for deriving EFs is the same, or because EFs are derived from other animal categories.

The results of the Monte Carlo analysis (Approach2 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 category and for the national total, calculated with the Approach2 method for emissions in 2017 (%)

NFR category	NH_3	NO_x	SO_x	NMVOC	PM_{10}	$PM_{2,5}$
1	125	14	33	97	39	41
2	48	73	96	32	36	43

[1] The energy statistics are available on the website of Statistics Netherlands. The following link refers to the energy statistics of 2017. Using the button 'Change selection' on the website, it is possible to select the data for another year. Energy statistics of 2017:
https://opendata.cbs.nl/

NFR category	NH_3	NO_x	SO_x	NMVOC	PM_{10}	$PM_{2,5}$
3	33	114	-	124	25	39
5	59	105	141	151	170	173
6	96	28	-	229	68	68
Total	**30**	**19**	**32**	**55**	**21**	**28**

The uncertainty estimates from the Approach2 method used in 2017 are different from the uncertainty estimates from this method in 2016 (as presented in the IIR 2018). This can be explained by the following:

- Small changes in the total uncertainty of a sector/pollutant are caused by changes in absolute emissions.
- The uncertainty of emissions from agriculture has been recalculated (NFR 3).
- Some emissions have been added to the inventory, and also included in the uncertainty analysis. These are NH3 emissions from biomass combustion (NFR 1), NMVOC emissions in the agricultural sector (NFR 3), emissions from manure digestion (NFR 5) and emissions from bonfires (NFR 5).
- A new uncertainty estimate (expert judgement) for NMVOC emissions of product use is added.

Approach 1 method

Uncertainty estimates from earlier studies (van Gijlswijk et al., 2004; RIVM, 2001) are presented in Table 1.3. These uncertainty estimates of NH_3 and NO_x are similar to the NH_3 and NO_x uncertainty calculated for 2016. The uncertainty for SO_x in 2016 increased compared with the studies of van Gijlswijk et al. (2004) and RIVM (2001). 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 uncertain.

Table 1.3 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%

1.7 Explanation of the use of notation keys

The Dutch emission inventory covers all sources specified in the CLRTAP that are relevant to emissions to the 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 the why notation keys are used in the emission tables (NFR). The use of the notation keys is explained in Table A1.1 and A1.2 in Appendix A. For most cases in which 'NE' (not estimated) has been used as a notation key, the respective source is assumed to be negligible or there is no method available for estimating the respective source. 'IE' (included elsewhere) notation keys has been used mostly when activity data cannot be split or for reasons of confidentiality of activity data.

As a result of questions in subsequent reviews by UN-EMEP (United Nations European Monitoring and Evaluation Programme) and the EU-NECD (European National Emission Ceilings Directive) regarding the use of the notation keys NE and NA (not applicable), the task forces are asked to evaluate the correct use for each instance.

1.8 Explanation of 'Other' emission sources

Several source categories in the NFR format are used for allocating emission sources that are related to the NFR category, but that cannot be allocated to a specific source category in the specific source sector. In the NFR format are these source categories are named starting with 'Other'. In table 1.4 is explained which source sector for the Netherlands are allocated in the various "Other" source categories. These emission sources and their emissions are explained in the relevant chapters for each source sector.

Table 1.4 Subsources accounted for in reporting of NFR 'other' codes

NFR13 code	Substance(s) reported	Subsource description
1A2gvii	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins and PAHs	Combustion from mobile machinery in the sectors Industry and Construction.
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; • other transport production; • furniture production; • rug and carpet production; • wood products; • concrete, gypsum and cement production; • construction materials and glass production; • construction; • synthetic fibre production; • ceramics, bricks and roofing tile production; • waste preparation for recycling; • mineral extraction; • shipbuilding.
1A5a	NO_x, NMVOC, SO_x, CO, $PM_{2.5}$, PM_{10}, TSP, Dioxins and PAHs	Combustion gas from landfills.

NFR13 code	Substance(s) reported	Subsource description
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, NH3, CO, PM2.5, PM, TSP, Hg and PAHs	Process emissions of 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, paint, pharmaceutics, soap, detergents, glues and other chemical products.
2D3i	NOx, NMVOC, SOx, NH3, PM2.5, PM2.5, TSP, Pb, Cd, Cu, Ni, Zn, Dioxins and PAHs	Smoking of tobacco products, burning of candles, air conditioning, use of pesticides and cosmetics, fireworks, preservation and cleaning of wood and other materials.
2H3	NOx, SOx, NH3, PM2.5, PM2.5, Pb, Cd, Hg, Cr, Cu, Ni and Zn	Process emissions from production of wood, plastics, rubber, metal, textiles and paper. Storage and handling.
3B4h	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	Rabbits and furbearing animals.
3Da2c	NO_x, NH_3	Use of compost.
5C2	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	Bonfires.
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 fridges and freezers.
6A	NO_x, NMVOC, NH_3, CO, $PM_{2.5}$, PM_{10}, and TSP	Human transpiration and respiration; Manure sold and applied to private properties or nature areas; Domestic animals (pets), Privately owned livestock (horses and ponies, sheep, mules and asses).

2 Trends in Emissions

2.1 Trends in national emissions

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 were:

- emission reductions in the industrial sectors due to the introduction of cleaner production technologies and flue gas treatment technologies;
- use of cleaner fuels trough the desulphurisation of fuels and reduced use of coal and heavy oils;
- cleaner cars due to European emission regulations for new road vehicles.

The emissions of NH_3, NO_x and NMVOC increased with respect to the complete time series mainly due to the addition of new emission sources to the inventory for the Agricultural sector and Waste sector (see chapter recalculations). As a result of this, the Netherlands is in 2017 (and previous years) no longer in compliance with the NECD and CLRTAP emission ceilings for NH_3 and NMVOC. In accordance with the conditions relating to these ceilings, and the flexibility allowed by the rules, the Netherlands has applied for adjustments to the emissions in order to achieve compliance. Several emission sources in the agricultural sector are proposed to be adjusted. A complete discussion and justification for these proposed adjustments can be found in Chapter 12 (Adjustments).

Table 2.1 Total national emissions of main pollutants and PM, 1990–2017

	Main pollutants[3]				Particulate matter			
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	629	601	194	351	52.7	75.1	99.1	13.5
1995	527	424	133	224	39.6	56.0	75.2	11.2
2000	441	331	77	176	29.9	44.1	53.2	9.9
2005	381	265	67	155	24.0	36.9	45.4	8.0
2010	312	268	35	134	18.6	31.5	38.9	5.5
2015	265	256	31	129	15.0	27.9	36.0	3.6
2016	254	253	29	128	14.1	27.2	34.7	3.2
2017	246	254	27	132	14.0	26.9	34.1	3.0
1990–2017 period[1]	-383	-347	-167	-219	-38.7	-48.2	-65.0	-10.4
1990–2017 period[2]	-61%	-58%	-86%	-62%	-73%	-64%	-66%	-77%

1. Absolute difference in Gg.
2. Relative difference from 1990 in %.
3. For compliance with the NECD and Gothenburg, based on fuel used for road traffic.

Table 2.2 Total national emissions of priority heavy metals and POPs, 1990–2017

	Other	Priority heavy metals			POPs	
	CO	Pb	Cd	Hg	DIOX	PAH
Year	Tg	Mg	Mg	Mg	g I-Teq	Mg
1990	1.15	333	2.17	3.58	744	20.6
1995	0.93	154	1.16	1.48	68.0	11.0
2000	0.76	27.4	1.03	1.10	32.7	5.96
2005	0.73	29.9	1.79	0.95	31.1	5.94
2010	0.69	37.6	2.63	0.71	33.2	5.78
2015	0.58	8.68	0.66	0.66	23.4	5.68
2016	0.58	8.98	0.68	0.70	23.2	5.71
2017	0.56	8.62	0.76	0.59	23.0	5.78
1990–2017 period[1]	-0.59	-324	-1.41	-2.99	-721	-14.8
1990–2017 period[2]	-51%	-97%	-65%	-83%	-97%	-72%

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

Table 2.3 Total national emissions of other heavy metals, 1990–2017

	Other heavy metals					
	As	Cr	Cu	Ni	Se	Zn
Year	Mg	Mg	Mg	Mg	Mg	Mg
1990	1.28	11.9	36.3	74.9	0.39	225
1995	0.88	8.59	37.2	85.8	0.34	147
2000	0.88	5.09	37.8	19.5	0.46	96.5
2005	1.34	4.34	39.6	10.3	2.57	89.0
2010	0.63	3.85	43.5	2.09	1.52	103
2015	0.67	3.48	38.9	2.00	0.98	103
2016	0.73	3.72	39.8	2.21	0.65	101
2017	0.54	3.57	45.2	2.12	0.21	94.6
1990–2017 period[1]	-0.74	-8.31	8.89	-72.8	-0.18	-130
1990–2017 period[2]	-58%	-70%	24%	-97%	-47%	-58%

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

2.2 Trends in nitrogen oxides (NO_x)

Dutch NO_x emissions (NO and NO_2, expressed as NO_2) decreased by 383 Gg in the 1990–2017 period, corresponding to 61% of the national total in 1990 (Figure 2.1). The main contributors to this decrease were road transport and the energy sector. Although emissions per vehicle decreased significantly in this period, an increase in the number of vehicles and the miles travelled, partially negated the effect on total road transport emissions. In 2017 transport is still the main contributor to NO_x emissions, with 57% of the national total. The shares of the different NFR categories in the national total did not change significantly.

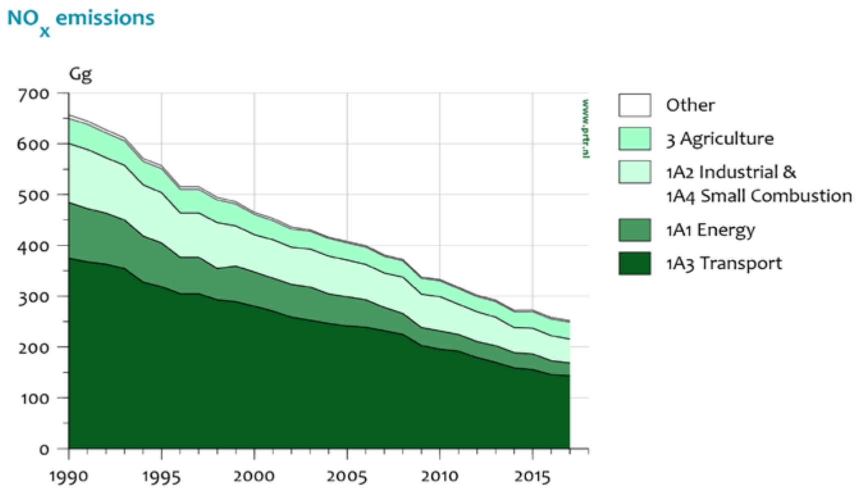

Figure 2.1 NO_x emission trends, 1990–2017

2.3 Trends in sulphur dioxide (SO_x)

Dutch SO_x emissions (reported as SO_2) decreased by 167 Gg in the 1990–2017 period, corresponding to 86% of the national total in 1990 (Figure 2.2). The main contributors to this decrease were the energy sector, industry, and the transport sector. The use of coal declined 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 period 1990–2017 refining was the main contributor to total SO_x emissions, with shares of 34% and 41% in 1990 and 2017, respectively. In 2017, the source sectors Industry, and Energy and Refining (IER) were responsible for 94% of national SO_x emissions.

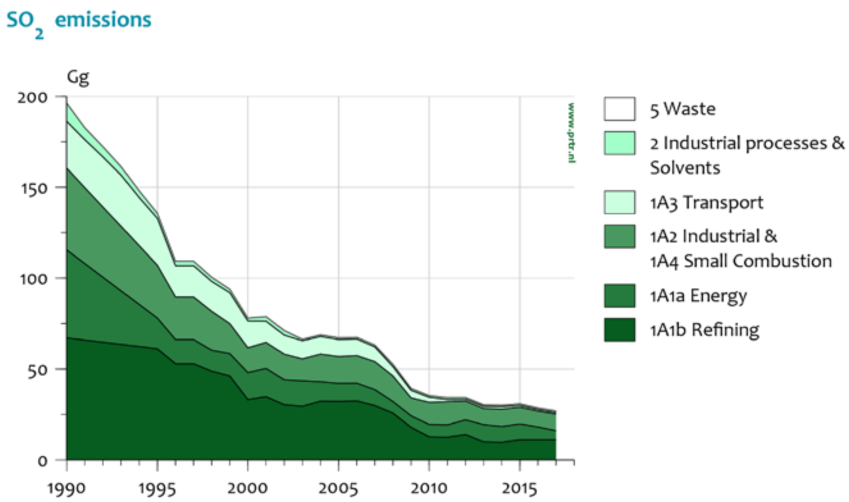

Figure 2.2 SO_x emission trends, 1990–2017

2.4 Trends in ammonia (NH_3)

In recent years, three new NH_3 emission sources were added to the emission inventory (crop ripening, manure treatment, and burning of wood). As a result of these new emission sources, emissions over the complete time series increased.

Most of the NH_3 emissions (87% in 2017) come from agricultural sources. From 1990 to 2013, the decreasing trend in NH_3 due to emission reductions in the agricultural sector also showed up in the decreasing trend of the national total. From 2014 onwards, NH_3 emissions increased again to just above 134 Gg in 2017. As a result of the abolition of milk quotas in 2015, breeding and dairy cattle numbers increased. As result of this, phosphate excretion increased and in 2016, the Netherlands introduced a phosphate reduction plan that led, at farm level, to a reduction of the number of dairy cows. In 2017, the number of dairy cows and the protein content of concentrate feed decreased, but the average weight of the cows increased and the share of grass in the roughage increased, both resulting in an increase in NH_3 emissions (see Chapter 6).

Due to the above-mentioned developments, in 2017 the Netherlands exceeded the NH_3 ceilings set by the NECD and CLRTAP. However, the introduction over the past years of several new emission sources and new emission factors justify an application for adjustments in order to achieve compliance (see Chapter 12).

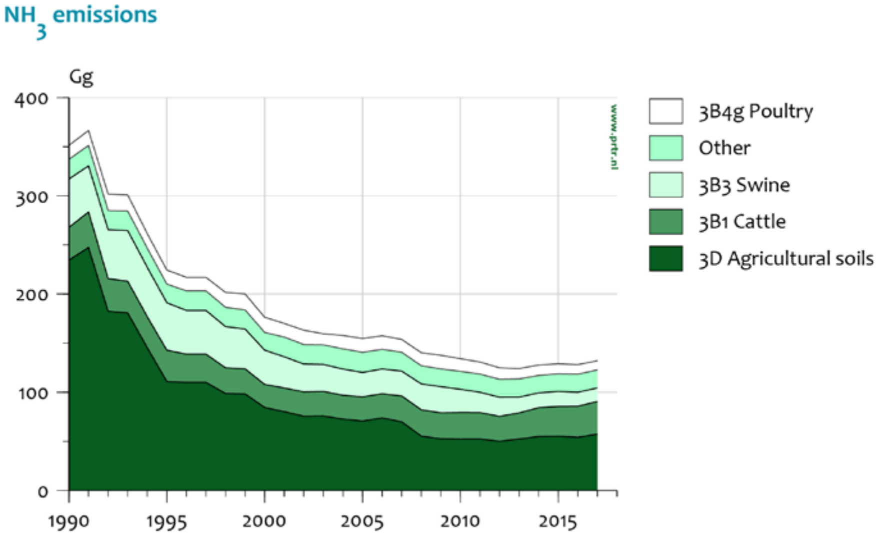

Figure 2.3 NH3 emission trends 1990–2017

2.5 Trends in non-methane volatile organic compounds (NMVOC)

In 2017, emissions from silage feeding (agriculture) were added as a new source to the inventory. As result of this new emission source, emissions of NMVOC over the complete time series increased.

In the period 1990–2017, NMVOC emissions decreased by 347 Gg, corresponding to 58% of the national total in 1990 (Figure 2.4). With the exception of agriculture, all major source categories contributed to this decrease: transport (introduction of catalysts and cleaner engines), product use (intensive programme to reduce NMVOC content in consumer products and paints) and industry (introducing emission abatement specifically for NMVOC).

Due to the adding of NMVOC emissions from silage feeding, in 2017 the Netherlands exceeded the NMVOC ceilings set by the NECD and CLRTAP. However, the introduction over the past years of several new emission sources and new emission factors justify an application for adjustments in order to achieve compliance (see Chapter 12).

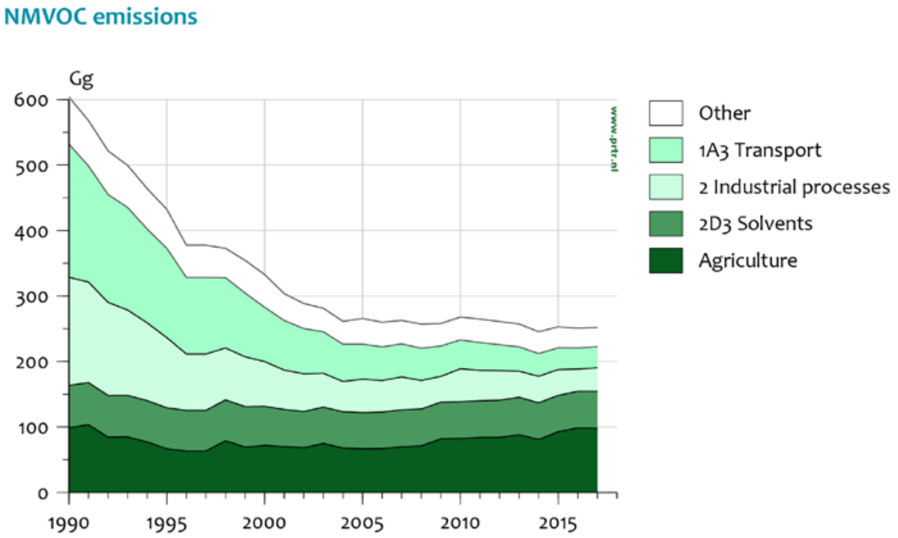

Figure 2.4 NMVOC emission trends, 1990–2017

2.6 Trends in $PM_{2.5}$

$PM_{2.5}$ emissions are calculated as a specific fraction of PM_{10} by sector (based on Visschedijk *et al.*, 2007). They decreased by 36 Gg in the 1990–2017 period, corresponding to 73% of the national total in 1990 (Figure 2.5). The two major source categories contributing to this decrease were the industrial sector (combustion and process emissions; due to cleaner fuels in refineries and the side effect of emission abatement for SO_x and NO) and the transport sector.

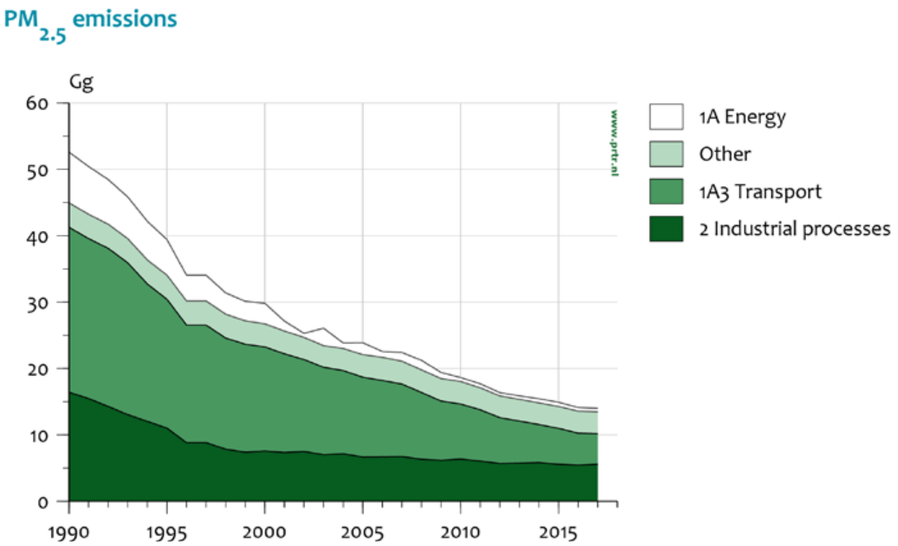

Figure 2.5 $PM_{2.5}$ emission trends, 1990–2017

2.7 Trends in PM_{10}

Dutch PM_{10} emissions decreased by 48 Gg in the 1990–2017 period, corresponding to 64% of the national total in 1990 (Figure 2.6). The major source categories contributing to this decrease were:

- industry (combustion and process emissions; due to cleaner fuels in refineries and the side-effect of emission abatement for SO_x and NO_x);
- traffic and transport.

PM_{10} emissions from agriculture gradually increased from 1990 to 2017 from 4.9 Gg to 6.2 Gg. This was mainly caused by increasing animal numbers in poultry (especially laying hens).

PM_{10} emissions from the source sectors Energy, Industrial processes, Other and Transport did not change significantly over the last year.

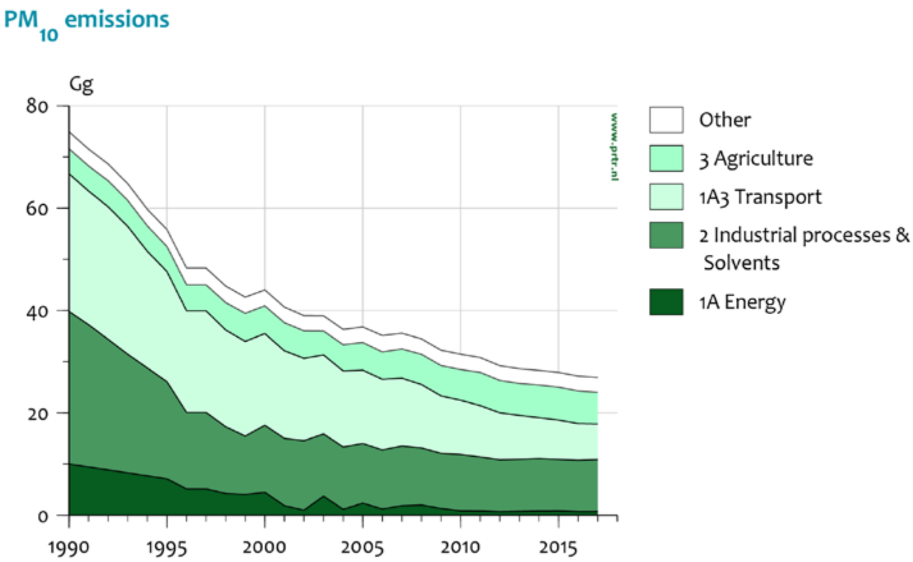

Figure 2.6 PM_{10} emission trends, 1990–2017

2.8 Trends in Pb

Lead (Pb) emissions in the Netherlands decreased by 324 Mg in the 1990–2017 period, corresponding to 97% of the national total in 1990 (Figure 2.7). This decrease is attributable primarily to the transport sector, where, due to the removal of Pb from gasoline, Pb emissions collapsed. The remaining sources contributing to the decrease are industrial process emissions, particularly from the iron and steel industry (due to the replacement of electrostatic filters and the optimisation of some other reduction technologies at Tata Steel).

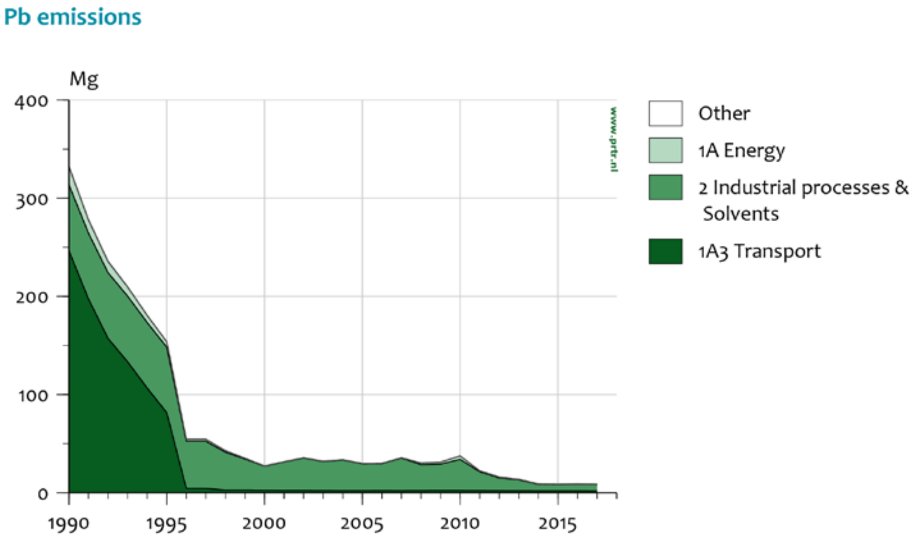

Figure 2.7 Pb emission trends, 1990–2017

3 Energy

3.1 Overview of the sector

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

Part of the emissions from stationary combustion for electricity production and industry (NFR categories 1A1 and 1A2) are based on the Annual Environmental Reports (AERs) made by large industrial companies. For SO_x, 97% of the emissions were based on environmental reports, while for other pollutants the proportions were 91% (NH_3), 83% (NMVOC), 87% (NO_x) and 80% (PM_{10}) in 2017. It should be noted that these percentages include not only the data directly from the AERs, but also the initial gap filling at company level performed by the competent authorities. The emission data in the AERs come from direct emission measurements or from calculations using fuel input and emission factors. Most of the emissions from other stationary combustion (categories 1A4 and 1A5) were calculated using energy statistics and default emission factors.

As in most other developed countries, the energy system in the Netherlands is largely driven by the combustion of fossil fuels. In 2017, natural gas supplied about 41% of the total primary fuels used in the Netherlands, followed by liquid fuels (38%) and solid fossil fuels (12%). The contribution of non-fossil fuels, including renewables and waste streams, is small (8%). Figure 3.1 and Figure 3.2 show the energy supply and energy demand in the Netherlands.

The energy statistics are available on the website of Statistics Netherlands. The following link refers to the energy statistics of 2017. Using the button 'Change selection' on the website, it is possible to select the data for another year.

Energy statistics of 2017: https://opendata.cbs.nl/

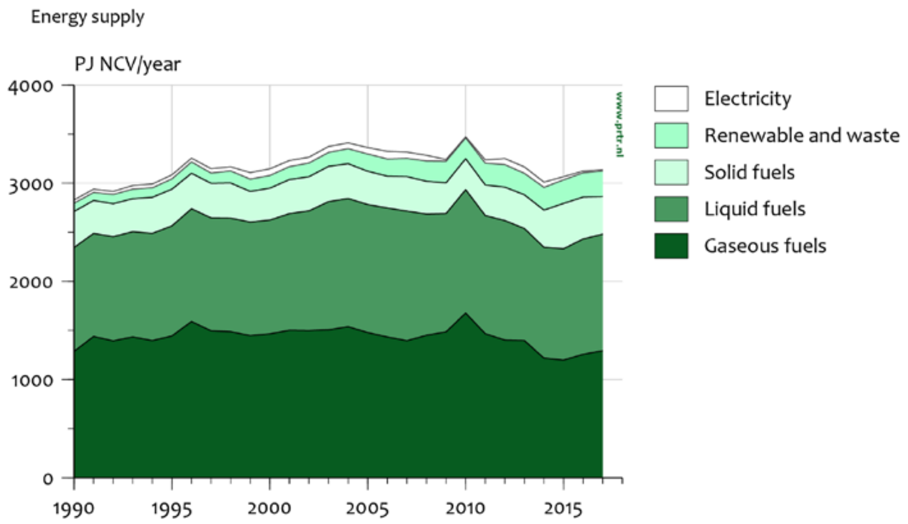

Figure 3.1 Energy supply in the Netherlands, 1990–2017 ('Electricity' refers to imported electricity only)

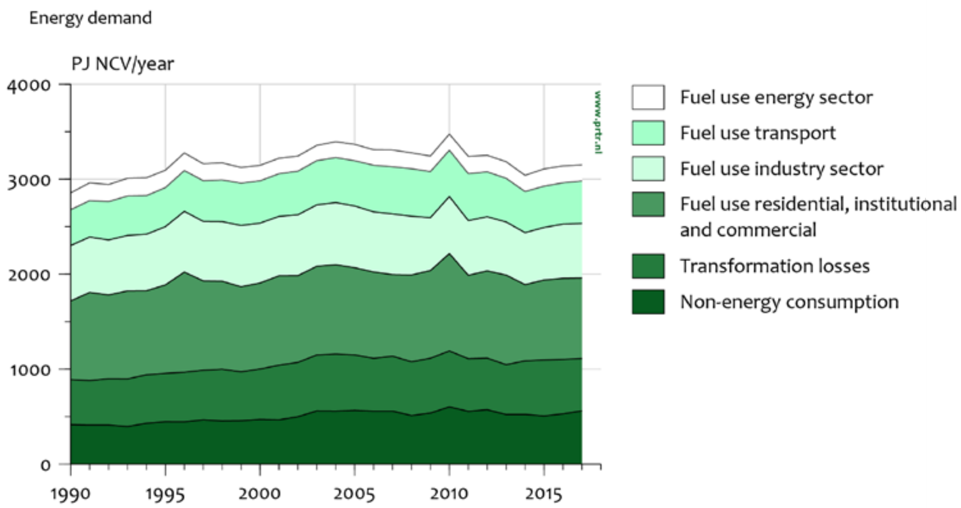

Figure 3.2 Energy demand in the Netherlands, 1990–2017

3.2 Public electricity and heat production (1A1a)

3.2.1 Source category description

In this sector, one source category is included: Public electricity and heat production (1A1a). This sector consists mainly of coal-fired power stations and gas-fired cogeneration plants, many of the latter being operated as joint ventures with industries. A relatively small amount of energy is generated by waste incineration plants in the Netherlands through energy recovery (see Peek et al. 2019). All waste incineration plants recover energy and are included in NFR category 1A1a. Relative to several other countries in the EU, nuclear energy and renewable energy (biomass and wind) provide a small amount of the total primary energy supply in the Netherlands.

3.2.2 *Key sources*

The sector 1A1a is a key source for the pollutants listed in Table 3.1.

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

Category / Subcategory		Pollutant	Contribution to national total of 2017 (%)
1A1a	Public electricity and heat production	SO_x	18
		NO_x	6.8
		Hg	29

3.2.3 *Overview of shares and trends in emissions*

An overview of the trends in emissions is shown in Table 3.2. For almost all pollutants, emissions decreased between 1990 and 2017, while fuel consumption increased over the same period.

NO_x and SO_x emissions decreased by 79% and 90%, respectively. Other pollutant emissions decreased by at least 54%. The decrease in emissions was partly caused by a shift in energy use, but also to technological improvements (especially the large decrease in dioxin emissions). The only pollutant for which emissions increased is NH_3, due to an increase in activity rate. For Se, the increase by a factor of 7 between 1995 and 2000 was caused by environmental reports being considered for the later years, while for the earlier years little or no information was available.

Table 3.2 Overview of trends in 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	**82.8**	**0.70**	**48.5**	**0.00**	**1.81**	**2.21**	**2.46**	**0.00**	**8.18**
1995	61.7	1.07	16.8	0.04	0.38	0.63	0.98	0.00	7.39
2000	51.1	2.19	14.9	0.04	0.24	0.32	0.32	0.00	15.8
2005	43.1	0.56	9.91	0.26	0.40	0.54	0.82	0.00	8.16
2010	25.6	0.37	6.73	0.07	0.21	0.29	0.60	0.00	4.49
2015	20.2	0.52	8.63	0.09	0.29	0.39	0.77	0.00	4.12
2016	17.9	0.51	6.85	0.10	0.23	0.28	0.39	0.00	4.02
2017	**17.0**	**0.53**	**4.92**	**0.08**	**0.16**	**0.25**	**0.37**	**0.00**	**3.78**
1990–2017 period[1]	-65.7	-0.17	-43.5	0.08	-1.65	-1.96	-2.10	0.00	-4.40
1990–2017 period[2]	-79%	-25%	-90%		-91%	-89%	-85%		-54%

Table 3.2 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**	**1.92**	**583**	**0.17**	**0.50**	**0.68**	**2.05**	**2.49**	**0.02**	**40.7**
1995	1.56	0.16	0.38	6.05	0.05	0.20	0.37	0.44	1.41	0.05	3.34
2000	0.18	0.08	0.40	0.09	0.00	0.08	0.19	0.17	0.08	0.45	0.26
2005	0.24	0.09	0.38	0.73	0.01	0.16	0.33	0.28	1.91	1.68	0.52
2010	0.34	0.18	0.22	1.16	0.01	0.11	0.14	0.15	0.16	1.33	3.91
2015	0.16	0.03	0.22	1.00	0.03	0.06	0.16	0.18	0.17	0.91	4.07
2016	0.12	0.04	0.22	1.12	0.02	0.04	0.21	0.20	0.12	0.57	4.30
2017	**0.10**	**0.03**	**0.17**	**1.50**	**0.04**	**0.04**	**0.14**	**0.14**	**0.05**	**0.13**	**3.73**
1990–2017 period[1]	-16.2	-0.92	-1.75	-581	-0.14	-0.46	-0.54	-1.92	-2.44	0.11	-36.9
1990–2017 period[2]	-99%	-97%	-91%	-100%	-80%	-92%	-80%	-93%	-98%	576%	-91%

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

3.2.4 *Activity data and (implied) emission factors*

Emission data are based on Annual Environmental Reports (AERs) and collectively estimated industrial sources. For this source category, 97–100% of the emission figures are based on AERs. To estimate emissions from collectively estimated industrial sources, national energy statistics (from Statistics Netherlands) are combined with implied emission factors (IEFs) from the AERs or with default emission factors (see Table 3.3).

Table 3.3 Default emission factors for electricity production (g/GJ)

Substance name	**Natural gas**	**Bio-gas**	**Cokes**	**Diesel**	**LPG**	**Petro-leum**	**Coal**	**Fuel oil**	**Wood**
NMVOC	3.8	9.75	45.5	15	1.3	5	0.44	4	48
Sulphur dioxide	0.3	2	370	87		46	300	450	10
Nitrogen oxides as NO_2	37	80	100	60	27	50	45	64	120
Ammonia									37
Carbon monoxide	29	20	12,437	30	10	10	50	10	160
PM_{10}	0.2	2	6	4.5	2.0	3.6	60	42.5	12
Total Suspended Particles (TSP)	0.2	2	10	5.0	2.0	4.0	100	45	12

If emissions in AERs are calculated on the basis of stack measurements, they are calculated using uncorrected measurement data. To calculate industrial emissions, Dutch companies are obliged to use the guidance given in the Netherlands PRTR regulations. The relevant documents are to be found on the government website www.infomil.nl (in Dutch only). They apply to three types of plant:

- Small combustion plants
- Large combustion plants
- Waste incineration plants

These documents explicitly state that emissions shall be calculated 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.

3.2.5 *Methodological issues*

Emissions are based on data in the AERs from individual facilities (Tier 3 methodology). Emissions and fuel consumption data in the AERs are 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 emissions from companies that are not individually assessed.

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

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

Next, combustion emissions from 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 are insufficient to calculate an IEF, then a default emission factor is used (see Table 3.3).

$$\mathbf{ER\text{-}C\_emission}_{\text{(NACE, fuel)}} = \mathbf{EF}_{\text{ER-I (NACE, fuel)}} * \mathbf{energy\ statistics}_{\text{(NACE, fuel)}}$$

where:
ER-C = Emission Registration database for collective emission sources

Total combustion emissions are the sum of emissions from the individual companies (ER-I) plus emissions from the companies that are not individually assessed (ER-C).Uncertainties and time series consistency Uncertainties are explained in Section 1.7.

3.2.6 *Source-specific QA/QC and verification*

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

3.2.7 *Source-specific recalculations*

The following recalculations have been performed:

- The emission factors of SO_x, CO, PM_{10} and TSP for natural gas combustion have been updated. These emission factors are now based on the EMEP/EEA Guidebook (EMEP/EEA, 2016). These emission factors are only used to calculate emissions from companies that did not individually report their emissions.
- The energy statistics for 2015 and 2016 have been improved.
- New $PM_{2.5}$/PM_{10} ratios have been derived; these have been used to calculate $PM_{2.5}$ emissions (Visschedijk & Dröge, 2019).
- NH_3 emissions from biomass have been calculated.

3.2.8 *Source-specific planned improvements*

The following two sector-specific improvements are planned:

- The emission factors for the other fuels are still under investigation.
- The AERs from individual companies are not complete. In the coming years, a few sectors will be studied and AERs will be completed as far as possible. It is yet to be decided which sector will be improved in which year.
- Emissions of PCBs will be calculated in 2019.

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

3.3.1 *Source category description*

This source category comprises the following 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 sector 1A2gviii includes industries for: mineral products (cement, bricks, other building materials, glass), textiles, wood and wood products and machinery.

3.3.2 *Key sources*

The sectors 1A1b, 1A2c and 1A2gviii are key sources for the pollutants mentioned in Table 3.4.

Table 3.4 Pollutants for which the Industrial combustion (NFR 1A1b, 1A1c and 1A2) sector is a key source

Category / Subcategory		**Pollutant**	**Contribution to total of 2017 (%)**
1A1b	Petroleum refining	SO_x	41
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	SO_x CO	12 9.9
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	NO_x	3.6
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	SO_x	8.8

3.3.3 *Overview of shares and trends in emissions*

An overview of the trends in emissions is shown in Table 3.5. Emissions have been reduced since 1990 for most pollutants, except for dioxins. A 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 3.5 Overview of trends in 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	**101**	**6.26**	**110**	**0.57**	**5.84**	**7.79**	**8.21**	**0.41**	**266**
1995	77.7	6.94	88.9	0.32	4.98	6.49	6.71	0.39	215
2000	49.3	2.14	45.9	0.05	2.86	4.16	4.90	0.30	160
2005	49.3	2.15	46.3	0.11	1.40	1.82	2.02	0.12	155
2010	40.2	3.90	24.3	0.48	0.38	0.56	0.80	0.02	126
2015	35.1	2.94	19.8	0.45	0.34	0.46	0.61	0.02	97.6
2016	33.4	2.47	19.4	0.48	0.32	0.45	0.59	0.02	93.7
2017	**33.3**	**2.26**	**19.7**	**0.45**	**0.35**	**0.48**	**0.61**	**0.02**	**87.3**
1990–2017 period[1]	-67.4	-4.00	-90.3	-0.12	-5.49	-7.31	-7.60	-0.40	-179
1990–2017 period[2]	-67%	-64%	-82%	-21%	-94%	-94%	-93%	-96%	-67%

Table 3.5 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	**1.90**	**0.14**	**0.18**	**0.01**	**0.99**	**0.17**	**2.57**	**1.42**	**67.1**	**0.05**	**2.96**
1995	3.90	0.17	0.08	1.02	0.38	0.16	3.18	2.17	80.5	0.05	3.52
2000	0.06	0.01	0.11	0.35	0.00	0.00	0.54	0.16	18.1	0.00	0.89
2005	0.01	0.00	0.00	0.94	0.10	0.78	0.08	0.09	6.50	0.08	0.51
2010	3.08	1.28	0.02	5.79	0.13	0.01	0.14	1.13	0.02	0.12	9.81
2015	0.09	0.00	0.05	0.19	0.10	0.00	0.01	0.00	0.11	0.00	1.16
2016	0.04	0.00	0.04	0.19	0.10	0.00	0.01	0.00	0.11	0.00	0.65
2017	**0.01**	**0.00**	**0.03**	**0.09**	**0.09**	**0.00**	**0.28**	**0.11**	**0.26**	**0.00**	**0.43**
1990–2017 period[1]	-1.89	-0.14	-0.15	0.08	-0.91	-0.16	-2.29	-1.31	-66.8	-0.05	-2.53
1990–2017 period[2]	-99%	-100%	-83%	928%	-91%	-100%	-89%	-92%	-100%	-100%	-85%

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

3.3.4 *Activity data and (implied) emission factors*

Petroleum refining (1A1b)
All emission data are based on Annual Environmental Reports (AERs).

Manufacture of solid fuels and other energy industries (1A1c)
Emission data are based on AERs and collectively estimated industrial sources.

Iron and steel (1A2a)
Emission data are based on AERs and collectively estimated industrial sources. For this source category, 1% of the SO_x emissions were collectively estimated (in 2017), thus 99% were based on the AERs.

Non-ferrous metals (1A2b)
Emission data are based on AERs and collectively estimated industrial sources. For this source category, 36% of the NMVOC emissions, 16% of the NO_x emissions and 19% of the SO_x emissions were collectively estimated (in 2017).

Chemicals (1A2c)
Emission data are based on AERs and collectively estimated industrial sources. For this source category, 4% of the NO_x emissions, 3% of the SO_x emissions and 4% of the NMVOC emissions and 1% of the PM_{10} emissions were collectively estimated (in 2017).

Pulp, paper and print (1A2d)
Emission data are based on AERs and collectively estimated industrial sources. For this source category, 55% of the NMVOC emissions and 13% of the NO_x emissions were collectively estimated (in 2017).

Food processing, beverages and tobacco (1A2e)
Emission data are based on AERs and collectively estimated industrial sources.

Non-metallic minerals (1A2f)
Emission data are based on AERs and collectively estimated industrial sources. Emissions from non-metallic minerals were 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 are based on AERs and collectively estimated industrial sources.

For some of the above-mentioned categories, emissions were not entirely available from the AERs. For these sectors, emissions were calculated using national energy statistics and IEFs from the environmental reports or default emission factors (see).

Table 3.6 Emission factors for the industrial sector (g/GJ)

Substance name	Natural gas	Bio-gas	Cokes	Diesel	LPG	Petro-leum	Coal	Fuel oil	Wood (wood indus-tries)	Wood (other indus-try)
NMVOC	3.8	9.7	45.5	8.5	1.3	5	0.4	4	48	48
Sulphur dioxide	0.3	2	370	87		46	300	450	10	10
Nitrogen oxides as NO_2	37	80	100	60	27	50	45	64	150	120
Ammonia									37	37
Carbon monoxide	15	20	12,437	30	10	10	50	10	750	160
PM_{10}	0.2	2	6	4.5	2	3.6	60	42.5	27	12
Total Suspended Particles (TSP)	0.2	2	10	5.0	2	4.0	100	45	27	12

3.3.5 *Methodological issues*

Emissions are based on data in the AERs from individual facilities (Tier 3 methodology). The emissions and fuel consumption data in the AERs are 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 from companies that are not individually assessed.

$$EF_{ER\text{-}I\ (NACE,\ fuel)} = \frac{Emissions_{ER\text{-}I\ (NACE,\ fuel)}}{Energy\ use_{ER\text{-}I\ (NACE,\ fuel)}}$$

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

Next, combustion emissions from 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 are insufficient to calculate an IEF, then a default emission factor is used (see Table 3.6).

$$ER\text{-}C\_emission_{(NACE,\ fuel)} = EF_{ER\text{-}I\ (NACE,\ fuel)} * energy\ statistics_{(NACE,\ fuel)}$$

where:
ER-C = Emission Registration database for collective emission sources

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

3.3.6 *Uncertainties and time series consistency*

Uncertainties are explained in Section 1.7.

3.3.7 *Source-specific QA/QC and verification*

Emissions and fuel consumption data in the AERs were 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 have been performed:

- The emission factors of SO_x, CO, PM_{10} and TSP for natural gas combustion have been updated. These emission factors are now based on the EMEP/EEA Guidebook (EMEP/EEA, 2016). These emission factors are only used to calculate emissions from companies that did not individually report their emissions.
- The energy statistics for 2015 and 2016 have been improved.
- New $PM_{2.5}/PM_{10}$ ratios have been derived; these have been used to calculate the $PM_{2.5}$ emissions (Visschedijk & Dröge, 2019).
- NH_3 emissions from biomass have been calculated.

3.3.9 *Source-specific planned improvements*

The following two sector-specific improvements are planned:

- The emission factors for the other fuels are still under investigation;
- The AERs from individual companies are not complete. In the coming years, a few sectors will be studied and AERs will be

completed as far as possible. It is yet to be decided which sector will be improved in which year;
- Emissions of PCBs will be calculated in 2019.

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

3.4.1 *Source-category description*

This source category comprises the following subcategories:
- 1A4ai Commercial/Institutional: Stationary. This sector 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 waste-water treatment plants.
- 1A4bi Residential: Stationary. This sector 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 sector comprises stationary combustion emissions from agriculture, horticulture, greenhouse horticulture, cattle breeding and forestry.
- 1A5a Other: Stationary. This sector includes stationary combustion of waste gas from dumping sites.

3.4.2 *Key sources*

The Small combustion sector is a key source of the pollutants listed in Table 3.7.

Table 3.7 Pollutants for which the Small combustion (NFR 1A4 and 1A5) sector is a key source

Category / Subcategory	Pollutant	Contribution to total of 2017 (%)
1A4ai Commercial/institutional: Stationary	NO_x	2.6
1A4bi Residential: Stationary	NO_x	2.9
	NMVOC	4.4
	CO	14
	PM_{10}	7.7
	$PM_{2.5}$	14
	BC	22
	Dioxine	30
	PAH	73
1A4ci Agriculture/forestry/fishing: Stationary	NO_x	3.1

3.4.3 *Overview of shares and trends in emissions*

An overview of the trends in emissions is shown in Table 3.8. Emissions of almost all pollutants have decreased since 1990, while fuel use has increased slightly.

Table 3.8 Overview of trends in 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	**42.4**	**14.6**	**2.11**	**0.90**	**2.62**	**2.75**	**5.45**	**0.96**	**84.1**
1995	45.8	15.3	1.36	0.93	2.54	2.68	5.18	0.97	89.8
2000	40.2	14.0	0.85	0.88	2.34	2.47	4.80	0.87	85.7
2005	37.3	13.6	0.65	0.91	2.32	2.44	4.71	0.82	87.4
2010	37.6	13.4	0.61	0.95	2.22	2.33	4.54	0.75	88.6
2015	26.0	12.4	0.53	1.00	2.11	2.21	4.48	0.69	85.2
2016	25.1	12.4	0.56	1.03	2.13	2.23	4.52	0.69	86.5
2017	21.8	12.5	0.59	1.06	2.14	2.24	4.56	0.68	87.2
1990–2017 period[1]	-20.6	-2.16	-1.53	0.17	-0.48	-0.51	-0.89	-0.27	3.06
1990–2017 period[2]	-49%	-15%	-72%	19%	-18%	-19%	-16%	-29%	4%

	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	0.76	0.07	0.12	108	3.78	0.05	3.51	0.71	1.97	0.00	1.97
1995	0.12	0.05	0.04	8.09	4.00	0.02	0.05	0.34	0.53	0.00	0.78
2000	0.08	0.05	0.03	7.34	3.91	0.01	0.01	0.32	0.23	0.00	0.70
2005	0.08	0.05	0.03	7.04	4.09	0.00	0.01	0.35	0.23	0.00	0.76
2010	0.09	0.05	0.03	6.85	4.10	0.01	0.00	0.38	0.01	0.00	0.82
2015	0.09	0.06	0.04	6.97	4.20	0.00	0.00	0.41	0.00	0.00	0.86
2016	0.09	0.06	0.04	7.06	4.26	0.00	0.00	0.42	0.00	0.00	0.89
2017	0.10	0.06	0.04	7.14	4.32	0.00	0.00	0.42	1.97	0.00	0.91
1990–2017 period[1]	-0.67	0.00	-0.08	-101	0.54	-0.04	-3.50	-0.28	-1.97	0.00	-1.06
1990–2017 period[2]	-87%	-7%	-68%	-93%	14%	94%	-100%	-40%	-100%	-100%	-54%

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

3.4.4 *Activity data and (implied) emission factors*

Commercial/institutional (1A4ai)

Combustion emissions from the commercial and institutional sectors are based on fuel consumption data (from Statistics Netherlands) and emission factors (see Table 3.9).

Table 3.9 Emission factors for stationary combustion emissions from the services sector (g/GJ)

Substance name	Natural gas	Biogas	Diesel	Coal	Fuel oil	Wood
NMVOC	3.8	9.75	8.5	3	4	16
Sulphur dioxide	0.22	2	87	300	450	10
Nitrogen oxides as NO_2	49	80	60	45	64	122
Ammonia						37
Carbon monoxide	15	20	30	50	10	150
PM_{10}	0.3	2	4.5	60	36.5	34
Total Suspended Particles (TSP)	0.3	2	5	100	38.7	34

Residential (1A4bi)
Combustion emissions from central heating, hot water and cooking are based on fuel consumption data (from Statistics Netherlands) and emission factors (see Table 3.10). The fuel most used in this category is natural gas. The use of wood in stoves and fireplaces for heating is almost negligible compared with the amount of natural gas used. Combustion emissions from (wood) stoves and fireplaces were calculated by multiplying the fuel consumption per apparatus type and fuel type (Statistics Netherlands) by emission factors (Jansen, 2016).

Table 3.10 Emission factors for combustion emissions from households (g/GJ)

Substance name	Natural gas (heating)	Natural gas (cooking)	Diesel	LPG	Petroleum	Coal
NMVOC	1.92	2.02	8.5	1.3	5	30
Sulphur dioxide	0.22	0.22	70	0.22	70	420
Nitrogen oxides as NO_2	[1]	[1]	51	40	51	75
Carbon monoxide	22	30	57	10	57	2,000
PM_{10}	0.2	2.2	1.9	2	1.9	120
Total Suspended Particles (TSP)	0.2	2.2	2.4	2	2.1	200

1. See table on NO_x emission factors in van Soest-Vercammen et al. (2002) and Kok (2014).

Agriculture / forestry / fishing (1A4ci)
Stationary combustion emissions are based on fuel consumption obtained from Statistics Netherlands, whose figures are in turn based on data from Wageningen Economics Research and default emission factors (Table 3.11).

Table 3.11 Agriculture/Forestry/Fishing sectors (g/GJ)

Substance name	Natural gas	Biogas	LPG	Wood
NMVOC	3.8	9.1	1.3	16
Sulphur dioxide	0.22	2	0.22	11
Nitrogen oxides as NO_2	[1]	74	40	80
Ammonia				37
Carbon monoxide	15	30	10	170
PM_{10} [2]	0.2	2	0.3	17
Total Suspended Particles (TSP)[2]	0.2	2	0.3	17

1. See table on NO_x emission factors in van Soest-Vercammen et al. (2002) and Kok (2014).
2. See table on dust emissions from Visschedijk *et al.* (2007).

3.4.5 *Methodological issues*

A Tier 2 methodology was used to calculate emissions from the sectors for several techniques by multiplying the activity data (fuel consumption) by the emission factors (see previous section).

The biomass combusted in 1A5a consist of gaseous biomass, and not solid biomass. Therefore, no NH_3 emissions are calculated in this sector.

3.4.6 *Uncertainties and time series consistency*

Uncertainties are explained in Section 1.7.

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 have been performed:

- The emission factors of SO_x for natural gas combustion have been updated. Also the emission factors of SO_x, NO_x, CO and PM_{10} for diesel and petroleum in the residential sector have been updated. These emission factors are now based on the EMEP/EEA Guidebook (EMEP/EEA, 2016).
- The energy statistics for 2015 and 2016 have been improved.
- New $PM_{2.5}/PM_{10}$ ratios have been derived; these have been used to calculate the $PM_{2.5}$ emissions (Visschedijk & Dröge, 2019).
- NH_3 emissions from biomass have been calculated.

3.4.9 *Source-specific planned improvements*

The following two sector-specific improvements are planned:

- The emission factors for the other fuels are still under investigation.
- Emissions of PCBs will be calculated in 2019.

3.5 Fugitive emissions (1B)

3.5.1 *Source category description*

This source 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
- 1B2d Other fugitive emissions from energy production

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

3.5.2 *Key sources*

The Fugitive emissions sector is a key source of the pollutants presented in Table 3.12

Table 3.12 Pollutants for which the Fugitive emissions sector category (NFR 1B) is a key source

Category / Subcategory	**Pollutant**	**Contribution to total of 2017 (%)**
1B2aiv Refining	NMVOC	1.4
1B2av Distribution of oil products	NMVOC	1.5
1B2b Fugitive emissions from natural gas	NMVOC	1.9

3.5.3 *Overview of shares and trends in emissions*

An overview of the trends in emissions is shown in Table 3.13. The emissions from NMVOC decreased between 1990 and 2016.

Table 3.13 Overview of trends in emissions

	Main pollutants	Particulate matter			POPs
	NMVOC	$PM_{2.5}$	PM_{10}	TSP	PAH
Year	Gg	Gg	Gg	Gg	Mg
1990	**47.4**	**0.11**	**0.19**	**0.57**	**0.01**
1995	33.5	0.14	0.21	0.38	0.02
2000	29.2	0.07	0.10	0.10	0.00
2005	20.8	0.07	0.10	0.11	0.04
2010	15.4	0.00	0.00	0.01	0.00
2015	14.3	0.05	0.05	0.05	0.00
2016	12.9	0.02	0.02	0.02	0.00
2017	**12.2**	**0.00**	**0.00**	**0.00**	**0.00**
1990–2017 period[1]	-35.2	-0.11	-0.18	-0.56	-0.01
1990–2017 period[2]	-74%	-96%	-98%	-99%	-100%

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

3.5.4 *Activity data and (implied) emission factors*

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

3.5.5 *Methodological issues*

Fugitive NMVOC emissions from category 1B2av comprise process emissions from oil refining and storage. The emissions are derived from the companies' e-AER's (electronic Annual Environmental Report) (Tier 3 methodology).

Fugitive NMVOC emissions from category 1B2aiv comprise dissipation losses from gasoline service stations, leakage losses during vehicle and aircraft refuelling and refinery processes. Emissions were calculated on the basis of annual fuel consumption (Tier 2 methodology).

Fugitive NMVOC emissions from category 1B2b comprise emissions from oil and gas extraction (exploration, production, processing, flaring and venting), from 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 of 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 of the distribution sector as input (Tier 2 methodology).

Detailed information on activity data and emissions can be found in Peek (2019).

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 1.6.

3.5.8 *Source-specific recalculations*

No source-specific recalculations have been made for this sector.

In previous submissions, emissions from the extraction of oil and gas, as reported by the operators in their e-AER, were allocated within category 1B2ai Fugitive emissions oil. As extraction in the Netherlands is mainly gas extraction, these emissions have been reallocated to 1B2b. Emissions from the distribution of oil products had been allocated to category 1B2aiv Fugitive emissions oil: refining/storage but have now been reallocated to category 1B2av Distribution of oil products now.

3.5.9 *Source-specific planned improvements*

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 $PM_{2.5}$. 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 source category Transport (1A3) comprises the following subcategories: Civil aviation (1A3a), Road Transport (1A3b), Railways (1A3c) and Waterborne navigation (1A3d). 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 all four source categories, national activity data and (mostly) country-specific emission factors were used. Emissions from civil aviation and waterborne navigation were based on fuel used, whereas emissions from railways and road transport were calculated using fuel sales data.

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

NS = National Statistics.
CS = Country-specific.

It should be noted that, since the 2016 submission, emissions of NO_x, PM_{10}, $PM_{2.5}$, EC, NMVOC, CO and NH_3 from road transport have been reported on a fuel-sold basis (for the entire time series). Up until the 2015 submission, road transport emissions were reported on a fuel-used basis. The difference between fuel-used and fuel-sold emissions is described in Section 4.3.

This chapter also covers non-road mobile machinery, recreational craft and national fishing. Emissions from non-road mobile machinery are reported in several different source categories within the inventory (i.e. 1A2gvii, 1A4aii, 1A4bii, 1A4cii), as shown in Table 4.1. Emissions from non-road mobile machinery were calculated using a Tier 3 method based on fuel used, using national activity data and a combination of country-specific and default emission factors. Emissions from recreational craft and vehicles operating at airports were reported under 1A5b Other, mobile and were calculated using a Tier 3 and Tier 2 methodology, respectively. Emissions from fisheries were reported under 1A4ciii National fishing and were calculated using a Tier 3 method.

This chapter describes shares and trends in emissions for the different 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 Klein *et al*. (2019a), supplemented by tables with detailed emission and activity data, and the emission factors used in the emission calculations (Klein *et al*., 2019b).

4.1.1 Key sources

The source categories within the transport sector are the key sources of various pollutants, as shown in Table 4.2. The percentages in Table 4.2 relate to the 2017 level assessment and the 1990–2017 trend assessment (in italics). Some source categories are the key sources for both the trend and the 2017 level assessment. In those cases, Table 4.2 shows which of the two source categories contributes more. The full results of the key source analysis are presented in Annex 1.

Table 4.2 Key source analysis for the transport sector (%)

NFR code	Source category description	SO_x	NO_x	NMVOC	CO	PM_{10}	$PM_{2.5}$	BC	Pb
1A3ai(i)	International aviation LTO (civil)		*2.3*						8.3
1A3aii(i)	Domestic aviation LTO (civil)								
1A3bi	Passenger cars	*4.9*	*19.6*	*13.9*	40.6	*7.5*	*9.0*	*15.4*	*44.8*
1A3bii	Light-duty vehicles	[2]	*8.0*		*7.7*	*4.4*	5.0	17.1	
1A3biii	Heavy-duty vehicles and buses	*7.9*	12.8	[2]		*9.8*	*12.8*	*28.1*	
1A3biv	Mopeds and motorcycles			4.2	*10.7*				
1A3bv	Gasoline evaporation			*6.2*					
1A3bvi	Automobile tyre and brake wear					5.5	1.9		
1A3bvii	Automobile road abrasion					4.4			
1A3c	Railways								
1A3di(ii)	International inland waterways		6.5			1.9[1]	3.4	8.8	
1A3dii	National navigation (shipping)		*5.3*				2.5	*7.3*	
1A2gvii	Mobile Combustion in manufacturing industries and construction		3.8			1.9[1]	3.5	8.1	
1A4aii	Commercial/institutional: mobile								
1A4bii	Residential: household and gardening (mobile)				*7.9*				
1A4cii	Agriculture/forestry/ fishing: off-road vehicles and other machinery		3.1				2.5	[2]	
1A4ciii	Agriculture/forestry/ fishing: National fishing	*3.1*	2.8						
1A5b	Other, Mobile (including military, land based and recreational boats)				*5.2*[1]				

Percentages in italics are from the trend contribution calculation.
[1] No longer a key source (cf. IIR2018).
[2] New key source (cf. IIR2018).

4.2 Civil aviation

4.2.1 *Source category description*

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

The civil aviation source category does not include emissions from ground support equipment at airports. This equipment is classified as mobile machinery, and the resulting emissions were 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 3,000 feet) are not part of the national emission totals and were not estimated. Due to a lack of data, the split of LTO-related fuel consumption and resulting emissions between domestic and international aviation was not made. However, due to the small size of the country, there is hardly any domestic aviation in the Netherlands. Therefore, all fuel consumption and resulting emissions in civil aviation are reported under International aviation (1A3i) in the NFR.

Condensables are included in PM_{10} and $PM_{2.5}$ emissions.

4.2.2 *Key sources*

Civil aviation is a key source for lead (2017 level) and for NO_x (1990–2017 trend) 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, more than doubled between 1990 and 2016, increasing from 4.5 to 10.6 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 Klein et al. (2019a, b)). Fuel consumption (LTO) at Amsterdam Airport Schiphol more than doubled between 1990 and 2008. After a 9% decrease in 2009 due to the economic crisis, fuel consumption increased again in 2010 and 2011 and was approximately at pre-crisis levels in 2011. In 2016, total fuel consumption in civil aviation at Schiphol Airport increased by 5% compared with 2015. This increase corresponded with the increase in the number of flights (+6%) and the number of air passengers (+9%) at Amsterdam Airport Schiphol in 2016, as reported by Statistics Netherlands.

Fuel consumption in civil aviation at regional airports was fairly constant at 0.4–0.5 PJ between 1990 and 2004. From 2004, fuel consumption increased steadily to 0.9 PJ in 2016. This increase can be attributed to an increase in air traffic at regional airports. The total number of flights at the four biggest regional airports in the Netherlands (Eindhoven, Rotterdam The Hague, Maastricht Aachen and Groningen Eelde) increased by 67% between 2003 and 2016, whereas the number of air passengers increased by 364% according to Statistics Netherlands.

The trends in emissions from civil aviation in the Netherlands are shown in . The increase in air transport and related fuel consumption has led to an increase in the emissions of NO_x, SO_x, TSP, PM_{10} and $PM_{2.5}$. Fleet average NO_x emission factors have not changed significantly throughout the time series, therefore NO_x emissions more than doubled between 1990 and 2017, following the trend in fuel consumption. PM_{10} emissions from civil aviation increased significantly between 1990 and 2017. This increase was mainly due to the increase in tyre and brake wear emissions. PM_{10} emissions due to tyre and brake wear 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 emission factors (per unit of fuel) have decreased since 1990. As a result, the share of wear emissions in total emissions of PM_{10} in civil aviation has increased.

Table 4.3 Trends in emissions from 1A3a Civil aviation

	Main pollutants			Particulate matter				Other	Priority heavy metals
	NO_x	NMVOC	SO_x	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg
1990	**1.24**	**0.38**	**0.10**	**0.02**	**0.03**	**0.03**	**0.02**	**3.51**	**1.83**
1995	1.78	0.34	0.14	0.03	0.03	0.03	0.02	3.97	1.94
2000	2.41	0.29	0.19	0.03	0.04	0.04	0.02	3.73	1.49
2005	2.75	0.27	0.22	0.03	0.04	0.04	0.02	3.52	1.11
2010	2.78	0.27	0.21	0.03	0.04	0.04	0.02	3.67	1.25
2015	3.16	0.29	0.23	0.03	0.04	0.04	0.02	3.36	0.82
2016	3.33	0.31	0.24	0.03	0.04	0.04	0.02	3.45	0.80
2017	**3.49**	**0.31**	**0.25**	**0.03**	**0.04**	**0.04**	**0.02**	**3.42**	**0.72**
1990–2017 period[1]	2.25	-0.07	0.15	0.00	0.01	0.01	0.00	-0.09	-1.11
1990–2017 period[2]	182%	-17%	147%	17%	51%	51%	8%	-2%	-61%

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

The $PM_{2.5}/PM_{10}$ ratio for brake and tyre wear emissions in 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 much smaller and the trend in total $PM_{2.5}$ emissions in civil aviation has been influenced more heavily by the trend in exhaust emissions. This explains why $PM_{2.5}$ emissions increased less throughout the time series than PM_{10} emissions.

Aviation petrol 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, thereby becoming a key source in the 2017 level assessment. The share that civil aviation contributed to total emissions of NO_x, SO_x, BC and other substances is small.

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 in the Netherlands were calculated using a flight-based Tier 3 method. Specific data were used for the number of aircraft movements per aircraft type and per airport, which were derived from the airports and from Statistics Netherlands. These data were used in the CLEO model (Dellaert & Hulskotte, 2017) to calculate LTO fuel consumption and resulting emissions. The CLEO model was derived from the method used to calculate aircraft emissions at the US Environmental Protection Agency (EPA). The emission factors used in CLEO were taken from the ICAO Engine Emissions DataBank. A detailed description of the methodology can be found in chapter 8 of Klein *et al.* (2019a).

NH_3 emissions from civil aviation are not estimated due to a lack of emission factors. Emissions are expected to be negligible.

4.2.5 *Methodological issues*

The split of fuel consumption and resulting emissions between domestic and international aviation was not made. The activity data used to derive civil aviation emissions (i.e. the number of LTO cycles per airport, as derived from Statistics Netherlands) do not include the origin or destination of the flights. As a result, making a split between domestic and international LTO emissions is not straightforward. Due to the small size of the country, there is hardly any domestic aviation in the Netherlands, with the exception of general aviation. Fuel sales data for civil aviation are reported separately in the greenhouse gas inventory, which shows that only 0.3% of total fuel deliveries to civil aviation were used for domestic flights in 2016. Given the minimal share of domestic aviation, fuel consumption and (LTO) emissions from both domestic and international aviation are reported under International aviation (1A3i).

The methodology for calculating fuel consumption and resulting emissions from Auxiliary Power Units (APUs) needs to be updated because the assumed fuel consumption per passenger has not been verified in recent years. Yet it should be noted that the 2016 EEA Emission Inventory Guidebook does not provide a methodology for estimating emissions from APUs.

4.2.6 *Uncertainties and time series consistency*

Consistent methodologies have been used throughout the time series. In 2016, an experts' workshop was organised to discuss and estimate the uncertainties in the activity data and emission factors 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 (%)

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

Source: Dellaert & Dröge (2017).

4.2.7 *Source-specific QA/QC and verification*

Trends in the estimated fuel consumption for civil aviation were compared with trends in LTOs and passenger numbers at Amsterdam Airport Schiphol and regional airports (see also Section 4.2.3). The two trends correspond closely.

4.2.8 *Source-specific recalculations*

There were a few minor adjustments (<1%) to the activity data, due to a correction for an error in the labels for aircrafts. The emissions for the 2009 and 2014–2016 periods changed slightly (<1%) as a result of the adjusted activity data.

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 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.

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 in the IIR 2017, reported emissions from road transport have been based on *fuel sold* (for the entire time series) in accordance with the UNECE guidelines.

4.3.2 Key sources

The different source categories within Road transport are key sources of many substances in both the 1990–2017 trend assessment and in the 1990 and 2017 level assessments, as shown in Table 4.5.

Table 4.5 Key source analysis for Road transport subcategories

Source category	Name	1990 level	2017 level	1990–2017 trend
1A3bi	Passenger cars	NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, BC, Pb	NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, BC, Pb, Cd, Hg	SO_2, NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, BC, Pb, Cd, Hg
1A3bii	Light-duty vehicles	NO_x, CO, PM_{10}, $PM_{2.5}$, BC	NO_x, PM_{10}, $PM_{2.5}$, BC	NO_x, CO, PM_{10}, $PM_{2.5}$
1A3biii	Heavy-duty vehicles and buses	SO_2, NO_x, NMVOC, PM_{10}, $PM_{2.5}$, BC	NO_x, $PM_{2.5}$, BC	SO2, NO_x, PM_{10}, $PM_{2.5}$, BC
1A3biv	Mopeds and motorcycles	NMVOC, CO	NMVOC, CO	CO
1A3bv	Gasoline evaporation	NMVOC		NMVOC
1A3bvi	Tyre and brake wear		PM_{10}, $PM_{2.5}$	PM_{10}
1A3bvii	Road abrasion		PM_{10}	PM_{10}

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 different source categories within road transport accounted for 33% of NO_x emissions (national totals), 17% of PM_{10}, 17% of $PM_{2.5}$, 37% of BC, 11% of NMVOC and 53% of CO emissions in 2017. The trends in emissions from road transport are shown in Table 4.6. 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 2017 as emissions in other sectors decreased as well. Road transport, therefore, is still a major source of pollutant emissions in the Netherlands.

Table 4.6 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	282	188	15.4	0.95	18.8	20.5	20.5	9.07	712
1995	223	121	14.4	2.40	13.7	15.5	15.5	7.04	523
2000	179	67.6	3.57	4.35	10.3	12.3	12.3	6.16	399
2005	157	41.3	0.24	5.29	7.76	9.83	9.83	5.00	387
2010	128	34.8	0.20	4.83	5.29	7.42	7.42	3.20	372
2015	91.4	26.5	0.18	3.97	2.95	5.09	5.09	1.53	298
2016	84.7	25.7	0.18	3.93	2.55	4.75	4.75	1.21	290
2017	83.2	26.4	0.19	4.16	2.43	4.65	4.65	1.12	296
1990–2017 period[1]	-199	-162	-15.2	3.21	-16.3	-15.8	-15.8	-7.95	-416
1990–2017 period[2]	-71%	-86%	-99%	337%	-87%	-77%	-77%	-88%	-58%

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

Emissions of SO_x decreased by 99% between 1990 and 2016 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 slightly. 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% in national emission totals in 2017.

Emissions of heavy metals have increased, with the exception of Pb. Pb 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 in 1990 to 108 billion in 2017 (see Figure 4.1).

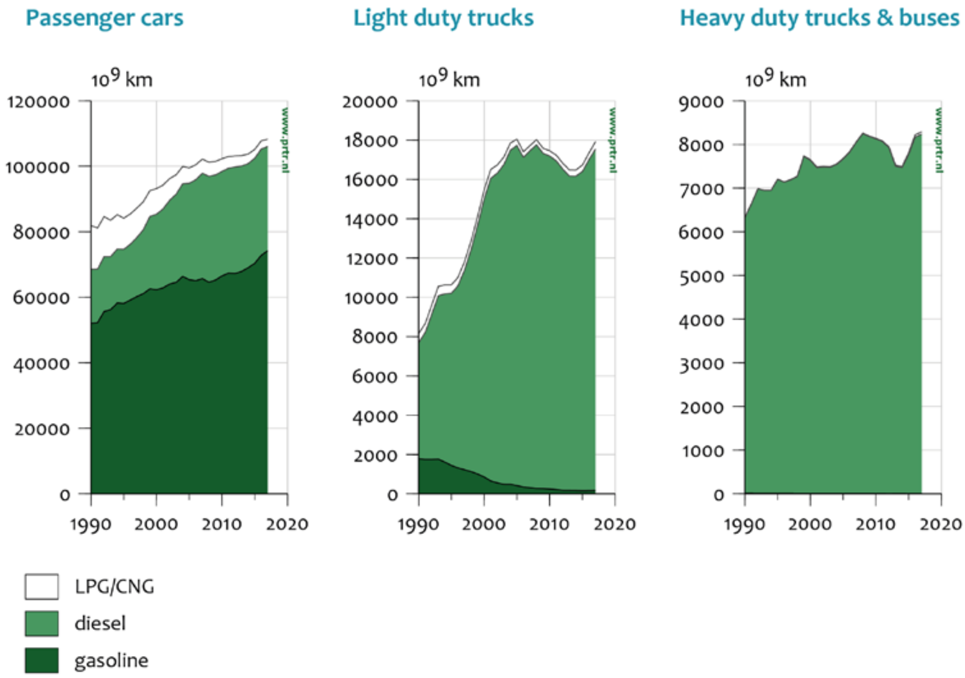

Figure 4.1 Kilometres driven per vehicle and fuel type in the Netherlands Source: Statistics Netherlands.

Since 1995, the share of diesel-powered passenger cars in the Dutch car fleet has grown significantly, leading to an increase in diesel mileage by 93% between 1990 and 2017. Petrol mileage increased by 43% between 1990 and 2017. Yet since 2008, the total diesel mileage has remained constant. The share of LPG in the passenger car fleet decreased significantly, from 16% in 1990 to 2% in 2017. Figure 4.1 shows 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 total kilometres driven by passenger cars. The market share of diesel increased throughout the time series, mostly at the expense of LPG.

NO_x emissions from passenger cars decreased significantly throughout the time series, even though traffic volumes increased: from 145 Gg in 1990 (24% of total NO_x emissions in the Netherlands) to 31 Gg in 2017 (12% of total NO_x). This decrease can mainly be attributed to the introduction of the three-way catalyst, which led to a major decrease in NO_x emissions from petrol-powered passenger cars. NO_x emissions from diesel-powered passenger cars increased between 1995 and 2007 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 disappointing real-world NO_x emission performance from recent generations of diesel-powered passenger cars. Due to the decrease of NO_x emissions from petrol-powered passenger cars, NO_x has become mostly a diesel-related issue. Since 2007, NO_x emissions from diesel cars have decreased.

The introduction of the three-way catalyst 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 2017, passenger cars were responsible for 5% of NMVOC emissions (not including evaporative NMVOC emissions) (down from 21% in 1990) and 41% of CO emissions (down from 52% in 1990) in the Netherlands.

Passenger cars (source category 1A3bi, including only exhaust emissions) were responsible for 5% of $PM_{2.5}$ emissions and 3% of PM_{10} emissions in the Netherlands in 2017. PM_{10} exhaust emissions from passenger cars decreased by 91% between 1990 and 2017. 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-5 PM emission standard, which came into force at the start of 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 new diesel-powered passenger cars were equipped with a DPF. In 2008, the share of new diesel passenger cars with a DPF was above 90%. $PM_{2.5}$ exhaust emissions from passenger cars (and other road transport) are assumed to be equal to PM_{10} exhaust emissions.

NH_3 emissions from passenger cars increased from 0.9 Gg in 1990 to 5.3 Gg in 2006, as a result of the introduction of the three-way catalyst. From 2007, emissions decreased to 3.7 Gg in 2017. 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 emission factor. Lead emissions from passenger cars decreased by more than 99% between 1990 and 2017 due to the phase-out of leaded petrol.

Light-duty trucks (1A3bii)
The light-duty truck fleet in the Netherlands grew significantly between 1990 and 2005, 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 stabilized since. The number of vehicle kilometres driven varied between 17 and 18 billion between 2005 and 2011, decreased somewhat in 2012 and 2013, and increased slightly after 2015. These fluctuations in recent years can probably 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.

NO_x emissions from light-duty trucks have fluctuated between 19 and 24 Gg since 1994. NO_x emissions in 2017 were 18% lower than they were in 1990, even though the number of vehicle kilometres driven more than doubled during this time span. 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-5 light-duty trucks, the fleet average NO_x emission factor 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 less than 1% of the national totals for both substances in 2017. Exhaust emissions of NMVOC and CO from light-duty trucks decreased significantly throughout the time series. Increasingly stringent EU emissions standards for both substances have led to a major (85–87%) decrease in the fleet average emission factors for both petrol and diesel trucks between 1990 and 2017. Petrol-powered trucks emit far more NMVOC and CO per kilometre than diesel-powered trucks; therefore, the decrease in the number of petrol-driven trucks has also contributed significantly to the decrease in NMVOC and CO emissions.

The exhaust emissions of PM_{10} and $PM_{2.5}$ from light-duty trucks decreased throughout the time series. The fleet average PM_{10} emission factor 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 emission factor for diesel-powered light-duty trucks has decreased by 9–12% annually in recent years due to the market penetration of diesel-powered light-duty trucks with a DPF. Combined with the stabilisation in the number of vehicle kilometres driven since 2005, PM_{10} exhaust emissions decreased by 72% between 2005 and 2017.

Heavy-duty vehicles and buses (1A3biii)

The number of vehicle kilometres driven by heavy-duty vehicles (rigid trucks, tractor-trailer combinations and buses) in the Netherlands increased by approximately 30% between 1990 and 2008 (see Figure 4.2). After a decrease during the economic crisis, transport volumes increased again to pre-crisis levels. Diesel dominates the heavy-duty vehicle fleet, with a share of 99%.

NO_x emissions from heavy-duty vehicles decreased from 113 Gg in 1990 to 32 Gg in 2017 (see Figure 4.2). Emissions have decreased significantly in recent years due to the decrease in vehicle mileages between 2008 and 2014 (Figure 4.1) and a decrease in the fleet averaged NO_x emission factor (Figure 4.2). The latter decreased significantly throughout the time series, mainly due to the 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 emission factor for heavy-duty vehicles has decreased significantly since 2008. The current generation of Euro-VI trucks that have entered the market since 2013 are fitted with a combination of Exhaust Gas Recirculation (EGR) and a Selective Catalytic Reduction (SCR), resulting in very low real-world NO_x emission levels (Kadijk *et al.*, 2015b).

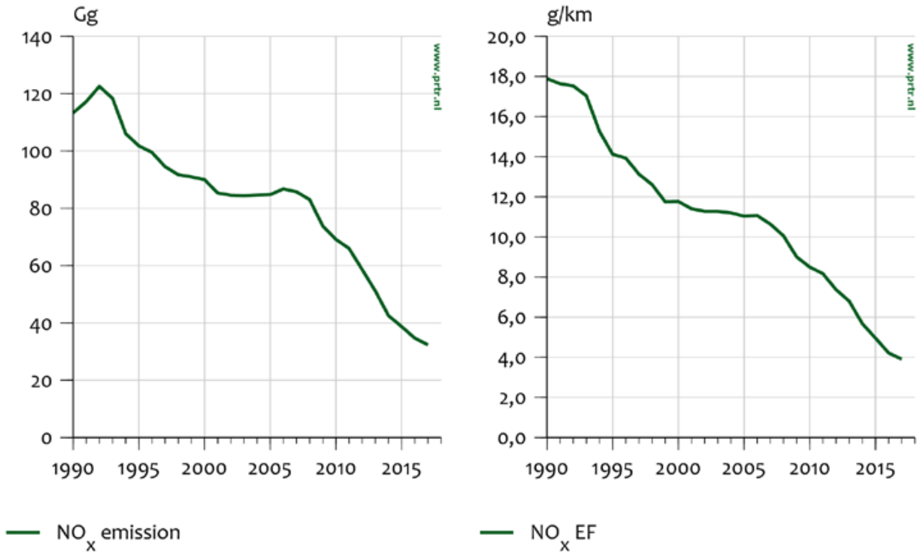

Figure 4.2 NO_x emissions and NO_x implied emission factors of heavy-duty vehicles in the Netherlands

NMVOC exhaust emissions decreased by 94% throughout the time series and PM_{10} and $PM_{2.5}$ exhaust emissions decreased by 94%. These decreases were also caused by changes to EU emission legislation. Heavy-duty vehicles were only a minor source of NMVOC emissions in the most recent year. Their share in $PM_{2.5}$ and PM_{10} emissions was slightly higher at 2-3% of national totals.

Heavy-duty trucks and buses are a minor source of NH_3 emissions in the Netherlands (0.1% of national totals). Yet NH_3 emissions from heavy-duty vehicles increased significantly between 2005 and 2017. This increase was caused by the increasing use of SCR catalysts on heavy-duty trucks and buses. High SCR conversion rates may yield NH_3 slip, as described in detail in Stelwagen *et al*. (2015). NH_3 emission factors for Euro-V trucks and buses are approximately five times higher than emission factors for previous Euro classes, as shown in table 3.17 of Klein *et al.* (2019b). Emission factors for Euro-VI trucks and buses are estimated to be 30 times higher than previous Euro classes. As a result, NH_3 emissions from heavy-duty trucks and buses have increased tremendously due to the market introduction of Euro-VI vehicles. In 2017, emissions amounted to 377 Mg, which corresponded to an increase of 200% compared with 2013.

Motorcycles and mopeds (1A3biv)
Motorcycles and mopeds are a small emission source in the Netherlands, being responsible for less than 1% of national totals for most substances. They were a key source, however, for NMVOC and CO in both the 1990 and 2017 level assessment and in the trend assessment (CO only). Motorcycles and mopeds were responsible for 4% of NMVOC emissions and 9% of CO emissions in the Netherlands in 2017. Even though the number of vehicle kilometres driven almost doubled between 1990 and 2017, exhaust emissions of NMVOC decreased significantly due to increasingly stringent EU emissions standards for two-wheelers. The share of motorcycles and mopeds in NO_x emissions in the

Netherlands was still small (<1%) in 2017. The share in $PM_{2.5}$ emissions was approximately 1% in 2017.

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 gasoline 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 2017 (down from 7% in 1990). Petrol-powered passenger cars were by far the major source of evaporative NMVOC emissions from road transport in the Netherlands, although their share decreased from more than 90% in 1990 to below 60% in 2017 (motorcycles and mopeds were mainly responsible for the rest of evaporative NMVOC emissions, other road vehicles contributed below1%).

PM emissions from tyre and brake wear and road abrasion (1A3bvi and 1A3bvii)
Vehicle tyre and brake wear (1A3bvi) and road abrasion (1A3bvii) were key sources of PM_{10} emissions in the Netherlands in 2017, being responsible for 5% and 4% of PM_{10} emissions, respectively. PM_{10} emissions from brake wear, tyre wear and road abrasion increased throughout most of the time series, as shown in Figure 4.3, due to the increase in vehicle kilometres driven by light- and heavy-duty vehicles. PM_{10} emission factors 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 share of tyre and brake wear (2%) and road abrasion (1%) in total $PM_{2.5}$ emissions in the Netherlands was smaller than it was for PM_{10}.

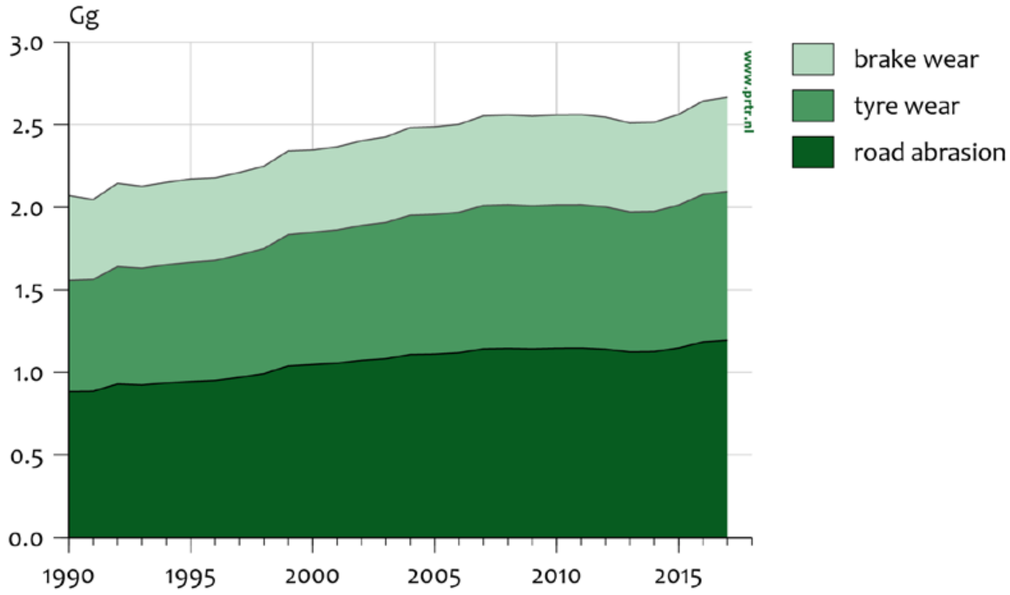

Figure 4.3 Emissions of PM_{10} resulting from brake and tyre wear and road abrasion

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 emission factors expressed in grams per vehicle kilometre ($g\ km^{-1}$). Emissions of SO_x and heavy metals were calculated using fuel consumption estimates combined with the sulphur and heavy metal content of different 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 for road transport.

Activity data on vehicle kilometres driven

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

1. the size and composition of the Dutch vehicle fleet;
2. the average annual mileage for different vehicle types, and;
3. the number of kilometres driven by foreign vehicles in the Netherlands.

Data on the size and composition of the Dutch vehicle fleet (1) were derived from RDW (Driver and Vehicle Licensing Agency), which has information on all vehicles registered in the Netherlands, including vehicle weight, fuel type and year of manufacture. The annual mileage for each type of road vehicle (2) was calculated from odometer readings derived from RDW. This database contains odometer readings from road vehicles (excluding mopeds) that have been to a garage for maintenance or repairs. Every year, Statistics Netherlands uses these data, combined with RDW data on vehicle characteristics, to derive average annual mileages for different vehicle types (age classes and fuel types). This methodology was applied to derive average annual mileage for passenger cars, light-duty and heavy-duty trucks and buses. The resulting mileages were corrected for the number of kilometres driven abroad, using various statistics, as described in Klein *et al*. (2019a). The average annual mileage for motorcycles and mopeds was derived by Statistics Netherlands using a survey conducted among owners, as described in detail in Jimmink *et al*. (2014).

The vehicle kilometres driven in the Netherlands by foreign passenger cars (3) were estimated by Statistics Netherlands using different tourism-related data, as described in Klein *et al*. (2019a). Vehicle kilometres driven by foreign trucks were derived from statistics on road transport in the Netherlands and in other EU countries collected by Eurostat. The vehicle kilometres driven by foreign buses in the Netherlands were estimated using different (inter)national statistics on buses and tourism, such as the Dutch Accommodations Survey, the UK Travel Trends and the Belgian Travel Research (Reisonderzoek), as described in Molnár-in ‘t Veld & Dohmen-Kampert (2010).

For the emission calculations, a distinction was made between three road types: urban, rural and motorway. The road type distributions for different vehicle types were derived from Goudappel Coffeng (2010). In this study, a national transport model was used to estimate the distribution of vehicle kilometres driven on urban roads, rural roads and motorways by passenger cars and light- and heavy-duty trucks. Additionally, data from on the-road observations, alongside different road types throughout the Netherlands, were used to differentiate these distributions according to fuel type and vehicle age. In general, it was concluded that the proportion of petrol-powered passenger cars on urban roads is higher than it is on motorways. Also, vehicles driving on motorways are younger on average than those on urban roads. These differences can mainly be related to differences in average annual mileage: a higher mileage generally results in a higher proportion of motorway driving in the total mileage of all vehicles. The road type distribution for different vehicle categories is reported in detail in table 3.12 of Klein *et al.* (2019b).

Total fuel consumption per vehicle and fuel type, used for calculating SO_x emissions and emissions of heavy metals, was calculated by combining the data on vehicle kilometres driven per vehicle type with average fuel consumption figures (litre per vehicle kilometre driven). Fuel consumption (litre/kilometre) figures were derived by TNO using insights from emission measurements and fuel-card data (Ligterink *et al.*, 2016).

Emission factors
The CO, NMVOC, NO_x and PM exhaust emission factors for road transport were calculated using the VERSIT+ model (Ligterink & De Lange, 2009). With the use of VERSIT+, emission factors can be calculated for different transport situations and scale levels. The emission factors follow from various analyses fed by different 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 emission factors, the driving behaviour dependence and the statistical variation per vehicle are investigated. Next, the results are used in a model with currently more than 50 light-duty vehicle categories for each of the emission components. The resulting model separates driving behaviour and vehicle category dependencies.

VERSIT+ HD (Spreen *et al.*, 2016) was used to predict the emission factors of heavy-duty vehicles (i.e. lorries, road tractors and buses). For older vehicles, VERSIT+ HD uses input based on European measurement data. These data have been obtained from less reliable tests, meaning that, in some cases, only the engine has been tested and, in other cases, measurements have been executed with several constant engine loads and engine speeds (rpm). For newer vehicles (Euro-III – Euro-VI), measurement data are available which more closely resemble the real-world use of the vehicles. These new data are based on driving behaviour, taken from both on-road measurements and measurements on test stands, and these data have been used in a model to represent emissions during standard driving behaviour. The emission factors for buses often originate from test stand measurements with realistic driving behaviour for regular service buses.
To determine the emission factors for heavy-duty vehicles, the PHEM model developed by the Graz University of Technology was used, also

using measurement data from TNO. For pre-Euro-III, the emission factors are still based on this model. Euro-III and later emission factors are based on in-house, on-road measurements (Ligterink *et al*., 2012). As with VERSIT+ LD, the input is composed of speed/time diagrams, which make the model suitable for the prediction of emissions in varying transport situations. In VERSIT+ HD, the most important vehicle and usage characteristics for emissions are determined. For Euro-V, the actual payload of a truck is important for NO_x emissions because the operation of the SCR relies on sufficiently high engine loads, resulting in high temperatures which are needed for the SCR. The average payloads of trucks in the Netherlands were derived from on-road measurements taken on motorways (Kuiper & Ligterink, 2013). The usage of trailers was also collected from these data. PM emissions also have a strong correlation with payload and the resulting engine load, which is taken into account in the emission factors (Stelwagen & Ligterink, 2015).

Over the years, many measurement data have become available for most vehicle categories, which means that the reliability of VERSIT+ in determining emission factors is fairly high. However, individual vehicles can have large deviations from the average. TNO has even ascertained large variations in measured emissions between two sequential measurements of the same vehicle. This is not the result of measurement errors, but is rather due to the great sensitivity of the engine management system, especially in petrol and LPG vehicles, to variations in how the test cycle is conducted on the dynamometer. Diesel emission control systems also show great sensitivity to variations in test circumstances. It is important that the emissions in the model correspond to the on-road test results. VERSIT+ is used to predict emissions in specific transport situations; the commercial software EnViVer links the emission model to traffic simulations, but it can also be used to predict emission factors at a higher level of aggregation.

VERSIT+ takes into account additional emissions during the cold start of vehicles. The additional emissions are expressed in grams per cold start. Data on the number of cold starts are derived from the Dutch Mobility Survey (OViN; see also Klein *et al.* 2019a). The effects of vehicle aging on emission levels are also incorporated in VERSIT+, using data from the in-use compliance programme that TNO runs for the Dutch Ministry of Infrastructure and the Environment. Details regarding the emission factors per vehicle type and road type is provided in Klein *et al*. (2019a). The methodology used for the in-service testing programmes by TNO and the subsequent analysis of measurement data and the calculation of representative emissions factors for over 300 different vehicle types are described in detail in Spreen *et al*. (2016).

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 with fuel- and year-specific emission factors (grams per litre of fuel). The emission factors for SO_x and heavy metals were based on the sulphur, carbon and heavy metal content of the fuels, as described in Klein *et al*. (2019a). It is assumed that 75% of the lead is emitted as particles and 95% of the sulphur is transformed to sulphur dioxide. NMVOC evaporative emissions are estimated using the methodology from the EEA Emission Inventory Guidebook (EEA, 2007). The NH_3 emission factors were derived from (Stelwagen *et al*., 2015).

PM emission factors
PM_{10} emission factors and $PM_{2.5}/PM_{10}$ ratios for brake and tyre wear and for road abrasion were derived from literature (ten Broeke *et al*., 2008; Denier van der Gon *et al*., 2008; RWS, 2008). An overview of these emission factors is provided in Klein *et al*. (2019b: tables 3.20 and 3.35). For tyre wear, the emission factors are calculated as the total mass loss of tyres resulting from the wear process and the number of tyres per vehicle category. $PM_{2.5}$ emission factors are derived from $PM_{10,}$ using ratios of 15% (brake wear and road abrasion) and 20% (tyre wear), respectively. It should be noted that PM_{10} emission factors for tyre and brake wear and for road abrasion, and specifically the $PM_{2.5}/PM_{10}$ ratios, are highly uncertain due to a lack of data.

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 3.21 of Klein *et al.* (2019b). Resulting emissions are included in the emission factors for transport and are not estimated separately, with the exception of heavy metals. These are considered to be extra emissions and are therefore calculated separately by multiplying the consumption of lubricant oil and the lubricant oil profile (see table 3.26B of Klein *et al*., 2018b).

Deriving fuel-sold emissions for 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 fuel sold as reported by Statistics Netherlands. shows both the bottom-up estimates for fuel used by road transport and reported fuel sold to road transport per fuel type for the 1990–2016 time series.

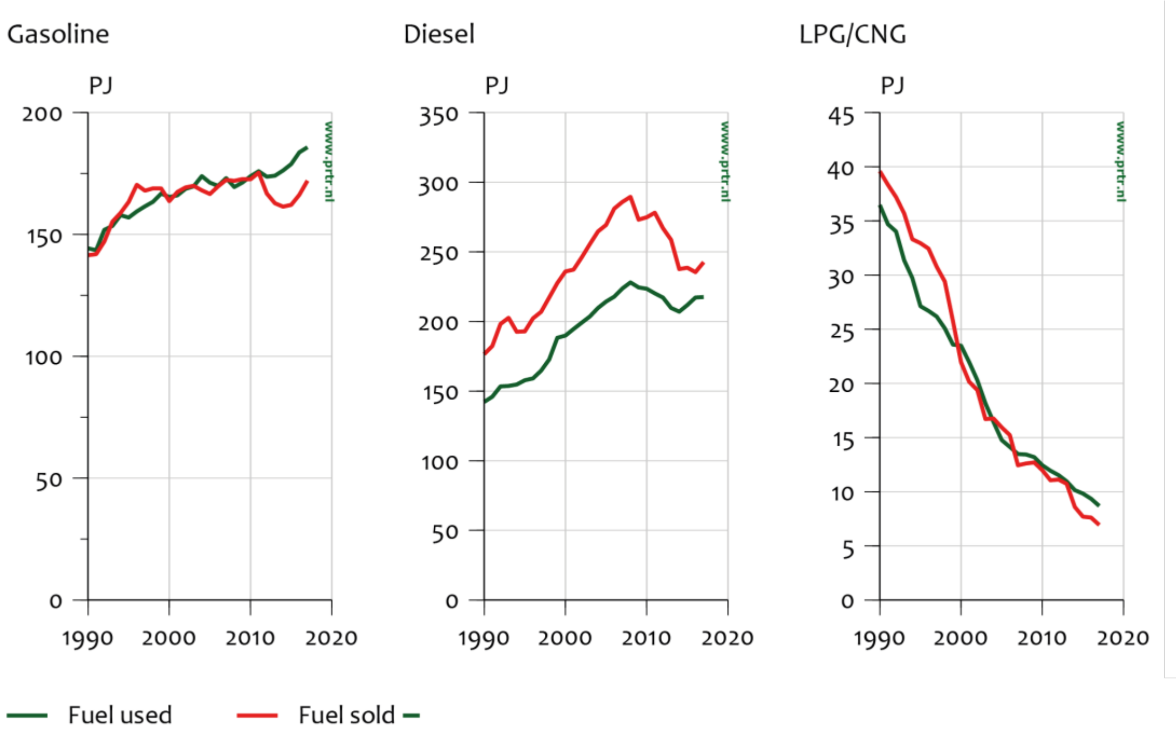

Figure 4.4 Fuel used vs. fuel sold trends, for gasoline- (petrol), diesel- and LPG-fuelled road transport in the Netherlands

For petrol, the time series show close agreement, except for the 2011–2014 period, when fuel sold decreased by 9%, whereas fuel used remained constant. This discrepancy can probably be attributed to an increase in cross-border refuelling resulting from an increasing difference in fuel prices in the Netherlands compared with Belgium and Germany, as is shown in Geilenkirchen *et al.* (2017).

The time series for diesel-powered vehicles show similar trends, but there is a bigger difference in absolute levels, with the fuel sold being substantially higher than fuel used throughout the time series. The difference between fuel used and fuel sold varies between 20 and 30 per cent throughout the 1990–2013 period. Part of this difference might be attributed to the use of diesel in international freight transport, modern trucks being able to drive >1,000 kilometres on a single tank of diesel. Freight transport volumes in (and through) the Netherlands are substantial due to, among other things, the Port of Rotterdam being the largest port in the EU. The Netherlands being a rather small country, it might very well be that a substantial part of the diesel fuel that is sold in the Netherlands for freight transport is used abroad. This could at least partially explain why substantially more diesel fuel is sold than is used by road transport in the Netherlands. But the extent to which this explains the differences between diesel fuel sold and diesel fuel used is unknown. Other possible explanations are that the diesel fuel is used for purposes other than road transport, such as mobile machinery. This seems unlikely, though, because up until 2013 excise duties were higher for diesel used in road transport than for diesel used for other purposes such as mobile machinery and rail transport.

The difference between diesel fuel used and fuel sold decreased substantially between 2013 (23%) and 2016 (8%). This can also, for the most part, be attributed to differences in diesel fuel prices between the Netherlands and surrounding countries, as described in Geilenkirchen *et al.* (2017).

The time series for LPG show similar trends, with both fuel used and fuel sold decreasing rapidly. For recent years of the time series, the level of energy use also shows close agreement, but for earlier years, the differences are larger due to cross-border refuelling.

Because fuel-sold emissions are estimated using a generic correction on the fuel-used emissions per fuel type, the difference between fuel-used and fuel-sold emissions depends solely on the share of the different fuel types in emission totals per substance. Diesel vehicles, for example, are a major source of NO_x and PM emissions; therefore, fuel-used emissions of NO_x and PM for road transport are adjusted upwards, especially in the earlier years of the time series, as can be seen in Figure 4.5. NMVOC emissions in 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 shown in Figure 4.5. 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.

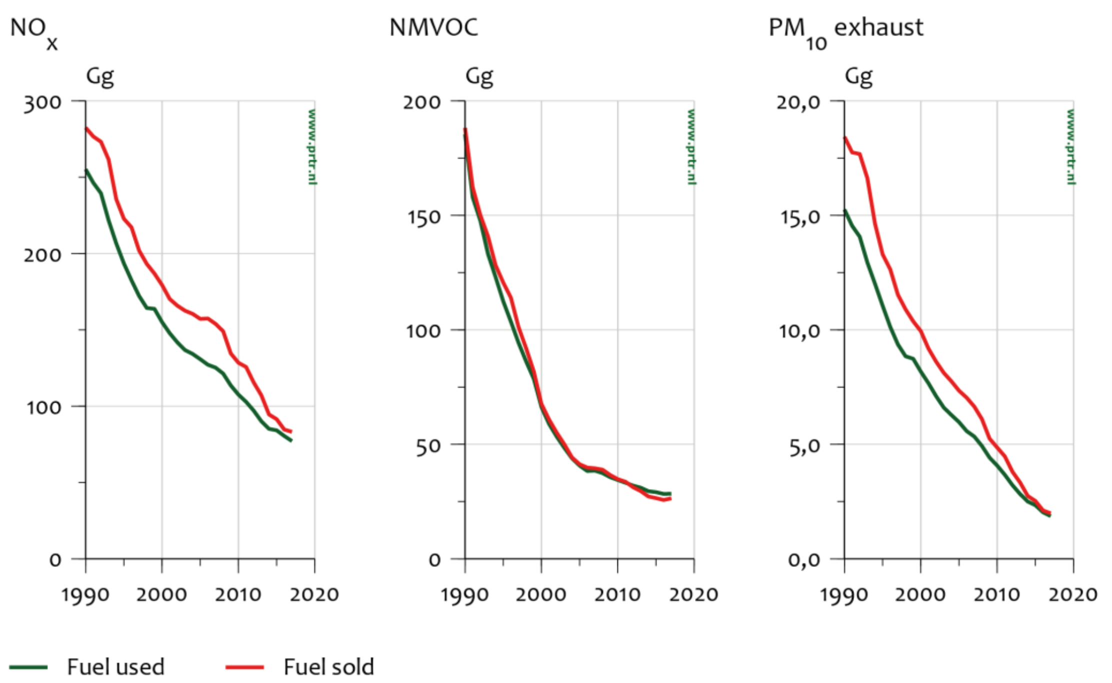

Figure 4.5 NO_x, NMVOC and PM_{10} exhaust emissions from road transport in the Netherlands based on fuel used and fuel sold

Biofuels

Emissions resulting from the use of biofuels in road transport were not reported separately in the NFR. Emission measurements are based on representative fuel samples, including a share of biofuels, and resulting emission factors are therefore representative of the market fuels used in the Netherlands. Activity data for biofuels are included under liquid fuels. Activity data are not yet reported separately in the NFR tables, but in next year's inventory, this will be implemented.

4.3.5 *Methodological issues*

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

- The PM_{10} and $PM_{2.5}$ emission factors for brake and tyre wear and for road abrasion are rather uncertain due to a lack of measurements.
- NH_3 emission factors for SCR-equipped Euro-6 diesel passenger cars and light-duty trucks are uncertain and need verification based on new measurements.
- The road type distribution of all vehicle categories was last updated in 2010 and needs to be verified.
- Average annual mileage for mopeds and motorcycles was last estimated in 2013 and needs to be updated.
- The methodology for estimating fuel-sold emissions could be improved by taking into account different vehicle types where differences between fuel used and fuel sold occur.

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 jack-knife approach, the variation in the different 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. In 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 been improved in recent years, but the number of vehicles tested has decreased over time. This method to determine uncertainties has proven to be very time-consuming. For this reason, a decision was taken to use an expert-based approach to estimate uncertainties for NFR categories.

In 2016, an experts' workshop was organised to discuss and estimate the uncertainties in the activity data and emission factors used for the emission calculations for the transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for road transport are provided in Table 4.7.

Table 4.7 Uncertainty estimates for road transport (%)

NFR	Fuel	Uncertainty activity data	Uncertainty emission factor						
			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 with trends in traffic intensities on the Dutch motorway network, as reported by Rijkswaterstaat. In general, both time series show good agreement, with some annual fluctuations. Trends in fuel sales data compare with trends in fuel used, as described in Section 4.3.4. Emission factors for road transport are, for the most, part derived from national measurement programmes. Resulting emission factors are discussed by TNO with international research institutions, e.g. in 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 Klein et al. (2019)):

- Passenger cars: In a recent test programme on the emission performance of older petrol cars, it was found that 1 in 6 had problems that caused a large increase in NO_x emissions. The effect is significant in the total emissions of petrol vehicles, and it was taken into account in the overall emission factors. It is expected that from an age of 10–15 years petrol vehicles (Euro-3 to Euro-5) emit 300 mg/km more NO_x. This results in an increase in the trend of NO_x emissions of 1.4% in 2010 to +17.8% in 2016 compared with the IIR2018.

- Passenger cars: In another measurement programme, the frequency and consequences of tampering with vehicles equipped with diesel particulate filters was assessed. It was found that these lead to an increase in $PM_{2.5}$/PM_{10} emissions of 8–11% for 2014–2016 compared with the IIR2018.
- There was an error correction in NH_3 emissions for passenger cars, as a result of which the IEF has been adjusted downwards by 5–13% as of 2010 compared with last year's inventory.
- Light-duty vehicles: An error was found and corrected for the IEF in 2016 for $PM_{2.5}$/PM_{10}/TSP/BC and NMVOC emissions. As a result, the emission factors for 2016 have been adjusted downwards by 18–23% in this year's inventory.
- Heavy-duty vehicles: A measurement programme for Euro-VI trucks showed that NO_x emissions are higher than was estimated earlier, based on first Euro-VI models in the fleet. Emission factors have been adjusted upwards accordingly, leading to a 4% increase in NO_x emissions in 2016 compared with last year's inventory.
- NH_3 emission factors for SCR-equipped Euro-VI trucks and buses have been adjusted upwards based on new measurements from 3 g/km to 86 g/km for HDV. This has resulted in an increase of NH_3 emissions in 2016 of >250%.
- Emission factors for motorcycles/mopeds have been adjusted on the basis of an on-road measurement programme.

In 2017, TNO carried out a measurement programme for 15 different mopeds. The selection consists mainly of Euro 2 and a few Euro 3 mopeds, mopeds with a carburettor and mopeds with electronic fuel injection, with 2-stroke and 4-stroke engines. An important goal of the measurement programme was to gain insight into the emission performance of a large number of mopeds representative of the Dutch moped market. Another comprehensive test programme was carried out in the evaluation of EU Directive 168/2013 and 134/2014. Almost 50 vehicles from the L category were tested. At the time of this investigation, there were only a limited number of Euro 4 models on the market. To map the emissions of (used) Euro 4 vehicles, various Euro 4 mopeds and motorcycles were measured within the European Research for Mobile Emission Sources (ERMES) group.

4.3.9 *Source-specific planned improvements*

The integration of new insights on the road type distribution of passenger cars, light-duty trucks and heavy-duty trucks and buses, which was planned for this year's inventory, is planned for next year due to budget constraints. The new insights are based on (Ligterink, 2017b). Studies are also planned with a view to improving the fuel-sold emission calculation.

4.4 Railways

4.4.1 Source-category description

The source category Railways (1A3c) includes emissions from diesel-powered rail transport in the Netherlands. This includes 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 mostly 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.

4.4.2 Key sources

Railways are not a key source in the 2019 inventory.

4.4.3 Overview of emission shares and trends

Railways are a small source of emissions in the Netherlands, accounting for less than 1% of national totals for all substances except lead and copper in both 1990 and 2017. 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 2012, fuel consumption fluctuated around 1.4 PJ and since 2012 around 1.2 PJ. 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 sector is estimated to be approximately 30–35%. The remainder is used for freight transport.

The trends in emissions from railways are shown in Table 4.8. NO_x and PM_{10} emissions from railways follow trends in activity data because emission factors are similar for all years of the time series. Pb emissions increased between 1990 and 2017. Pb emissions from railways result from the wear on carbon brushes. Wear emissions were estimated on the basis of the total electricity use by railways (in kWh). Trends in Pb emissions therefore follow the trends in electricity use for railways. Railways are also an important source of copper emissions, amounting to 6 Mg (around 15% of the total copper emissions in the Netherlands). Emissions of other heavy metals are very low. SO_x emissions from railways decreased by 99% 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 (required from 2011 onwards but already applied in 2009 and 2010).

Table 4.8 Trends in emissions from 1A3c Railways

Year	Main pollutants				Particulate matter				Other	Priority heavy metals
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb
	Gg	Gg	Gg	Mg	Gg	Gg	Gg	Gg	Gg	Mg
1990	**2.23**	**0.07**	**0.10**	**0.29**	**0.05**	**0.06**	**0.06**	**0.02**	**0.26**	**0.22**
1995	2.31	0.08	0.10	0.30	0.06	0.06	0.06	0.02	0.27	0.26
2000	2.81	0.09	0.12	0.36	0.07	0.07	0.07	0.03	0.32	0.28
2005	2.60	0.08	0.11	0.33	0.06	0.06	0.06	0.02	0.29	0.27
2010	2.61	0.08	0.02	0.33	0.06	0.06	0.06	0.02	0.29	0.29
2015	2.25	0.07	0.00	0.29	0.05	0.06	0.06	0.02	0.27	0.25
2016	2.24	0.07	0.00	0.29	0.05	0.06	0.06	0.02	0.27	0.26
2017	**2.10**	**0.07**	**0.00**	**0.27**	**0.05**	**0.05**	**0.05**	**0.02**	**0.25**	**0.24**
1990–2017 period[1]	-0.13	0.00	-0.10	-0.02	0.00	0.00	0.00	0.00	-0.01	0.03
1990–2017 period[2]	-6%	-5%	-99%	-6%	-2%	-2%	-2%	-5%	-5%	13%

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

4.4.4 *Activity data and (implied) emission factors*

To calculate emissions from railways in the Netherlands, a Tier 2 method was applied using fuel sales data and country-specific emission factors. Statistics Netherlands reports data on fuel sales to the Dutch railways sector in the Energy Balance. Since 2010, these fuel sales data have been derived from Vivens, a cooperation of rail transport companies that purchases diesel fuel for the railways sector in the Netherlands. Before 2010, diesel fuel sales to the railways sector were obtained from Dutch Railways (NS), which used to be responsible for the purchases of diesel fuel for the entire railway sector in the Netherlands.

Emission factors for CO, NMVOC and PM_{10} for railways were derived by the PBL Netherlands Environmental Assessment Agency in consultation with the NS. NO_x emission factors were determined in a measurement programme in 2017 (Ligterink et al., 2017c). Emission factors of NH_3 were derived from Ntziachristos & Samaras (2000). The emission factors for railways (except for NO_x) have not been updated recently and therefore are rather uncertain.

PM_{10} emissions due to wear on overhead contact lines and carbon brushes from railways are calculated using a study conducted by NS-CTO (1992) on the wear on overhead contact lines and the carbon brushes of the collectors on electric trains. For trams and metros, the wear on the overhead contact lines has been assumed to be identical to that on railways. The wear on current-collectors has not been included, because no information was available on this topic. Carbon brushes, besides copper, contain 10% lead and 65% carbon. Based on the NS-CTO study, the percentage of particulate matter in the total quantity of wear debris was estimated to be 20%. Because of their low weight, these particles probably remain airborne. It is estimated that approximately 65% of the wear debris ends up in the immediate vicinity of the railway, while 5% enters the ditches alongside 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 Klein *et al.* (2019a).

4.4.5 *Methodological issues*

Emission factors for railways have not been updated recently (except NOx) and are therefore 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 organised to discuss and estimate the uncertainties in the activity data and emission factors used for the emission calculations for the transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for railways are provided in Table 4.9.

Table 4.9 Uncertainty estimates for railways (%)

NFR	Type	Fuel	Uncertainty activity data	Uncertainty emission factor						
				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	-
	Panto-graph wear[2]	Electri city	-	-	-	-		200	200	-

Source: Dellaert & Dröge (2017).

4.4.7 *Source-specific QA/QC and verification*

Trends in fuel sales data have been compared with trends in traffic volumes. Between 2010 and 2014, the total vehicle kilometres decreased by 12%, while the Mg.kms increased by 4% according to data from Statistics Netherlands. Diesel consumption decreased by 6% in the same period.

The trends in both time series show fairly close agreement, although agreement has been less close in recent years. This can be explained by the electrification of rail freight transport. In recent years, more electric locomotives have been used for rail freight transport in the Netherlands. Figures compiled by Rail Cargo (Rail Cargo, 2007, 2013) show that in 2007 only 10% of all locomotives used in the Netherlands were electric, whereas by 2012 the proportion of electric locomotives had increased to

[2] Overhead line for power supply to electric rail transport

over 40%. For this reason, there has been a decoupling of transport volumes and diesel deliveries in recent years in the time series. Consequently, the decline in diesel consumption for railways, as derived from the Energy Balance, is deemed plausible.

4.4.8 *Source-specific recalculations*

There are a few recalculations in this year's inventory for rail transport emissions:

- Activity data for railways has been adjusted downwards for 2015–2016 by 10% (0.2 PJ) due to an error correction. The emissions decreased accordingly.
- The NO_x emissions factors have been updated on the basis of measurements of NO_x emissions resulting from the normal use of diesel engines (Ligterink *et al.*, 2017). Both a modern and an older diesel train showed high NO_x emissions, indicating limited improvement over the years. As the increase for NOx emission factors result from long idling periods and low-load operation, which are common in the park, it is expected the emission factors are common for all diesel-propelled trains.

4.4.9 *Source-specific planned improvements*

There are no source-specific planned improvements for railways. Emission factors remain uncertain, but since railways are a small emission source and not a key source for any substance, updating the emission factors 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 (1A3dii) and International (1A3di(ii)) inland navigation in the Netherlands and from International maritime navigation (1A3di(i)). 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. Emissions from recreational craft are reported under Other: Mobile (1A5b), but are described in this section as well. It should be noted that 1A5b also includes emissions from ground service equipment at airports (see Section 4.6).

Condensables are included in PM_{10} and $PM_{2.5}$ emissions.

4.5.2 *Key sources*

Both the source categories 1A3di(ii) International inland waterways and 1A3dii National navigation (shipping) are key sources of NO_x, $PM_{2.5}$ and BC emissions. International inland waterways is a key source of PM_{10} emissions. The source category 1A5b Other: Mobile is a key source of CO.

4.5.3 *Overview of emission shares and trends*

In total, (inter)national inland navigation was responsible for 10% of NO_x emissions and 6% of $PM_{2.5}$ emissions in the Netherlands in 2017. With emissions from road transport decreasing rapidly, the share of inland navigation in national totals increased throughout the time series. The share of inland navigation as a percentage of national emissions of PM_{10}, NMVOC, CO and SO_x was small in 2017.

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 100 Gg in 2017 and were higher than the combined NO_x emissions from all road transport in the Netherlands. PM_{10} emissions amounted to 2.7 Gg in 2017. In contrast, recreational craft were only a small emission source, with 2.6 Gg of NO_x, 1.4 Gg of NMVOC and 0.06 Gg of PM_{10} emitted in 2017.

The trends in emissions from inland navigation in the Netherlands are shown in Table 4.10. Since 2000, fuel consumption in inland navigation has fluctuated between 20 and 28 PJ. The economic 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. Emissions of NO_x, CO, NMVOC and PM from inland navigation follow, for the most part, the trends in the activity data. The introduction of emission standards for new ship engines (CCR stages I and II) has led to a small decrease in the fleet average NO_x emission factor (per kilogram of fuel) in recent years, but since fuel consumption has increased significantly, total NO_x emissions still increased between 2009 and 2017.

Table 4.10 Trends in emissions from Inland navigation in the Netherlands (combined emissions of 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**	**1.83**	**0.01**	**1.25**	**1.31**	**1.31**	**0.56**	**8.00**
1995	25.2	1.79	1.85	0.01	1.25	1.32	1.32	0.57	7.30
2000	27.8	1.75	2.05	0.01	1.24	1.31	1.31	0.56	7.22
2005	25.9	1.45	1.91	0.01	1.07	1.13	1.13	0.48	6.03
2010	22.3	1.43	0.50	0.01	0.86	0.91	0.91	0.44	5.77
2015	25.5	1.44	0.01	0.01	0.85	0.91	0.91	0.47	6.05
2016	25.1	1.39	0.01	0.01	0.83	0.88	0.88	0.45	5.87
2017	**25.5**	**1.38**	**0.01**	**0.01**	**0.83**	**0.88**	**0.88**	**0.45**	**5.90**
1990–2017 period[1]	-3.25	-0.62	-1.82	0.00	-0.42	-0.43	-0.43	-0.11	-2.10
1990–2017 period[2]	-11%	-31%	-99%	12%	-34%	-33%	-33%	-19%	-26%

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

SO_x emissions from inland navigation decreased by 99% between 2009 and 2017 due to the decrease in the maximum allowable sulphur content of diesel fuel for non-road applications. Since the start of 2011, EU regulation requires all diesel fuel for inland navigation to be sulphur-free. Since sulphur-free diesel fuel was introduced in 2009 to inland navigation in the Netherlands, SO_x emissions decreased significantly from 2009 onwards. 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 also decreased between 2009 and 2017.

Energy use and resulting emissions from maritime navigation showed an upward trend between 1990 and 2008. Since the start of the economic 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 2017, total fuel consumption by maritime navigation on Dutch territory decreased by 2% compared with 2016.

Recreational shipping is reported under source category 1A5b Other: Mobile. This source category is a key source of CO emissions, amounting to 3.7% of total national CO emissions. The share of emissions of all other pollutants from recreational shipping in total emissions in the Netherlands in 2017 was less than 1%.

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 method. 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, the 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. The speed per vessel class per geographical water segment was taken from 1 month of AIS data (July 2015) provided by Pouwels *et al.* (2017). The average cargo situation (partial load) per vessel class for one specific year (2016) was provided by Statistics Netherlands.

The resulting fleet average emission factors throughout the time series are reported in Klein *et al*. (2019a). 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. The auxiliary engines are used for manoeuvring the vessel (bow propeller engines) and generating electricity for the operation of the vessel and the residential compartments (generators). Fuel consumption by auxiliary engines is estimated as 13% of the fuel consumption of the main 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 were applied for all subsequent years of the time series.

Emissions by recreational craft were calculated by multiplying the number of recreational craft (open/cabin motor boats and open/cabin sailing boats) by the average fuel consumption per boat type times the emission factor per substance, expressed in emissions per engine type per quantity of fuel (Hulskotte *et al.*, 2005). The emission factors depend on the engine types per vessel. The implied emission factors are reported in Klein *et al.* (2019a, b).

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 IMO number of each individual ship is linked to a ship characteristics database acquired from Lloyd's List Intelligence (LLI). Emission factors for each ship were 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 (2018).

A detailed description of the methodology for inland navigation (chapter 5), recreational craft (chapter 5) and maritime shipping (chapter 7) can be found in Klein *et al.* (2019a).

4.5.5 *Methodological issues*

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

- Data on fuel consumption and emission factors for passenger ships and ferries have not been updated for some time.
- Data on the number of recreational craft and their average usage rates are rather uncertain and need to be verified.
- Activity data for inland shipping could be improved, through using AIS data to derive shipping movements. The stability and completeness of AIS data have to be tested over at least one or two years instead of one month.
- The methodology for calculating required engine power vs. speed and other ship characteristics needs to be verified for inland navigation.
- 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 throughout the time series for inland waterborne navigation. For maritime navigation, AIS data have 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*., 2003).

In 2016, an experts' workshop was organised to discuss and estimate the uncertainties in the activity data and emission factors used for the emission calculations for the transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for waterborne navigation and recreational craft are provided in Table 4.11. The resulting uncertainty estimates for waterborne navigation and recreational craft are provided in Table 4.11.

Table 4.11 Uncertainty estimates for waterborne navigation and recreational craft (%)

NFR	Type	Fuel	Uncertainty activity data	Uncertainty emission factor						
				NO_x	SO_x	NH3	PM_{10}	$PM_{2.5}$	EC	NMVOC
1A3di(i)	Anchored NCP[3]	HFO	20	50	50	500	50	50	200	200
1A3di(i)	Anchored NCP	MDO	20	50	50	500	50	50	200	200
1A3di(i)	Sailing NCP	HFO	20	50	50	500	50	50	200	200
1A3di(i)	Sailing NCP	LNG	50	100	100	-	-	100	200	-
1A3di(i)	Sailing NCP	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	50	35	20	500	50	50	50	100
1A3dii	Inland, national	Diesel	50	35	20	500	50	50	50	100
1A3dii	Passenger and ferryboats	Diesel	100	50	20	500	100	100	100	200
1A5b	Recreational shipping, exhaust gases	Petrol	200	50	20	100	100	100	100	50
1A5b	Recreational shipping, exhaust gases	Diesel	200	-	-	-	-	-	-	100
1A5b	Recreational shipping, petrol evaporation		100	-	-		-	-	-	200
2D3i	Inland shipping, degassing cargo		100	-	-	-	-	-	-	100

Source: Dellaert & Dröge (2017).

[3] Netherlands continental shelf (NCP)

4.5.7 *Source-specific QA/QC and verification*

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

4.5.8 *Source-specific recalculations*

A significant improvement to the modelling of inland navigation was implemented this year. Activity data for inland shipping have been improved by using AIS data. The former methodology did not take into account the (differences in) sailing speeds. Also, movements of empty vessels were not included in previous statistics, resulting in an underestimation of emissions.

The most important model adjustments that have been made contain the following elements:

- The movements of inland waterway vessels are derived from AIS data (Pouwels *et al.*, 2017) instead of using (outdated) estimates by experts.
- Draft of loaded vessels has been adjusted so that it corresponds to the measured load factor (CBS, 2018).
- The traffic composition of the various types of vessel on the various waterways (i.e. the BIVAS network) is taken from the BIVAS model, loaded with data for 2016.
- The model parameters that are used to model the renewal of the engines have been modified, i.e. the lifetime of the engines in the model has been increased.
- As with the calculation of emissions from seagoing vessels, correction factors are used per substance on the emission factors of the engines, which reflect the effect of differences in engine load (depending on the type of vessel, fairway type, load and speed on the BIVAS network).

The recalculations result in a decrease in NO_x emissions compared with 2009 (by 6–10%) and an increase in $PM_{2.5}$ emissions (by 2–4%) (Figure 4.6). The adjustments for PM emissions are different because of the power-dependent correction factors that are new for each substance. The correction factor for low engine power is relatively higher for PM. NMVOC emissions are 13–16% higher for the period 2009–2016.

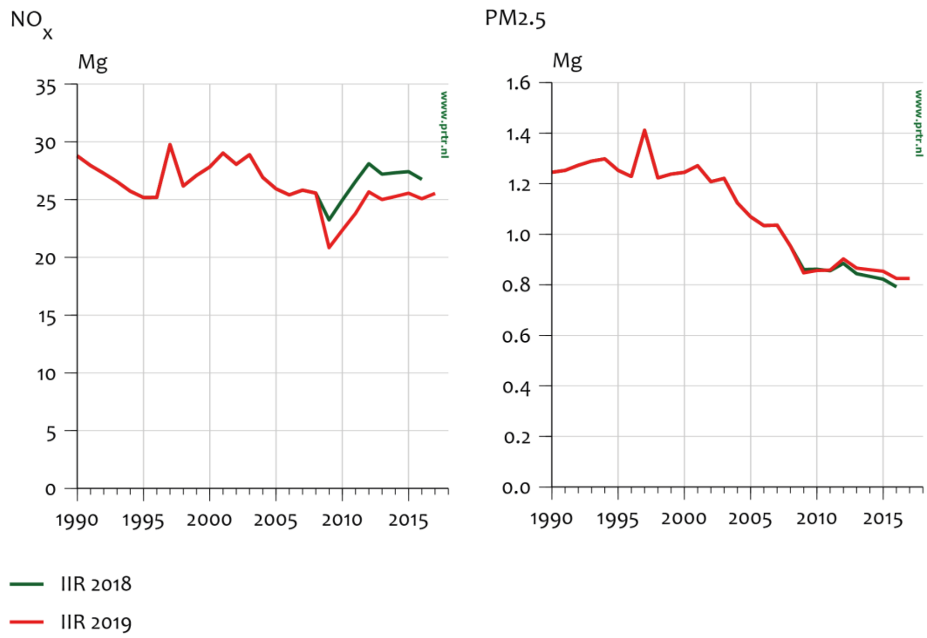

Figure 4.6 NO_x and $PM_{2.5}$ emissions from inland navigation (both domestic and international)

4.5.9 *Source-specific planned improvements*

There are no source-specific planned improvements for waterborne navigation.

4.6 Non-road mobile machinery (NRMM)

4.6.1 *Source category description*

Non-road mobile machinery (MRMM) covers a variety of equipment that is used in different economic sectors and by households in the Netherlands. Mobile machinery is typified 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 most important deployment of NRMM in the Netherlands is in agriculture and construction. The largest volumes of fuel are used in tillage, harvesting and earthmoving. Furthermore, NRMM is used in forest, park and garden maintenance, as in lawn mowers, aerator machines, forest mowers and leaf blowers.

Emissions from NRMM were reported under 1A2gvii Mobile combustion in manufacturing industries and construction, 1A4aii Commercial/ institutional: Mobile, 1A4bii Residential: Household and gardening (mobile), 1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery and 1A5b Other: Mobile. The last source category is used for emissions from ground support equipment at airports. 1A5b also includes emissions from recreational craft.

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, $PM_{2.5}$ and BC emissions in the 2017 level assessment. Source category 1A4bii Residential: Household and gardening (mobile) is a key source of emissions of CO in both the 2017 level and trend assessments, whereas source category 1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery is a key source of NO_x and $PM_{2.5}$ emissions in the 2017 level assessment. Source category 1A4ii Commercial is not a key source.

4.6.3 *Overview of shares and trends in emissions*

NRMM was responsible for 9% of CO emissions, 8% of NO_x and $PM_{2.5}$ emissions and 4% of PM_{10} emissions in the Netherlands in 2017. CO emissions mainly resulted from the use of petrol-driven equipment by households (lawn mowers) and of machinery for public green space maintenance. NO_x, PM_{10} and $PM_{2.5}$ emissions were, for the most part, due to diesel machinery used in agriculture (tractors) and construction.

Total energy use in NRMM has fluctuated between 38 PJ and 47 PJ throughout the time series. Energy use in 2017 remained the same as in 2016. Since the start of the economic crisis, energy use by construction machinery has decreased from 26 PJ in 2008 to 21.9 in 2017. Figure 4.7 shows total energy use within the different sectors in which mobile machinery is applied. Construction and agricultural machinery were responsible for more than 85% of total energy use by NRMM in 2017.

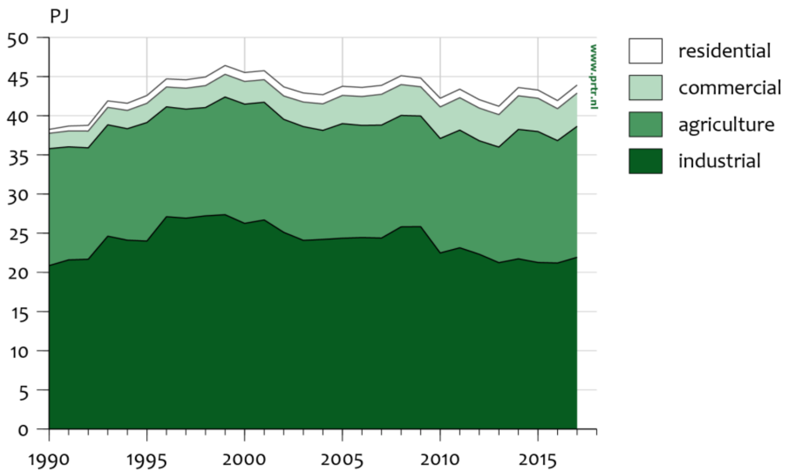

Figure 4.7 Fuel consumption in non-road mobile machinery in different sectors in the Netherlands

The trends in emissions from NRMM in the Netherlands are shown in Table 4.9. With the introduction of EU emission standards for NRMM in 1999 and the subsequent tightening of emission standards in later years, NO_x emissions from NRMM have steadily decreased, as shown in . Since 1990, NO_x emissions have decreased by 48%, whereas fuel consumption has increased by 13%.

Table 4.12 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	**37.1**	**8.05**	**3.01**	**0.01**	**3.59**	**3.78**	**3.78**	**1.83**	**36.9**
1995	41.0	8.36	3.05	0.01	3.13	3.30	3.30	1.59	54.5
2000	42.8	7.97	3.24	0.01	2.81	2.95	2.95	1.42	57.6
2005	34.8	6.15	3.12	0.01	2.34	2.46	2.46	1.18	54.2
2010	25.9	4.45	0.30	0.01	1.52	1.60	1.60	0.76	51.0
2015	21.7	3.24	0.02	0.01	1.15	1.21	1.21	0.57	48.5
2016	19.7	2.95	0.02	0.01	1.02	1.07	1.07	0.50	47.9
2017	**19.3**	**2.77**	**0.02**	**0.01**	**0.97**	**1.02**	**1.02**	**0.48**	**47.7**
1990–2017 period[1]	-17.8	-5.28	-2.99	0.00	-2.62	-2.76	-2.76	-1.35	10.7
1990–2017 period[2]	-48%	-66%	-99%	14%	-73%	-73%	-73%	-74%	29%

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

Emissions of most other substances have 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 siesel is required in NRMM since 2011), which have reduced the sulphur content of the diesel fuel used by NRMM. CO emissions have increased throughout the time series.

Emissions from ground service equipment (GSE) at airports are reported under source category 1A5b Other: Mobile. This source category is not a key source of any of the emissions. The share of emissions from GSE at airports as a percentage of the total emissions in the Netherlands in 2017 was less than 1% for all pollutants.

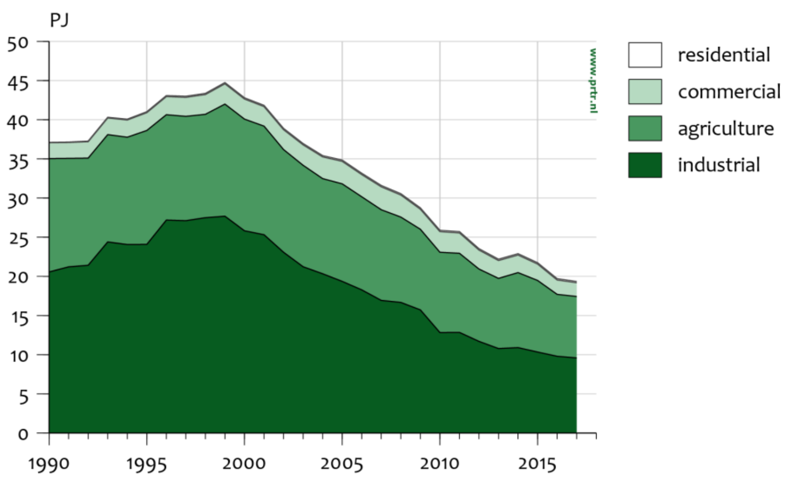

Figure 4.8 NO_x emissions by non-road mobile machinery in different sectors in the Netherlands

4.6.4 *Activity data and (implied) emission factors*

Fuel consumption by mobile machinery in the different 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). The so-called EMMA model uses sales data and survival rates for different types of machinery to estimate the NRMM fleet in any given year. Combined with assumptions made on the average usage rate (annual operating hours) and the fuel consumption per hour of operation of the different types of machinery, the total annual fuel consumption by NRMM is estimated. The methodology used in the EMMA model is similar to the methodology used in the EPA NON-ROAD USA model by the US Environmental Protection Agency (EPA), as described in Harvey *et al*. (2003). Emission factors were originally taken from a similar model TREMOD-MM (Lambrecht *et al*., 2004) and partially updated with data taken from Helms *et al*. (2010).

Annual sales data for the different types of NRMM are derived from trade organisations such as the BMWT and Federatie Agrotechniek. Fuel consumption and resulting emissions of CO, NO_x, PM and NMVOC are calculated using the following formula:

Emission = Number of machines x Hours x Load x Power x Emission factor x TAF-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;
- Hours = the average annual running hours for this type of machinery;
- Load = the average fraction of full power used by this type of machinery;
- Power = the average full power for this type of machinery (kW);
- Emission factor = the average emission factor or specific fuel consumption belonging to the year of construction (related to emission standards, in grams/kWh);
- TAF factor = the adjustment factor applied to the average emission factor to correct the deviation from the average use of this type of machine due to varying power demands.

The report on the EMMA model (Hulskotte & Verbeek, 2009) provides the emission factors of the various technologies and the different stages in the European emission standards. The emission factors are linked to the different machine types for each sales year. Emissions of SO_x were calculated based on total fuel consumption and sulphur content per fuel type as provided in Klein *et al*. (2019a). Emission factors for NH_3 were derived from Ntziachristos & Samaras (2000).

The distribution of total fuel consumption by NRMM to different economic sectors was estimated using different data sources. First, the different types of machinery in EMMA were distributed over 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 Centre. 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 difference between this total and the EMMA results for agriculture was consequently added to the fuel consumption by construction machinery as reported by EMMA. EMMA overestimates total energy use in agriculture because in the model all agricultural machinery is reported under the agricultural sector, whereas in reality some agricultural machinery (e.g. tractors) is used in construction.

The resulting fuel consumption in construction was subsequently adjusted to take into account the impact of economic fluctuations. Because EMMA is based on sales data and assumptions about the average annual use of the machinery, it is not able to properly take into account cyclical effects that lead to fluctuations not only in the sales data but also in the usage rates of the machinery (i.e. the annual operational hours). The latter effect is not included in the model. For this reason, the EMMA results were adjusted on the basis of economic indicators from Statistics Netherlands for the specific sectors in which the machinery was used. The adjusted EMMA results were used to calculate emissions from NRMM. The resulting fuel consumption (energy use) is also reported by Statistics Netherlands in the Energy Balance. The annual correction factors used to adjust the energy use, as reported by EMMA, are provided in Klein *et al*. (2019a).

Emissions from ground support equipment and vehicles used for ground transport at airports were estimated using data on diesel use for ground operations at Amsterdam Airport Schiphol that were provided by KLM Royal Dutch Airlines. KLM is responsible for the refuelling and maintenance of the equipment at Schiphol Airport and therefore has precise knowledge of the types of machinery used and the amount of energy used per year. These data have been used to derive emission estimates. The resulting emissions have also been used to derive an average emission factor per MTOW at Schiphol Airport, which was subsequently used to estimate emissions at regional airports.

A detailed description of the methodology can be found in chapter 9 of Klein *et al.* (2019a).

4.6.5 *Methodological issues*

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

1. The diesel used in the construction sector is liable to relatively strong economic fluctuations. At present, the correction for this phenomenon takes place using economic indicators derived from Statistics Netherlands instead of physical indicators. It could be investigated whether there are enterprises or institutions that have figures for diesel consumption at their disposal.
2. There is a lack of input data for several types of machinery and sectors. In the garden and private households sector, weakly

founded or extrapolated figures have been used to estimate the size of the fleet.

3. The application of generic survival rates for all types of machinery may have led to declines in the fleet composition (age profile) compared with reality in the case of certain important types of machinery, including agricultural tractors, excavators and shovels. Investigations into the age profile and the use of the active fleet could lead to a considerable improvement in the reliability of the emission figures.
4. The effect of varying engine loads on emissions has hardly been examined. For some types of machinery, it is of great importance to have a better understanding of the effect this has on emissions. A specific measurement programme for investigating the effect of transient engine loads on the machine's daily operation could lead to a far better foundation for the emission data.
5. Via a specific measurement scheme the effect of longer or shorter postponement of maintenance on the emissions of building machinery due to highly varying hire and lease practices, as they occur in the market, 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 1994. For the earlier years, no reliable machinery sales data were available. Fuel consumption in 1990 was derived from estimates taken from Statistics Netherlands, while fuel consumption in 1991, 1992 and 1993 was derived by interpolation.

In 2016, an experts' workshop was organised to discuss and estimate the uncertainties in the activity data and the emission factors used for the emission calculations for the transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for NRMM are provided in Table 4.10.

Table 4.13 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	35	50	20	200	100	100	100	100
1A2gvii	Industry	Diesel	35	50	20	200	100	100	100	100
1A2gvii	Industry	LPG	35	50	20	200	100	100	100	100
1A4aii	Public services	Petrol	100	50	20	200	100	100	100	100
1A4aii	Public services	Diesel	35	50	20	200	100	100	100	100
1A4aii	Container handling	Diesel	35	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

Source: Dellaert & Dröge (2017).

4.6.7 *Source-specific QA/QC and verification*
There are no source-specific QA/QC and verification procedures for non-road mobile machinery.

4.6.8 *Source-specific recalculations*
In 2017, emission measurements were performed by TNO on several types of NRMM to assess the load profile and actual NO_x and CO_2 emissions during use and idling (Ligterink *et al.*, 2018). Based on these measurements, the NO_x emission factors for several diesel engine categories have been increased in the model to better match the emissions under actual use conditions.

An error correction on the $PM_{2.5}$/PM_{10} emission factors was performed. The decrease in sulphur content of the fuels, leading to a decrease in PM emissions, was not fully integrated in the EMMA model. This has led to a decrease in $PM_{2.5}$, PM_{10}, TSP and BC emissions of 4–9% as of 2008.

4.6.9 *Source-specific planned improvements*
Emissions from cooling units on trucks are currently not estimated in the EMMA model. In 2019, a study will be performed to estimate fuel use and the resulting emissions from cooling units.

Data on annual sales of new machinery were previously provided by different trade organisations, but recently those data have become unavailable. In the coming years, a new methodology will be developed to estimate annual sales.

4.7 National fishing

4.7.1 *Source category description*
The source category 1A4ciii National Fishing 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 in the emission inventory for NO_x and SO_2.

4.7.3 *Overview of emission shares and trends*
National fishing is a small emission source in the Netherlands. In 2017, national fishing was responsible for 1% of SO_x and 3% of NO_x emissions. The contribution to the national totals for PM_{10}, $PM_{2.5}$ and BC was 1–3% and for other substances less than 1%. Fuel consumption by national fishing has been decreasing since 1999.

The trends in emissions from national fishing are shown in Table 4.11. For the most part, emissions from national fishing show similar trends to fuel consumption. NO_x emissions decreased significantly between 1990 and 2017, as well as PM_{10} emissions. SO_x emissions decreased due to the use of sulphur-free diesel fuel.

Table 4.14 Trends in emissions from National fishing in the Netherlands

Year	Main pollutants				Particulate matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
	Gg	Gg	Gg	Mg	Gg	Gg	Gg	Gg	Gg
1990	**20.6**	**1.36**	**5.15**	**0.00**	**1.10**	**1.16**	**1.16**	**0.33**	**1.46**
1995	23.1	1.39	6.13	0.00	1.22	1.28	1.28	0.36	1.52
2000	22.5	1.28	5.44	0.00	1.13	1.19	1.19	0.34	1.41
2005	15.5	0.80	3.58	0.00	0.70	0.73	0.73	0.21	0.91
2010	10.9	0.50	1.51	0.00	0.47	0.49	0.49	0.14	0.60
2015	8.80	0.35	0.54	0.00	0.31	0.33	0.33	0.10	0.45
2016	8.27	0.33	0.39	0.00	0.28	0.30	0.30	0.09	0.42
2017	**7.15**	**0.28**	**0.31**	**0.00**	**0.25**	**0.26**	**0.26**	**0.08**	**0.36**
1990–2017 period[1]	-13.4	-1.08	-4.84	0.00	-0.85	-0.90	-0.90	-0.25	-1.10
1990–2017 period[2]	-65%	-79%	-94%	-60%	-78%	-78%	-78%	-77%	-75%

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

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 using AIS data. Two methodologies based on AIS data were applied from 2016 onwards. For deep-sea trawlers, the same methodology that is used for maritime navigation was applied (see Section 4.5.4) because it is assumed that no fishing activities take place in 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 and ter Brake (2017). This is essentially an energy-based method whereby the energy rates of fishing vessels are split up by activity (sailing and fishing), with a distinction made in the available power of propulsion engine(s). The methodology is described more elaborately in chapter 6 of Klein *et al.* (2019a).

4.7.5 *Methodological issues*

The emission factors of fishing vessels have not been measured. The measurement of the emission factors for the most important fishing vessels, during various operational conditions could improve the estimation of emissions.

4.7.6 *Uncertainties and time series consistency*

The AIS-based approach to calculating emissions from fisheries has been applied to the calculation of emissions in 2016. The IEFs for 2016 were subsequently adjusted to create a consistent time series for 1990–2015 using the trend in emission factors 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 organised to discuss and estimate the uncertainties in the activity data and emission factors used for the emission calculations for the transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for national fishing are provided in Table 4.12.

Table 4.15 Uncertainty estimates for national fishing (%)

NFR	Type	Fuel	Uncertainty activity data	Uncertainty emission factor					
				NO_x	SO_x	PM_{10}	$PM_{2.5}$	EC	NMVOC
1A4ciii	Fisheries	Diesel	15	30	20	50	50	50	100

Source: 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*

Trends in total fuel consumption in cutter fishing, as reported by Wageningen Economic Research, were compared with trends in the cutter fishing fleet in the Netherlands and the installed engine power of the fleet. The two trends show good agreement.

4.7.8 *Source-specific recalculations*

In this year's inventory, the emission factors for SO_x have been adjusted upwards as of 2010. This adjustment relates to a correction on the sulphur content of marine diesel for fishing vessels as of 2010. A value of 1,000 ppm of sulphur in marine diesel has been used instead of the previously used 10 ppm. This has caused an increase in SO_x emissions from 137 Mg to 389 Mg in 2016 compared with the IIR2018 (Figure 4.9).

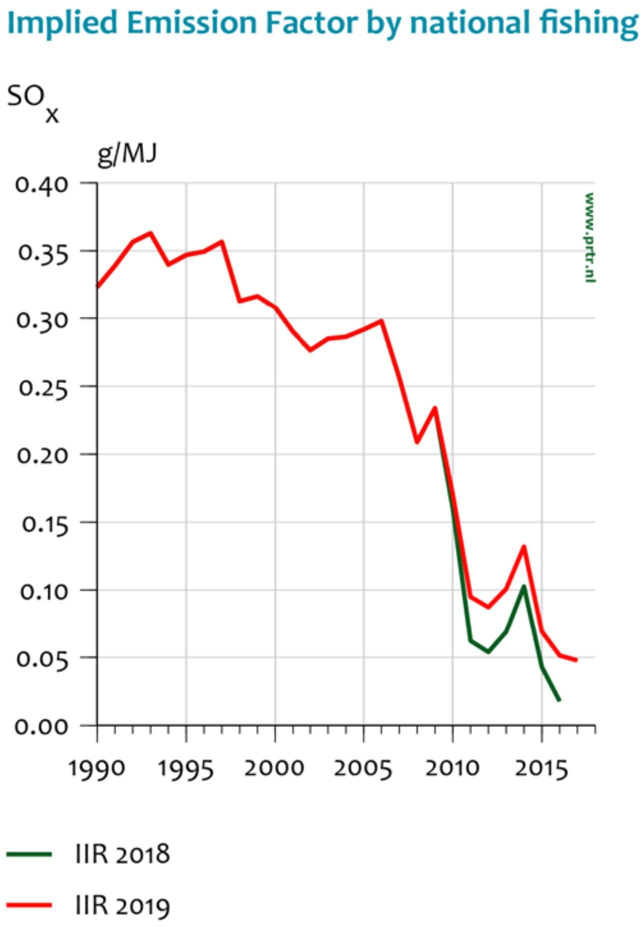

Figure 4.9 SO_x implied emission factors of the fishing fleet in the Netherlands

4.7.9 *Source-specific planned improvements*

There are no source-specific planned improvements for national fishing.

5 Industrial Processes and Product Use

5.1 Overview of the sector

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

The Industrial processes and product use (NFR 2) sector consists of the following 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 POPs. Emissions from the consumption of heavy metals are considered insignificant.

Because the 2016 Guidebook is not clear about which sources belong to 2G and 2L, 2G is included in 2D3i (Other solvent and product use) and 2L in 2H3 (Other industrial processes).

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, we do not include section 2I.

Table 5.1 provides an overview of the emissions from the Industrial processes and product use (NFR 2) sector.

More than 57% of the total NMVOC emissions in the Netherlands originate from this sector.

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

Year	Main pollutants				Particulate matter				Other
	NO_x	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$	BC	CO
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**5.16**	**230**	**10.0**	**5.43**	**16.4**	**29.8**	**49.6**	**0.13**	**10.1**
1995	3.28	170	2.75	5.18	11.0	19.0	34.3	0.07	4.71
2000	1.92	128	1.53	4.00	7.57	13.1	18.5	0.03	3.89
2005	0.58	106	1.02	3.64	6.67	11.7	16.9	0.02	2.65
2010	0.54	106	0.91	2.56	6.37	11.0	15.1	0.02	2.94
2015	0.74	94.8	0.87	2.16	5.58	10.0	14.7	0.02	3.15
2016	0.99	89.8	0.86	2.39	5.45	10.0	14.3	0.02	3.34
2016	**0.75**	**92.3**	**0.88**	**2.28**	**5.58**	**10.1**	**14.2**	**0.02**	**3.15**
1990–2016 period[1]	-4.42	-137	-9.14	-3.15	-10.9	-19.7	-35.4	-0.12	-6.91
1990–2016 period[2]	-86%	-60%	-91%	-58%	-66%	-66%	-71%	-88%	-69%

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	67.2	0.90	1.24	48.1	13.2	0.55	2.95	7.39	2.76	0.31	146
1995	66.6	0.66	0.84	48.6	4.51	0.49	2.83	8.99	2.75	0.22	103
2000	24.5	0.77	0.39	21.4	0.46	0.77	2.16	11.5	0.52	0.00	55.7
2005	27.3	1.50	0.36	19.4	0.38	0.38	1.59	11.9	0.94	0.79	38.9
2010	31.6	0.96	0.31	16.7	0.26	0.48	1.15	13.9	1.21	0.06	41.8
2015	6.36	0.42	0.26	12.8	0.16	0.59	0.88	10.9	1.03	0.06	49.7
2016	6.75	0.43	0.31	12.3	0.14	0.66	1.00	11.0	1.27	0.06	46.4
2017	6.50	0.52	0.25	11.8	0.14	0.47	0.63	16.3	1.09	0.06	40.5
1990–2016 period[1]	-60.6	-0.38	-0.98	-36.3	-13.1	-0.08	-2.32	8.95	-1.68	-0.25	-105
1990–2016 period[2]	-90%	-42%	-79%	-76%	-99%	-15%	-79%	121%	-61%	-80%	-72%

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 5.6. Because the TSP and Cd time series of most key sources were incomplete, they are not included in Sections 5.2 to 5.6. Incomplete time series will be completed, as far as possible, in future submissions.

5.1.2 *Activity data and (implied) emission factors*

Industrial processes
Data on production levels were derived from Statistics Netherlands. IEFs were determined up to 2007 (see Section 5.1.3).

Product use
The activity data and (implied) emission factors of the product use categories are included in Section 5.5, Solvents and product use (2D).

5.1.3 *Methodological issues*

Industrial processes
The emission totals of categories and subcategories consist of the sum of the data from individual facilities, complemented by the emissions from the non-reporting (small and medium-sized) facilities. Depending on the availability of data on emissions from individual companies, one of the following methods was used:

Method 1-IP
Up to 2007, the emissions from non-reporting facilities were calculated as follows:

Em non_IF = IEF * (TP -/- P_IF)

where
IEF = Implied emission factor;
TP = Total production (Production Statistics, Statistics Netherlands);
P_IF = Production of individual facilities (Production Statistics, Statistics Netherlands).

The IEFs were calculated as follows:

IEF = Em_IF / P_IF

Where
Em_IF = the sum of emissions from individual facilities (since 1999, most of the emissions from individual facilities have been derived from the Annual Environmental Reports (AERs)).

Since 2007, due to a lack of production figures, emissions from non-reporting facilities have been calculated as follows:

$$Em\ non\_IF = (PI_{(n)} / PI_{(n-1)}) * Em\ non\_IF_{(n-1)}$$

Where:
PI = Production indices at 2-digit level (Statistics Netherlands);
n = year.

Method 2-IP
Up to 2000, the emissions from non-reporting facilities were calculated as follows:

Em non_IF = IEF * (TP -/- 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 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 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 of the (sub)categories;
EmComp(n) = emissions from individually registered companies (PRTR-I).

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

Product use
The methodological issues of the product use categories are included in Section 5.5, Solvents and product use (2D).

5.1.4 *Uncertainties and time series consistency*
Consistent methodologies – except for TSP and Cd – were used throughout the time series for the sources in this sector.

Furthermore, the Netherlands implemented an Approach 2 methodology for uncertainty analyses. This methodology is 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	97%	101%	101%	99%	70%	78%
2B	78%	NA	NA	58%	71%	69%
2C	92%	NA	NA	64%	92%	89%
2D	103%	102%	115%	85%	76%	76%
2G	NA	NA	NA	NA	NA	NA
2H	82%	NA	NA	70%	60%	65%
2I	NA	NA	NA	NA	NA	NA
2J	NA	NA	NA	NA	NA	NA
2K	NA	NA	NA	NA	NA	NA
2L	NA	NA	NA	NA	NA	NA
Total IPPU sector	**56%**	**89%**	**80%**	**62%**	**36%**	**40%**

The Approach 2 uncertainty analysis shows relatively high uncertainties at the level of the source categories. This is relevant for these key sources:

- 2A6: $PM_{10}/_{2.5}$ (4% contribution to total);
- 2B10a: NMVOC and $PM_{10}/_{2.5}$ (2% and 5% contribution to total, respectively);
- 2C1: $PM_{10}/_{2.5}$ (5% contribution to total);
- 2D3a: NMVOC (13% contribution to total);
- 2D3d: NMVOC (6% contribution to total);
- 2D3i: NMVOC and $PM_{10}/_{2.5}$ (6 5% contribution to total, respectively);
- 2H2: $PM_{10}/_{2.5}$ (7% contribution to total);
- 2H3: NMVOC and $PM_{10}/_{2.5}$ (4 10% contribution to total, respectively).

These key sources for these pollutants do have a contribution to the uncertainty on national level. Although it is relatively small, we must take some modest attention in prioritising methodological improvements.

5.1.5 *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 of Chapter 1.

5.1.6 *Source-specific recalculations*

In comparison with the previous submission, NMVOC emissions from 2D3a and 2D3i have been recalculated. More information about these recalculations can be found in Section 5.5.6 and a description of the methodology of the emission sources is included in Jansen *et al.* (2019).

As a result of a study on $PM_{2.5}$ fractions, the emission series of $PM_{2.5}$ have been recalculated (Visschedijk&Dröge, 2019).

Furthermore, emission series of PAHs have been corrected due to review recommendations.

5.1.7 *Source-specific planned improvements*

Industrial processes

The CO time series from 2D3i will be corrected in the next submission. This correction will be done for the series Smoking of cigarettes (consumers). Furthermore, the incomplete TSP and Cd time series will be completed, where possible, in future submissions.

Product use

There are no source-specific improvements planned for this part of the sector.

5.2 Mineral products (2A)

5.2.1 *Source-category description*

This category comprises emissions related 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.

Because of allocation problems, emissions from 2A2, 2A5a and 2A5b were included in the subcategory of other mineral products (2A6). Because only emissions from the storage and handling of bulk products companies are available, the emissions from 2A5c were reported in the category of Other industrial processes (2H3).

The 2H3 subcategory in the Dutch PRTR includes 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.

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%) are obtained from the AERs of individual facilities (Tier 3 methodology), which are validated and approved by their Competent Authority. According to the Aarhus Convention, only total emissions have to be included in the AERs. This means that production levels, if they are included, are confidential information. However, in most cases 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 with the help of the production indices of the mineral industry from Statistics Netherlands.

5.2.2 Key sources

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

Table 5.3 Key sources of Mineral products (2A)

	Category / Subcategory	Pollutant	Contribution to total of 2017 (%)
2A3	Glass production	Pb	18.4
2A6	Other Mineral Products	$PM_{10}/PM_{2.5}$	4.0/6.8
		Hg	17.8

5.2.3 Overview of emission shares and trends

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

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

NFR Code:	2A3	2A6	
NFR Name:	Glass production	Other mineral products	
Pollutant:	Pb	PM_{10}	$PM_{2.5}$
Unit:	Mg	Gg	Gg
Year			
1990	7.3	2.0	1,6
1995	6.5	1.6	1,3
2000	2.9	1.0	0.9
2005	1.4	1.0	0.9
2010	0.8	1.1	1,0
2015	1.0	1.1	1,0
2017	1.6	1.1	1,0

From 1990 to 2017, Pb emissions from 2A3 decreased from 7.3 to 1.6 Mg. This reduction 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, etc.). As a result of the implementation of technical measures, PM_{10} emissions from 2A6 decreased from 2.0 Gg in 1990 to 1.1 Gg in 2017 and $PM_{2.5}$ emissions from 1.6 Gg to 1,0 Gg.

5.2.4 Methodological issues

Method 1-IP was used to estimate the emissions from Glass production (2A3) and Other mineral products (2A6). Emissions from non-reporting facilities are calculated with the help of the production indices of the mineral industry from Statistics Netherlands.

5.3 Chemical industry (2B)

5.3.1 Source-category description

This category comprises emissions related to 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.

Adipic acid (included in 2B3) and calcium carbide (included in 2B5) are not produced in the Netherlands. So emissions from these sources do not occur (NO). Because of allocation problems and for confidential reasons, emissions from 2B1, 2B2, Silicon carbide (2B5), 2B6 and 2B7 are included in 2B10a, Chemical industry: Other. Because only emissions from the storage and handling of bulk products companies are available, the emissions from 2B10b are reported in the category of Other industrial processes (2H3).

The 2H3 subcategory in the Dutch PRTR includes 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.

The emission total of 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%) are obtained from the AERs of individual facilities (Tier 3 methodology), which are validated and approved by their Competent Authority. The majority of those individual facilities produce several products, so in most cases the total emissions are the sum of the emissions of all the production processes. According to the Aarhus Convention, only total emissions have to be included in the AERs. This means that production levels and amounts of solvents used, if they are included, are confidential information. However, in most cases companies do not include any production data or amounts of solvents used. For this reason, it is not possible to provide activity data and determine/calculate IEFs, and the emissions of 2D3g are included in 2B10a.

The emissions from non-reporting facilities are calculated with the help of the 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 2017 (%)**
2B10a	Chemical industry: Other	NMVOC	1.9
		$PM_{10}/PM_{2.5}$	5.1/6.6

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 Name:		NFR Code: 2B10a Chemical industry: Other		
	Pollutant:	NMVOC	PM_{10}	$PM_{2.5}$
	Unit:	Gg	Gg	Gg
Year				
1990		33.0	4.1	2.6
1995		18.0	3.0	1.9
2000		13.0	1.2	0.8
2005		7.9	1.2	0.9
2010		5.7	1.3	1.0
2015		4.7	1.1	0.8
2017		4.7	1.4	0.9

From 1990 to 2017, NMVOC emissions decreased from 33 Gg to 4.7 Gg and PM_{10} emissions decreased from 4.1 Gg to 1.4 Gg. These reductions were mainly caused by the implementation of technical measures. Due to a major incidental emission, there was a jump in 2012.

5.3.4 *Methodological issues*

Method 1-IP was used to estimate the emissions from Other chemical industry (2B10a). The production indices of the chemical sector used to calculate the emissions from the non-reporting facilities are presented in Table 5.7.

Table 5.7 Overview of indices of the Chemical sector (2010=100)

Year	Index
2005	90.2
2006	95.5
2007	98.9
2008	92.7
2009	89.6
2010	100.0
2011	98.2
2012	103.5
2013	99.0
2014	98.5
2015	95.9
2017	105.4

5.4 Metal production (2C)

5.4.1 *Source category description*

This category comprises emissions related 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.

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.

For confidential reasons, the emissions from 2C4 are included in the 2H3 subcategory.

There are two lead, two copper and two zinc producers in the Netherlands. Since 2009, the two copper companies have not reported PM_{10} emissions because the emissions are far below the reporting threshold of 5,000 kg. For this reason, PM_{10} emissions are reported as 'NA' in 2C7a. Normally, the reported PM_{10} emissions are used to calculate $PM_{2.5}$ emissions. But this is not possible in this case. Therefore, $PM_{2.5}$ emissions are also reported as 'NA' in 2C7a.

The two lead and two copper companies do not report 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 and 2C7a.

Because it is not possible to split the SO_x from 2C6, all the SO_x emissions are reported in 1A2b.

Because only emissions from the storage and handling of bulk products companies are available, emissions from 2C7d are reported in the category of Other industrial processes (2H3).

The 2H3 subcategory in the Dutch PRTR includes 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.

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 2017 (%)
2C1	Iron and steel production	$PM_{10}/PM_{2.5}$	4.5/5.5
		Pb	41.0
		Hg	15.0
2C5	Lead production	Hg	7.0
2C6	Zinc production	Pb	12.0

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.

The 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).

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

NFR Code:	2C1					
NFR Name:	Iron and steel production					
Pollutant:	PM_{10}	$PM_{2.5}$	Pb	Hg	Dioxin	PAHs
Unit:	Gg	Gg	Mg	Mg	g I-Teq	Mg
Year						
1990	9.1	5.9	56	0.4	23	1.64
1995	4.8	3.1	58	0.3	26	1.62
2000	2.0	1.3	19	0.1	1.40	0.10
2005	1.7	1.1	23	0.2	1.40	0.09
2010	1.5	1.0	30	0.2	1.72	0.08
2015	1.3	0.8	3.5	0.1	0.27	0.07
2017	1.2	0.8	3.5	0.1	0.27	0.07

In addition to emissions of PM_{10}, $PM_{2.5}$, Pb and Hg (the key source pollutants), iron and steel production is responsible for 1.2% of total emissions of dioxins and for 1.1% of all PAH emissions in the Netherlands. Most types of emissions from this source decreased during the 1990-2000 period. These reductions 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 after 2010. Dioxin emission fluctuations were mainly caused by the varying process conditions.

Aluminium production (2C3)
Aluminium production is responsible for 0.23% of all PAH emissions in the Netherlands. PAH emissions originate from ‘producing anodes’ and the ‘use of anodes’ during primary aluminium production.

Up to 2011, anodes were produced in two plants (Aluchemie and Zalco) and primary aluminium was produced at two primary aluminium smelters (Zalco – previously Pechiney – and Aldel). The anode and primary aluminium producer Zalco was closed in 2011 and Aldel was closed at the end of 2013. Aldel made a restart under the name Klesch Aluminium Delfzijl in 2015.

Table 5.10 provides an overview of the PAH emissions from Aluminium production (category 2C3).

Table 5.10 Overview of PAH emissions from Aluminium production (2C3)

NFR Code:	2C3
NFR Name:	Aluminium production
Pollutant:	PAHs
Unit:	Mg
Year	
1990	6.909
1995	1.664
2000	0.128
2005	0.132
2010	0.108
2011	0.290
2012	0.001
2013	0.006
2014	0.006
2015	0.024
2016	0.011
2017	0.010

Between 1990 and 2000, PAH emissions decreased from 7 Mg to less than 0.13 Mg. This reduction was mainly caused by the implementation of technical measures.

During the 2012–2017 period, PAH emissions decreased further, to 0.01 Mg. This reduction was mainly caused by:

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

For these reasons, aluminium production is no longer considered a key source of PAHs.

Emission fluctuations were mainly caused by the varying process conditions, combined with an inaccuracy of 43% in PAH measurements during the production of anodes.

In 2015, the restart under the name Klesch Aluminium Delfzijl resulted in an increase in PAH emissions to 0.024 Mg.

Lead production (2C5) and zinc production (2C6)
Because of the decreased Pb and Hg emissions from 2C1, 2C5 is now a key source of Hg, and 2C6 of Pb. Hg emissions from lead production have remained fairly stable since 2012, while Pb and Zn emissions from zinc production increased sharply after 2013. The Netherlands is still trying to find an explanation for this sharp increase.

5.4.4 *Methodological issues*

Method 1-IP was used to estimate the emissions from iron and steel, aluminium, lead and zinc production. In cases without a complete registration for the four individual PAHs, a set of specific factors was used to calculate the emissions of the missing PAHs. These factors were obtained from the study conducted by Visschedijk *et al.* (2007).

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 from Road paving with asphalt (2D3b) and Asphalt roofing (2D3c) were not estimated because no activity data were available. Emissions from Chemical products (category 2D3g) are included in 2B10a (see Section 5.3.1).

More than 40% of the total NMVOC emissions in the Netherlands originate from Solvents and product use.

5.5.2 Key sources

The key sources of 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 2017 (%)**
2D3a	Domestic solvent use including fungicides	NMVOC	13
2D3d	Coating applications	NMVOC	6
2D3i	Other solvent use	NMVOC	6
		$PM_{10}/PM_{2.5}$	5.1/9.9
		DIOX	50

5.5.3 Overview of emission shares and trends

Table 5.12 provides an overview of the emissions from the key sources of this category.

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

NFR Code:	2D3a	2D3d	2D3i			
NFR Name:	Domestic solvent use including fungicides	Coating applications	Other solvent use			
Pollutant:	NMVOC	NMVOC	NMVOC	PM_{10}	$PM_{2.5}$	Dioxin
Unit:	Gg	Gg	Gg	Gg	Gg	g I-Teq
Year						
1990	24	93	18	1.9	1.9	25.0
1995	27	67	17	1.8	1.8	23.0
2000	29	41	15	1.8	1.8	20.0
2005	31	26	15	1.5	1.5	18.0
2010	33	28	16	1.5	1.5	15.0
2015	34	19	15	1.1	1.1	13.0
2017	34	15	16	1.4	1.4	11.5

Domestic solvent use including fungicides (2D3a)
The emission sources in this key source are:
- Cosmetics (and toiletries);
- Cleaning agents;
- Car products;
- Others.

Figure 5.1 shows the trend in NMVOC emissions from the sources of Domestic solvent use, including fungicides (2D3a).

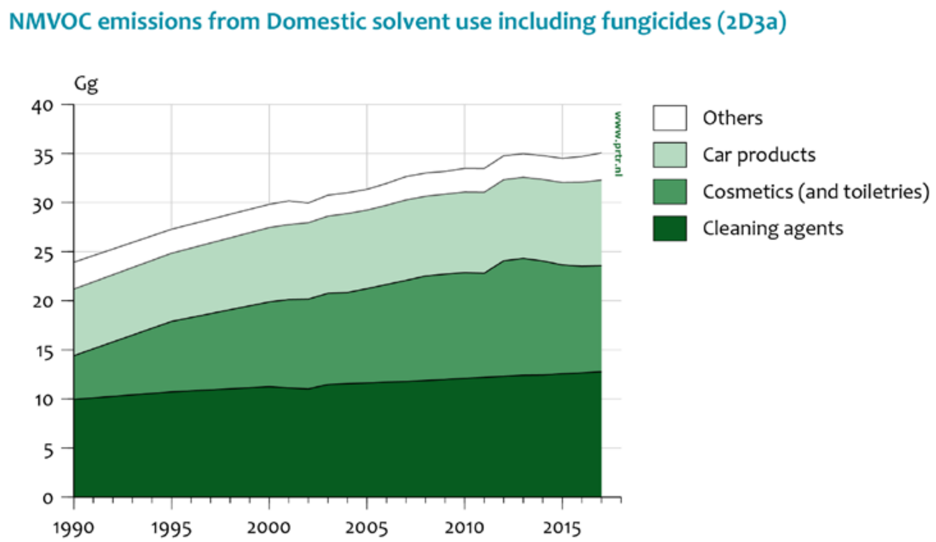

Figure 5.1 NMVOC emissions from sources of Domestic solvent use, including fungicides (2D3a)

During the period 1990–2016, NMVOC emissions increased from 16 Gg to 34 Gg. This was mainly the result of an increase in the consumption of cosmetics.

Coating applications (2D3d)
The emission sources in this key source are:
- Industrial paint applications;
- Domestic use;
- Construction and buildings;
- Car repairing;
- Boat building.

Figure 5.2 shows the trend in NMVOC emissions from the sources of Coating applications (category 2D3d) over the 1990–2017 period.

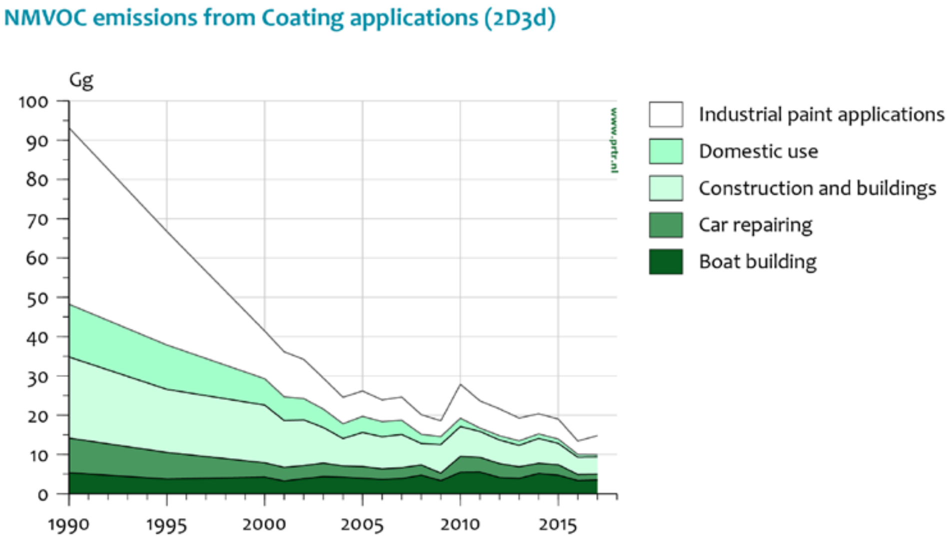

Figure 5.2 NMVOC emissions from sources of Coating applications (2D3d)

Mainly due to the lower average NMVOC content of the paints used, NMVOC emissions from coating applications decreased from 93 Gg in 1990 to 25 Gg in 2007. As a result of the credit crunch, paint consumption decreased in 2008 and 2009; therefore, NMVOC emissions decreased to 19 Gg in 2009.

In 2010, the biggest market segment, i.e. construction paints, continued to slide, while car repairs and the industry generally showed 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 of NMVOC emissions. Due to decreased paint consumption in 2016 (mainly in the market segments of Car repairs and Industry), NMVOC emissions decreased to 15 Gg in 2017.

Other solvent use (2D3i)
As already mentioned in 5.1, the 2016 Guidebook is not clear about which sources belong to 2G. Therefore, 2G is included in 2D3i.

For NMVOC, the following activities are included in 2D3i and 2G 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 HFC, N_2O, PFC and HCFCs;
- 060601 Use of fireworks;
- 060602 Use of tobacco.

Emissions from the use of HFC, PFC and HCFCs as refrigerants and other uses of HFCs, PFCs and HCFCs are obtained from the National Inventory Report.

Until 2000, NMVOC emissions due to most of the other sources were obtained from the Hydrocarbons 2000 project. Due to a lack of more recent data after the Hydrocarbons 2000 project, emissions after 2000 were placed on a par with those in 2000, the last year of the Hydrocarbons 2000 project.

For $PM_{2.5}$, the following activities are included in 2D3i, 2G in the Netherlands:
- 060601 Use of fireworks;
- 060602 Use of tobacco;
- 060604 Other: Burning of candles.

NMVOC emissions in this category decreased from 18 Gg in 1990 to 16 Gg in 2017. These reductions were mainly the result of a lower average NMVOC content of cleaning agents.

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 25 g I-TEQ in 1990 to about 12 g I-TEQ in 2017.

The most important source of PM_{10} and $PM_{2.5}$ emissions (76% of the total) in 2D3i is the smoking of cigarettes. As a result of the drop in the number of cigarettes smoked, emission from 2D3i decreased from 1.9 Gg in 1990 to 1.4 Gg in 2017.

5.5.4 *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.

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 197 Gg in 1990 to 122 Gg in 2017 and the NMVOC content decreased from 30% in 1990 to almost 13% in 2011. During the 2012–2014 periods, the NMVOC content remained fairly stable. In 2015, the NMVOC content decreased further, to 12%. From this submission onwards, no NMVOC content figures have been available. Therefore, the NMVOC content is kept equal to 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.

5.5.5 *Methodological issues*

For a detailed description of the methodology of the emission sources, see Jansen (2019).

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 VVVF and from VVVF estimations on imported paints. The VVVF, through its members, 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, see ENINA methodology report (Peek *et al*., 2019).

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.

5.5.6 *Source-specific recalculations*

For 2D3a the NMVOC emissions from domestic cleaning and cosmetic product use have been recalculated. The new emission figures are based on more types of products used (products for cleaning floors and dishes, hand-disinfecting products, etc.). The cleaning frequency and the NMVOC emission factor have also been adjusted. For cosmetics a better differentiation in products has been applied; as a result, the decreasing sale of hairspray and deodorants is reflected in the NMVOC emission figures.

5.6 Other production industry (2H)

5.6.1 *Source-category description*

This category comprises emissions related to 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, excl. 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.

All activities listed in the 2016 EMEP/EEA Guidebook (production of bread, wine, beer, spirits, sugar, flour, meat, fish, etc., and frying/curing) are included in these NACE activities.

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

5.6.2 *Key sources*

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

Table 5.13 Key sources of Other production industry (2H)

	Category / Subcategory	Pollutant	Contribution to total of 2017 (%)
2H2	Food and beverages industry	$PM_{10}/PM_{2.5}$	6.9/3.6
2H3	Other industrial processes	NMVOC	4.2
		$PM_{10}/PM_{2.5}$	9.7/5.4

5.6.3 *Overview of emission shares and trends*

Table 5.14 provides an overview of the emissions from the key sources of this category.

Table 5.14 Overview of emissions from the key sources of Other production Industry (2H)

NFR Code:	2H2		2H3		
NFR Name:	Food and beverages industry		Other industrial processes		
Pollutant:	PM_{10}	$PM_{2.5}$	NMVOC	PM_{10}	$PM_{2.5}$
Unit:	Gg	Gg	Gg	Gg	Gg
Year					
1990	4.3	0.8	25	5.4	1.6
1995	2.3	0.4	13	3.3	0.8
2000	1.9	0.3	6	3.2	0.9
2005	1.8	0.3	10	2.7	0.7
2010	1.6	0.3	10	2.6	0.7
2015	1.8	0.3	10	2.6	0.7
2017	1.9	0.5	10	2.6	0.8

Food and beverages industry (2H2)
From 1990 to 2017, PM_{10} emissions decreased from 4.3 to 1.9 Gg. These reductions were mainly caused by the implementation of technical measures.

Other industrial processes (2H3)
The 2H3 subcategory in the Dutch PRTR covers emissions from a variety of activities, including 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. Emissions from storage and handling by companies with main activities other than those listed above are assumed to be included in the relevant categories of this NFR sector.

From 1990 to 2017, NMVOC emissions decreased from 25 Gg to 10 Gg. The emission contribution of the storage and handling of liquid bulk products was 15 Gg in 1990 and 8 Gg in 2016.

PM_{10} emissions decreased from 5.4 Gg to 2.6 Gg during the 1990–2016 period. The emission contribution of the storage and handling of dry bulk products was 1.4 Gg in 1990 and 0.7 Gg in 2017. Reductions in NMVOC and PM_{10} emissions were mainly caused by the implementation of technical measures. After 2005, PM_{10} emission fluctuations were caused by the varying volume of products handled. Figure 5.3 shows the trend in PM_{10} emissions from the storage and handling of dry bulk products over the 1990–2016 periods.

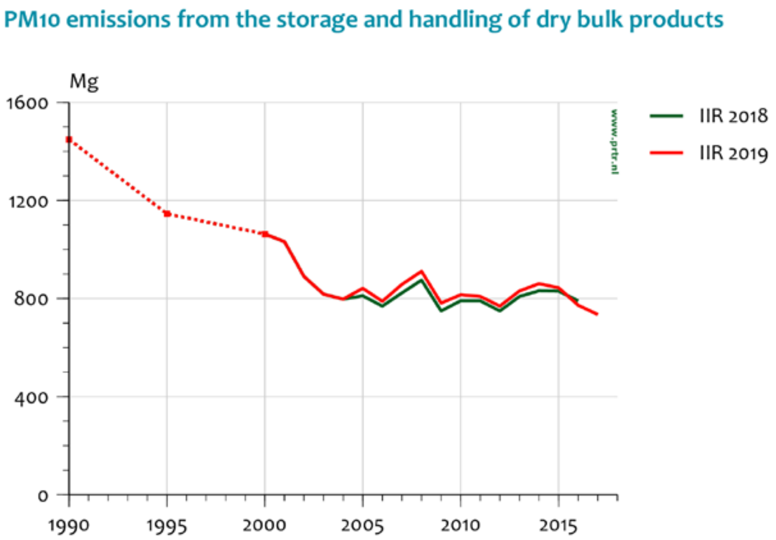

Figure 5.3 Storage and handling of dry bulk products: trend and emissions of PM_{10}

5.6.4 *Methodological issues*

Method 2-IP was used to estimate the emissions from the production of food and drink (category 2H2).

Method 1-IP was used to estimate particulate matter (PM) emissions from storage and handling in 2H3; method 2-IP was used to estimate all other emissions from 2H3.

5.6.5 *Source-specific recalculations*

Food and beverages industry (2H2)

No recalculations have been made.

Other industrial processes (2H3)

The PM_{10} emissions of some companies in the storage and handling sector have been corrected. This has resulted in small PM_{10} emission changes for the 2005–2016 period.

6 Agriculture

6.1 Overview of the sector

The agricultural sector includes all anthropogenic emissions from agricultural activities. Emissions from fuel combustion (mainly related 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;
- 3I Agriculture: Other.

This IIR focuses on emissions of ammonia (NH_3), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), particulate matter (PM_{10}, $PM_{2.5}$) 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 has been prohibited in the Netherlands during the whole time series (article 10.2 of the Environmental Management Act, or 'Wet Milieubeheer' in Dutch). NO_x emissions from the cultivation of organic soils are allocated to category 3I.

Emissions of the greenhouse gases methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) from the agricultural sector were reported in the annual National Inventory Report (NIR). All emissions were calculated according to the methods described in Lagerwerf *et al.* (2019).

In 2017, the agricultural sector was responsible for 86% of all NH_3 emissions in the Netherlands. Emissions of NO_x from agriculture amounted to 13% of the national total. Agriculture contributed 39% of the national NMVOC emissions, 23% of the national PM_{10} emissions and 4% of the national $PM_{2.5}$ emissions in 2017. Although zinc is not a priority heavy metal, emissions from drift following pesticide use are reported for the sake of completeness.

6.1.1 *Key sources*

According to the key source analysis, in 2017 the key sources of NH_3 emissions from agriculture were (see Appendix 2 for details):

- 3Da2a Animal manure applied to soils;
- 3B1a Dairy cattle;
- 3B3 Swine;
- 3B1b Non-dairy cattle;
- 3Da1 Inorganic N-fertilisers;
- 3B4gi Laying hens (trend only).

For NO_x emissions from agriculture, the key sources were:

- 3Da2a Animal manure applied to soils;
- 3Da1 Inorganic N-fertilisers;

- 3I Agriculture: Other: the cultivation of organic soils (trend only).

For PM_{10} emissions from agriculture, the key sources were:
- 3B4gi Laying hens;
- 3B4gii Broilers;
- 3B3 Swine (level only).

For emissions of $PM_{2.5}$, the agricultural sector had no key sources.

For NMVOC emissions from agriculture, the key sources were:
- 3B1a Dairy cattle;
- 3Da2a Animal manure applied to soils;
- 3B1b Non-dairy cattle;
- 3Dc Farm-level agricultural operations including the storage, handling and transport of agricultural products.

The NFR category 6A Other is also a key source of NH_3 emissions, and contributed 7% to the national total. Category 6A Other includes emissions from privately owned livestock (horses, ponies, mules and sheep) and from the application of inorganic N-fertiliser, animal manure and compost outside agriculture. Calculation methods for these emissions are similar to the methods described in this chapter.

6.1.2 *Trends*

Ammonia

NH_3 emissions decreased between 1990 and 2017, with the largest reduction in the first few years of the time series. This was mainly due to a ban on the surface spreading of manure, enforced in 1991, making it mandatory to incorporate manure into the soil either directly or shortly after application. In addition, it became mandatory to cover exterior manure storages. More recently, the introduction of low-emission housing for animals further decreased ammonia emissions.

Maximum application standards for manure and fertiliser (due to implementation of the Nitrates Directive) and systems of livestock production rights promoted greater efficiency of animal production. An example of this was the ongoing improvement in nutritional management, whereby a reduction of dietary crude protein in concentrate feed resulted in lower N excretions per animal and consequently reduced NH_3 emissions. However, in 2017 the share of grass in roughage increased (partly caused by a lower acreage and poor harvest of maize). Grass has a higher N content than maize (the alternative), resulting in higher N excretion overall.

Milk quotas led to increased feeding of maize to dairy cattle in order to increase milk production per cow, until 2014. Increased production per animal led to a decrease in animal numbers and consequently lower emissions. In anticipation of the abolition of milk quotas in 2015 more dairy cattle were kept, leading to a further increase in production, of both milk and manure. Increased manure production exceeded the phosphate production limits set in European agreements, which in turn led to the introduction of phosphate quotas for all cattle as of 1 January 2018, limiting the number of cattle a farmer can keep.

The amount of manure exported increased six-fold in the period 1990–2016, but did not further increase in 2017. Part of the NH_3 emissions from animal housing are included in emissions from 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. The same applied to nitrogen in manure used outside agriculture, as those emissions were allocated to category 6A Other.

Since most NH_3 emissions originated from the agricultural sector, the decreasing trend in NH_3 emissions from agriculture seen from 1990 to 2017 was reflected in a decreasing trend of the national total.

Nitrogen oxides
NO_x emissions decreased over the 1990–2017 period mainly because of lower inorganic N-fertiliser use, a decrease in N excreted during grazing and less N available for application.

Particulate matter
PM emissions for most animal categories decreased slightly over the 1990–2017 period due to decreased animal numbers; however, PM_{10} emissions from laying hens almost quadrupled and $PM_{2.5}$ emissions more than doubled. 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 emission factors for PM_{10} and $PM_{2.5}$. This gradual transition between 1990 and 2012 was initiated by an impending ban on battery cage systems in 2012 and led to an overall increase in PM emissions from manure management.

NMVOC
Overall, NMVOC emissions from agriculture remained stable from 1990 to 2017. However, the emissions reported under manure management increased significantly, due to an increased share of silage feeding and its NMVOC emissions in the animal house. 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.

6.2 Manure management

6.2.1 Source category description

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

- 3B1a Dairy cattle;
- 3B1b Non-dairy cattle;
- 3B2 Sheep;
- 3B3 Swine;
- 3B4a Buffalo;
- 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 not occur in the Netherlands. Emissions from category 3B4giv Other poultry include emissions from ducks. Under category 3B4h (Other animals), rabbits and fur-bearing animals are reported. Emissions resulting from the application of animal manure or during grazing were considered to be related to land use and are not reported under 3B Manure management, but are included in 3D Crop production and agricultural soils.

6.2.2 *Key sources*

Within sector 3B, in 2017 Dairy cattle (3B1a) had the largest contribution to NH_3 emissions, amounting to 17% of the national total. Swine (3B3, 10%) and Non-dairy cattle (3B1b, 8%), were also NH_3 key sources. The largest source of PM_{10} emissions within sector 3B was Laying hens (3B4gi), amounting to 10% of the national total. Broilers (3B4gii; 5%) and Swine (3B3; 3%) were also key categories for PM_{10}. For NMVOC emissions Dairy cattle (3B1a) is the largest contributor to the national total, with 18%. Non-dairy cattle (3B1b) is 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.

6.2.3 *Overview of emission shares and trends*

Table 6.1 presents an overview of emissions of the main pollutants NO_x and NH_3, together with the emissions of PM_{10} and $PM_{2.5}$, originating from sector 3B Manure management.

Table 6.1 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	**3.73**	**41.8**	**98.3**	**0.42**	**4.12**	**4.12**
1995	3.85	40.9	96.0	0.42	4.16	4.16
2000	3.22	44.7	75.3	0.45	4.65	4.65
2005	2.88	42.6	65.0	0.42	4.63	4.63
2010	3.11	59.3	65.0	0.45	5.25	5.25
2015	3.51	66.7	57.3	0.48	5.70	5.70
2016	3.64	70.2	56.9	0.47	5.67	5.67
2017	**3.65**	**69.7**	**57.9**	**0.45**	**5.47**	**5.47**
1990–2017 period[1]	-0.08	27.8	-40.4	0.03	1.36	1.36
1990–2017 period[2]	-2%	67%	-41%	7%	33%	33%

1. Absolute difference.
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 (Lagerwerf *et al.*, 2019).

Figure 6.1 presents a schematic overview of the N-flows, where the boxes with black letters highlight the NH_3 and NO_x emissions included in 3B Manure management and the boxes with grey letters are included in 3D Crop production and agricultural soils.

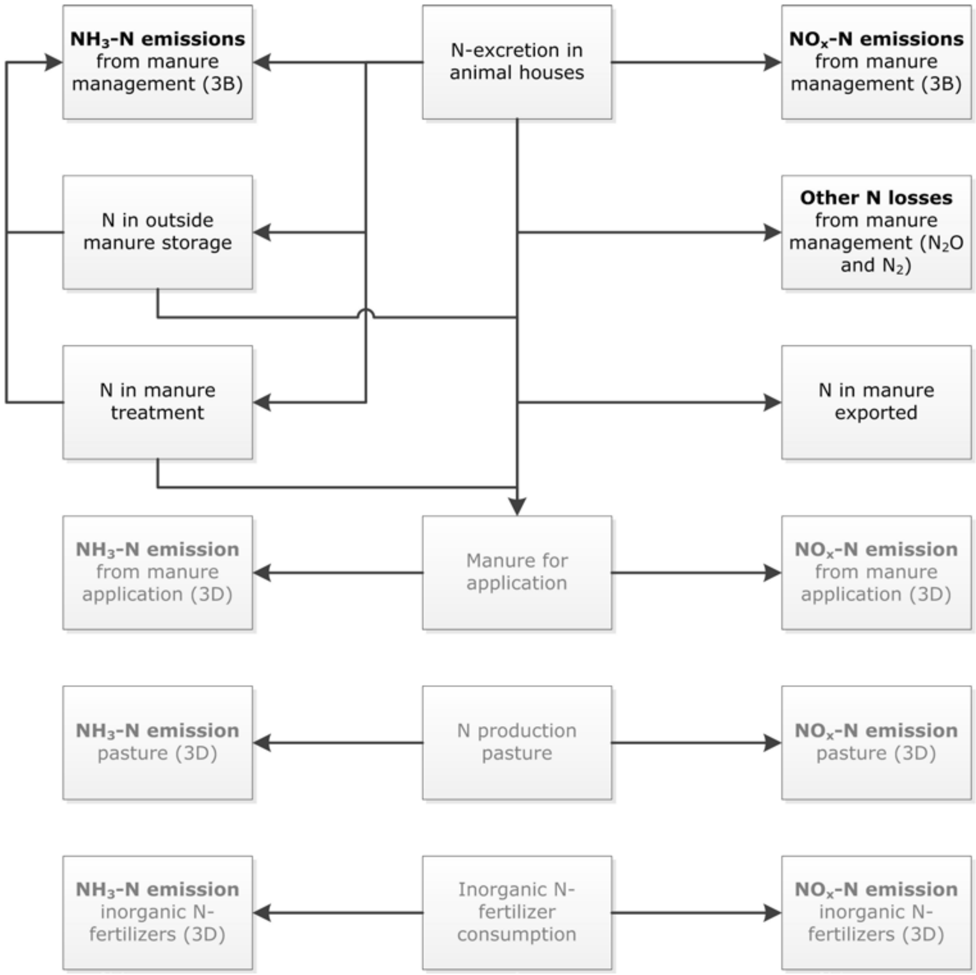

Figure 6.1 Nitrogen flows in relation to NH_3 and NO_x emissions
Boxes with black letters highlight the emissions included in 3B Manure management and boxes with grey letters are included in 3D Crop production and agricultural soils.

Between 1990 and 2017, NH_3 emissions from manure management were reduced by 41%. Higher production rates per animal and restrictions via quotas resulted in a decreasing trend in the numbers of cattle, sheep and swine, until 2014. N excretions per animal decreased over the time series due to lower dietary crude protein for all animal categories. In 2017, N excretion increased again for cattle, which can be explained by a decrease in fed maize and an increase in fed grass, which has a higher N content than maize. Besides the increased share of grass in the feed, nutrient requirements increased through a higher average milk production and body weight. For dairy cattle, N excretion increased from 130 kg N per animal in 2016 to 144 kg N per animal in 2017 (CBS, 2018). For poultry, a lower excretion rate was seen, because the disinfectant fipronil was found in eggs in the Netherlands, which led to the culling of poultry on the contaminated farms.

NH_3 emissions also decreased due to the increased proportion of low-emission housing. The share of treated manure increased over the years, which led to an increase in emissions of both NO_x and NH_3, due to an increased storage time and process emissions of manure treatment.

As NO_x emissions were also influenced by the above-mentioned developments, NO_x emissions decreased by 2% from 1990 to 2017.

Particulate matter
PM emissions from animal housing showed an increasing trend in the time series, caused mainly by the increased proportion of solid manure housing systems for poultry. The increased floor space per animal added to this effect.

NMVOC
Emissions of NMVOC showed an increasing trend of 67% from 1990 to 2017, mostly caused by an increase in silage feeding to dairy cattle in the animal house. The increase in poultry numbers also added to this increasing trend.

6.2.4 *Activity data and (implied) emission factors*

Basic input data include animal numbers as determined by the annual agricultural census (see the summary in Table 6.2 and van Bruggen *et al.* (2019) for a full overview of subcategories and years). For horses, an estimated 300,000 additional animals were included in the inventory to account for privately owned animals. The emissions of NH_3 and PM resulting from the manure management of these animals were calculated using the National Emission Model for Agriculture (NEMA), yet were reported under the source category Other (6A).

European agreements set a limit to phosphate production for the Netherlands, which in turn led to an introduction of phosphate quotas for all cattle as of 1 January 2018. These quotas limited the amount of cattle a farmer can keep, resulting in a reduction in animal numbers in 2017 by about 8% for dairy cattle and 12% for non-dairy cattle (van Bruggen *et al.*, 2019). Because the yearly agricultural census is done in April, the number of cattle present on the farms at that time was not representative of the yearly average in 2017. Therefore, for the emission calculations of 2017, the number of dairy cattle was adjusted, using the Identification and Registration system (I&R Runderen; data from the Netherlands Enterprise Agency).

Table 6.2 Animal numbers over the 1990–2017 period (in 1,000 head)

Animal type	1990	1995	2000	2005	2010	2015	2016	2017
Cattle	4,926	4,654	4,069	3,797	3,975	4,134	4,251	4,023
dairy cattle	1,878	1,708	1,504	1,433	1,479	1,622	1,745	1,672
non-dairy cattle	3,048	2,946	2,565	2,364	2,497	2,512	2,507	2,351
Sheep[1]	1,702	1,674	1,305	1,361	1,130	946	784	799
Swine	13,915	14,397	13,118	11,312	12,255	12,603	12,479	12,401
Goats	37	43	98	172	222	292	306	322
Horses[1]	70	100	117	133	141	117	82	85
Mules and asses[1]	IE	IE	IE	IE	1	1	1	1
Poultry	94,902	91,637	106,517	95,190	103,371	108,558	107,312	105,771
laying hens	51,592	45,734	53,078	48,418	56,500	57,656	56,431	55,858
broilers	41,172	43,827	50,937	44,496	44,748	49,107	49,188	48,233
turkeys	1,052	1,207	1,544	1,245	1,036	863	762	670
other poultry	1,086	869	958	1,031	1,087	932	931	1,009
Other animals	1,340	951	981	1,058	1,261	1,404	1,286	1,262
Fur-bearing animals	554	463	589	697	962	1.023	923	919
Rabbits	786	488	392	360	299	381	363	343

[1] Excluding privately owned animals.
Source: van Bruggen *et al.* (2019).

Animal numbers were distributed over the various housing types using information from the agricultural census. If required, additional data from environmental permits was used (van Bruggen *et al.*, 2019).

N emissions
Emissions of NH_3 and NO_x from animal manure in animal houses, manure treatment and outside 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, 2012a). The historical data were recalculated in 2009 (CBS, 2012a) and supplemented yearly, thereby ensuring consistency (CBS, 2011–2018).

The total ammoniacal nitrogen (TAN) in manure was calculated on the basis of the faecal digestibility of the N in various components of animal feed. From the N excretion data, the TAN excretion per animal type and NH_3 emission factor per housing type were calculated, taking into account mineralisation and immobilisation. The Tier 1 default N_2O emission factors from the IPCC 2006 Guidelines were applied to both N_2O and NO_x emissions, following research by Oenema *et al.* (2000) that set the ratio of these losses to 1:1. 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. From that, the amount of manure stored outside the animal house, 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. The sum of emissions from animal housing, manure treatment and outside 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 were 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 for calculating emissions from manure application, allocated to sector 3D.

Implied emission factors for NH_3 emissions in sector 3B Manure management were calculated for the main NFR categories (Table 6.2). The NH_3 emission per animal decreased for all animal species due to improved efficiency, low-NH_3-emission housing systems and the covering of external manure storages, except for cattle. For cattle, the effect of improved efficiency was counterbalanced by an increased living area for each animal. This resulted in a net increase in the IEF for cattle. Although the living area for each animal was also increased for swine and poultry, emission-reduction techniques such as air scrubbers and manure drying more than counterbalanced the effect of increased living area. The fluctuating N content of grass silage caused yearly changes in the IEF for cattle.

Table 6.3 Implied emission factors for NH_3 from sector 3B Manure management (in kg NH_3/animal)

Animal type	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**
Cattle	6.8	6.8	5.8	6.5	6.8	7.3	7.4	8.3
Dairy cattle	11.8	11.9	9.5	11.5	11.8	12.0	11.9	13.6
Non-dairy cattle	3.7	3.9	3.6	3.4	3.9	4.3	4.3	4.5
Sheep	0.4	0.4	0.4	0.2	0.1	0.1	0.1	0.1
Swine	3.5	3.4	2.7	2.2	1.9	1.2	1.1	1.1
Goats	1.6	1.6	1.4	1.2	1.2	1.3	1.3	1.3
Horses	4.5	4.5	4.5	4.3	4.0	4.0	4.1	4.1
Mules and asses	IE	IE	IE	IE	2.8	2.8	2.8	2.8
Poultry	0.15	0.16	0.14	0.15	0.12	0.09	0.09	0.09
Laying hens	0.16	0.17	0.17	0.18	0.16	0.13	0.13	0.13
Broilers	0.11	0.12	0.10	0.09	0.06	0.03	0.03	0.02
Turkeys	0.77	1.10	1.29	1.02	0.91	0.87	0.79	0.63
Other poultry	0.32	0.22	0.17	0.20	0.22	0.20	0.23	0.28
Other animals	0.40	0.38	0.32	0.28	0.22	0.24	0.24	0.24
Fur-bearing animals	0.37	0.36	0.29	0.22	0.17	0.19	0.18	0.18
Rabbits	0.42	0.39	0.37	0.40	0.36	0.38	0.38	0.38

NO_x emissions from denitrification processes in animal manure were not considered as a source when the National Emission Ceiling (NEC) was set. However, NO_x emissions from animal housing and storage were included in the national total, as they were considered non-natural.

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 houses produce a relatively large amount of PM_{10} compared with $PM_{2.5}$. The general input data used for these calculations were animal numbers and housing systems taken from the annual agricultural census and environmental permit applications. Emissions of PM_{10} and $PM_{2.5}$ were calculated using the NEMA model.

An overview of the resulting emission factors is presented in Lagerwerf *et al.* (2019). Implied emission factors for PM_{10} and $PM_{2.5}$ are shown in Table 6.4 and Table 6.5.

Table 6.4 Implied emission factors for PM_{10} from sector 3B Manure management (in g PM_{10}/animal)

Animal type	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**
Cattle	85	83	78	79	78	80	81	83
Dairy cattle	115	115	115	120	124	127	128	127
Non-dairy cattle	67	64	57	54	51	50	49	52
Sheep	4	4	4	4	2	2	2	2
Swine	113	112	112	110	104	77	74	72
Goats	19	19	19	19	19	19	19	19
Horses	220	220	220	220	220	220	220	220
Mules and asses	IE	IE	IE	IE	160	160	160	160
Poultry	22	23	26	32	35	40	41	40
Laying hens	15	16	23	34	39	50	51	50
Broilers	27	27	27	27	27	26	26	26
Turkeys	100	98	95	95	95	95	95	94
Other poultry	105	105	105	105	105	102	101	101
Other animals	4	5	5	6	7	6	6	6
Fur-bearing animals	8	8	8	8	8	8	8	8
Rabbits	1	1	1	1	1	1	1	1

Table 6.5 Implied emission factors for $PM_{2.5}$ from sector 3B Manure management (in g $PM_{2.5}$/animal)

Animal type	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**
Cattle	24	23	22	22	21	22	22	23
Dairy cattle	32	32	32	33	34	35	35	35
Non-dairy cattle	19	18	16	15	14	14	13	14
Sheep	1	1	1	1	1	1	1	1
Swine	6	6	6	5	5	4	4	3
Goats	6	6	6	6	6	6	6	6
Horses	140	140	140	140	140	140	140	140
Mules and asses	IE	IE	IE	IE	100	100	100	100
Poultry	2	2	3	3	3	3	3	3
Laying hens	1	1	2	2	2	3	3	3
Broilers	2	2	2	2	2	2	2	2
Turkeys	47	46	45	45	45	45	45	44
Other poultry	5	5	5	5	5	5	5	5
Other animals	2	2	3	3	3	3	3	3
Fur-bearing animals	4	4	4	4	4	4	4	4
Rabbits	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

NMVOC
NMVOC emissions reported under manure management include emissions from manure in animal houses, manure in exterior storage and silage feeding in animal houses. Most NMVOC emissions are emitted during the feeding of silage. The increase in IEF that can be seen with cattle is caused by increased feeding of silage. NMVOC is also released from the storage of manure in animal houses and exterior manure storage. All NMVOC emissions were calculated at a Tier 2 level using the default emission factors from the 2016 EMEP Guidebook, with the NEMA model. The activity data used for these calculations were animal numbers and feeding data as reported by the WUM. Implied emission factors for NMVOC are shown in Table 6.6.

Table 6.6 Implied emission factors for NMVOC from 3B Manure management (in kg NMVOC/animal)

Animal type	1990	1995	2000	2005	2010	2015	2016	2017
Cattle	6.0	6.2	8.0	8.4	12.1	13.3	13.7	14.3
Dairy cattle	8.2	8.0	15.1	16.9	24.1	25.7	25.9	27.0
Non-dairy cattle	4.6	5.1	3.8	3.2	5.0	5.3	5.2	5.2
Sheep	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Swine	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
Goats	0.9	0.8	0.4	0.8	0.9	0.9	0.8	0.8
Horses	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Mules and asses	IE	IE	IE	IE	0.3	0.3	0.3	0.3
Poultry	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Laying hens	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Broilers	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Turkeys	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Other poultry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Other animals	0.1	0.2	0.2	0.2	0.3	0.2	0.2	0.2
Fur-bearing animals	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Rabbits	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 was performed on NH_3 emissions in 2015, and this was updated in 2018 to include manure treatment and NMVOC emissions. Using reassessed uncertainty estimates of activity data (CBS, 2012b) and the judgement of experts, an uncertainty of 20% in total NH_3 emissions from sector 3B Manure management was calculated. Including emissions in sector 3D Crop production and agricultural soils, the combined uncertainty in NH_3 emissions from the agriculture sector was 25%. A Monte Carlo analysis of uncertainties in the total inventory was performed in 2017 and the results are presented in Section 1.7.

The same information sources were used throughout the time series when available. 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.

6.2.7 *Source-specific recalculations*

Animal numbers

With a redefinition of what is and what is not 'an active agricultural farm', adjustments were made to the animal numbers between 2000 and 2004 in the national statistics. To keep them in line with the national statistics small changes to the animal numbers were made (Table 6.7).

Table 6.7 Adjustments in animal numbers to agree with national statistics

Animal type	2000	2001	2002	2003	2004
Cattle					
Dairy cattle	0	0	-11	0	0
Non-dairy cattle	-146	-78	-87	-50	-45
Sheep	-619	-518	-468	-330	-296
Swine	-3	0	0	0	0
Horses	-9	-7	-8	-5	-5

Manure treatment emissions

Manure treatment emissions have been added for all years (Table 6.8). A detailed description of the methodology can be found in the methodology report (Lagerwerf *et al.*, 2019).

Table 6.8 Effect of the addition of manure treatment to the inventory and the change in manure management emissions for NH_3 and NO_x (Gg) compared with the IIR2018

	Gg	1990	1995	2000	2005	2010	2015	2016
Dairy cattle	NH_3	0	0	0	0	0.01	0.17	0.22
	NO_x	0	0	0	0	-0.02	0.01	0.02
Non-dairy cattle	NH_3	0.01	0.03	0.03	0.03	0.04	0.09	0.10
	NO_x	0.08	0.18	0.20	0.16	0.22	0.29	0.31
Swine	NH_3	0	0	0	0	0.07	0.45	0.52
	NO_x	0	0	0	0	-0.02	0.00	0.00
Poultry	NH_3	0	0	0.06	0.05	0.08	0.11	0.11
	NO_x	0	0	0	0	0	0	0
Total	NH_3	0.01	0.03	0.09	0.08	0.20	0.81	0.95
	NO_x	0.08	0.18	0.20	0.16	0.18	0.30	0.33
5B2 Anaerobic digestion	NH_3	0	0	0	0	0.15	0.21	0.24
	NO_x	0	0	0	0	0	0	0

Air scrubber emission factor

Melse *et al.* (2018) showed that combined air scrubbers (usually a biological washer with water curtain) do not achieve an efficiency of 85% NH_3 reduction as assumed previously, but only a reduction of 59%. This finding was incorporated into the emission factors for animal houses, resulting in an increase in NH_3 emissions from 0.04 Gg NH_3 in 2010 to 1.1 Gg NH_3 in 2016.

Particulate matter emissions from sheep

PM emissions from manure management for sheep were added to the inventory. Until 2018, there was no emission factor for PM_{10} and $PM_{2.5}$

for sheep. Now a new emission factor has been introduced, based on the default emission factor for goats, corrected for the time on pasture.

Particulate matter reduction measures in poultry
New information became available on the implementation of PM_{10}- and $PM_{2.5}$-reducing measures in houses with laying hens, turkeys and other poultry for 2015 and 2016. As a result, in other poultry (i.e. ducks) air scrubbers are now considered. This has resulted in a slight decrease in PM_{10} and $PM_{2.5}$ emissions – by 2.7 ton PM_{10} and 0.13 ton $PM_{2.5}$, respectively in 2015 and 3.3 ton PM_{10} and 0.16 ton $PM_{2.5}$ in 2016.

NMVOC emissions
NMVOC emissions were calculated for all years. The detailed calculation method is described in Lagerwerf *et al.* (2019).

6.2.8 Source-specific planned improvements
No improvements are planned.

6.3 Crop production and agricultural soils

6.3.1 Source category description
The category Crop production and agricultural soils (3D) includes emissions related to the agricultural use of land. Emissions were allocated to the following NFR subcategories:
- 3Da1 Inorganic N-fertilizers;
- 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 are allocated to categories 3Da2a, 3Da3, 3Dc and 3De; zinc emissions to category 3Df.

6.3.2 Key sources
Within sector 3D, Animal manure applied to soils (3Da2a) was the largest key source of NH_3 emissions, amounting to 30% of the national total. Inorganic N-fertilisers (3Da1) were also a key source of NH_3, making up 8% of the national total. Animal manure applied to soils (3Da2a, 5%) and inorganic N-fertilizers (3Da1, 4%) were key sources of NO_x. For NMVOC emissions animal manure applied to soils (3Da2a, 6%) and farm-level agricultural operations including storage, handling and transport of agricultural products (3Dc, 5%) were key sources. For emissions of PM_{10} and $PM_{2.5}$ the crop production and agricultural soils sector contained no key sources.

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 $PM_{2.5}$ and the other heavy metal Zn 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			Other heavy metals
	NO_x	NMVOC	NH_3	$PM_{2.5}$	PM_{10}	TSP	Zn
Year	Gg	Gg	Gg	Gg	Gg	Gg	Mg
1990	**45.6**	**57.1**	**233**	**0.11**	**0.76**	**0.76**	**0.00**
1995	43.7	25.8	109	0.11	0.75	0.75	0.00
2000	37.0	27.1	83.0	0.11	0.76	0.76	0.00
2005	31.0	24.1	69.2	0.11	0.77	0.77	6.85
2010	28.1	23.2	51.0	0.11	0.76	0.76	4.48
2015	29.4	26.0	53.8	0.11	0.73	0.73	4.48
2016	29.0	28.4	52.8	0.11	0.71	0.71	4.48
2017	**30.0**	**28.2**	**55.9**	**0.10**	**0.69**	**0.69**	**4.48**
1990–2017 period[1]	-15.6	-28.9	-177	-0.01	-0.07	-0.07	4.48
1990–2017 period[2]	-34%	-51%	-76%	-8%	-9%	-9%	

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

N emissions
Emissions of NH_3 decreased by 76% between 1990 and 2017, 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.

NO_x emissions reduced by 34% between 1990 and 2017, mainly as the result of lower N input through inorganic N-fertiliser and reductions in grazing time and manure application.

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

NMVOC
Like NH_3, NMVOC emissions show a decrease (51%) between 1990 and 2017 due to changing manure application methods to reduce the emission 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 fell by 35% from 2005 to 2017, due to a reduction in use. Before 2005, there were no zinc emissions related to pesticides then in use.

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

N emissions
For N emission calculations in sector 3D, activity data were calculated from N excretion in sector 3B minus N emissions from animal housing, manure treatment and exterior storage (Figure 6.2). After subtracting the N in manure removed from agriculture (exported), the remaining N was allocated to grassland and arable land. Implementation grades of application techniques were derived from the agricultural census. The associated NH_3 emission factors were reported in Lagerwerf *et al.* (2019). NO_x emissions related to manure, inorganic N-fertiliser and sewage sludge application, compost use and the grazing of animals were calculated using the EMEP default emission factor.

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 emission factor. In recent years, the amount of applied urea fertiliser has increased and a growing share is used as liquid urea 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 1990–2017 time series, as described in the methodology report of Lagerwerf *et al.* (2019). The relevant subcategories and the emission factors for each subcategory were originally published in van Bruggen *et al.* (2017a).

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 caused by crop ripening, a fixed estimate of 1.8 Gg NH_3/year was reported.

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

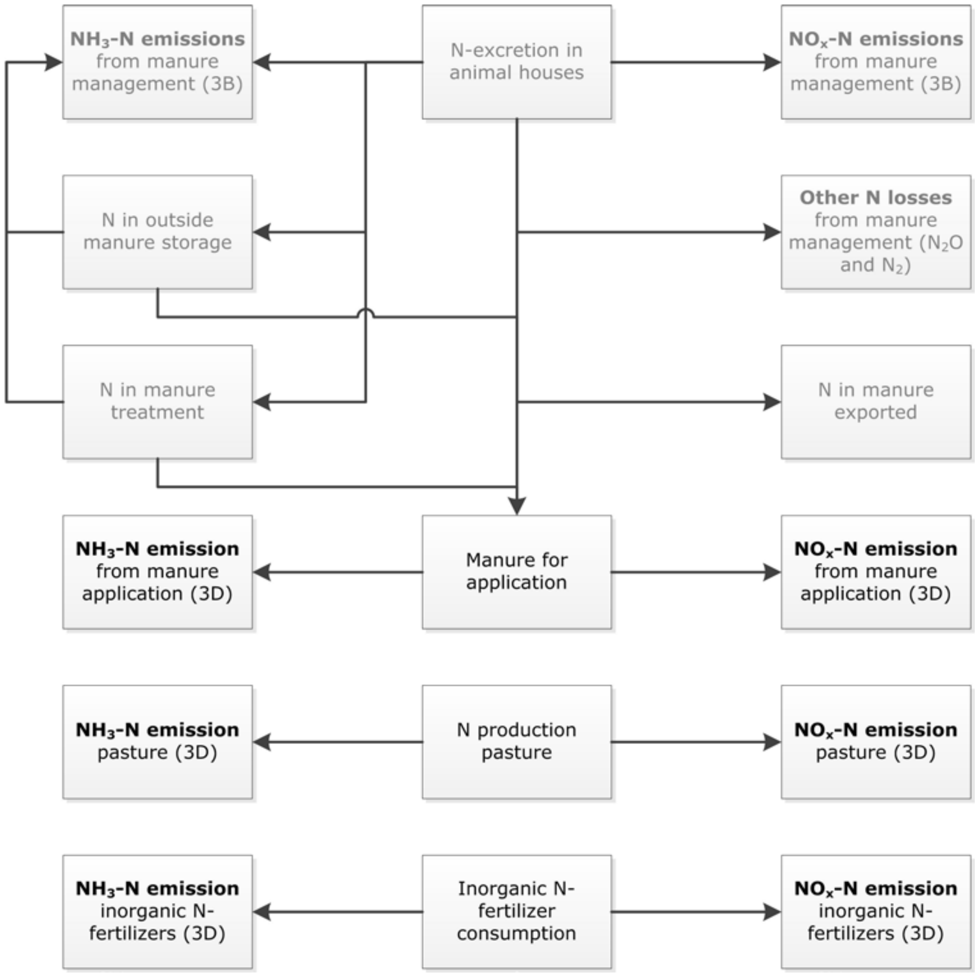

Figure 6.2 Nitrogen flows in relation to NH3 and NOx emissions where boxes with black letters highlight the emissions included in 3D Crop production and agricultural soils and boxes with grey letters are included in 3B Manure management.

Table 6.10 Implied emission factors for NH3 from 3D Crop production and agricultural soils (in kg NH3/kg N supply)

Emission source	1990	1995	2000	2005	2010	2015	2016	2017
Application of inorganic N-fertilisers	0.04	0.04	0.04	0.05	0.04	0.05	0.04	0.04
Application of animal manure	0.50	0.20	0.19	0.18	0.13	0.12	0.12	0.13
Application of sewage sludge	0.29	0.08	0.09	0.10	0.10	0.10	0.10	0.10
Application of other organic fertilisers (compost)	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07
Urine and dung deposited by grazing animals	0.08	0.08	0.04	0.03	0.03	0.03	0.03	0.03
Crop residues	0.05	0.05	0.04	0.03	0.03	0.03	0.03	0.03
Crop ripening	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 emission factors were applied (Lagerwerf *et al.*, 2019). PM from other agricultural processes (e.g. the supply of concentrate feed to farms, the use of pesticides and haymaking) was estimated using fixed amounts (Lagerwerf *et al.*, 2019). Crop harvesting was calculated on the basis of acreage data from the agricultural census and EMEP default emission factors (EMEP/EEA, 2016).

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, and cultivated crops. All were calculated using EMEP default emission factors, using a Tier 2 method. Only emissions from cultivated crops were calculated using the Tier 1 method.

Zinc
Zinc emissions were based on the amount of pesticide used in agriculture as calculated by the National Environmental Indicator Pesticides (NMI3) model (Kruijne *et al.*, 2012).

Uncertainties and time series consistency
A propagation of error analysis was performed on NH_3 emissions in 2015, with an update in 2018 to include NMVOC emissions. Using reassessed uncertainty estimates of activity data (CBS, 2012b) and the judgement of experts, an uncertainty of 38% was calculated for NH_3 emissions following animal manure application, 37% for inorganic N-fertiliser use and 56% for grazing emissions. The total uncertainty in ammonia emissions from sector 3D Crop production and agricultural soils then amounts to 29%. Including the emissions in sector 3B Manure management, the combined uncertainty in NH_3 emissions from agriculture comes to 25%. A Monte Carlo analysis on the uncertainties of the total inventory was performed in 2017 and the results are presented in Section 1.7.

The same information sources were used throughout the time series when available. 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.

6.3.5 *Source-specific QA/QC and verification*
This source category is covered in Chapter 1 under general QA/QC procedures.

6.3.6 *Source-specific recalculations*
Animal numbers
With a redefinition of what is and what is not ‘an active agricultural farm’, adjustments were made to the animal numbers between 2000 and 2004

in the national statistics. To keep them in line with the national statistics small changes to the animal numbers were made (Table 6.2).

Inorganic N-fertilisers activity data
New data became available for inorganic N-fertilisers in 2016. This resulted in a reduction of 2.4 Gg NH_3 from inorganic N-fertilisers in 2016.

NMVOC emissions
NMVOC emissions were calculated for all years. The detailed calculation method is described in Lagerwerf *et al.* (2019).

6.3.7 Source-specific planned improvements
No improvements are planned.

7 Waste (NFR 5)

7.1 Overview of the sector

Waste sector emissions (Table 7.1) include those 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 Waste-water handling;
- 5E Other waste.

Solid waste disposal on land (5A)
Emissions from this source category comprise those from landfills and those from extracted landfill gas. Since extracted landfill gas is mostly used for energy purposes, these emissions are allocated to the energy sector (source category Other: Stationary (1A1a)).

Composting and anaerobic digestion (5B)
Emissions from this source category comprise those from facilities for the composting and/or fermenting of separately collected organic waste for composting and/or biogas production. During processing, relevant emissions of NH_3, SO_x and NO_x occur. The biogas produced is used for energy purposes, so these emissions are allocated to the energy sector (source category Small combustion (1A4)).

Waste incineration (5C)
Emissions from 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 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). These emissions, therefore, are included in the source category Commercial/Institutional: Stationary (1A4ai).

Waste-water handling (5D)
The data on emissions from industrial and urban waste-water treatment plants (WWTP) come from the AERs made by individual treatment plants/companies. WWPTs produce methane, amongst other pollutants. Around 80% of this methane is captured and is either used in energy production or flared. For this reason, WWPT emissions are reported under the source category Commercial/Institutional: Stationary (1A4ai).

Other waste (5E)
Emissions from the Other waste source category comprise those from Waste preparation for recycling, Scrap fridges/freezers and Accidental building and car fires.

7.1.1 *Key sources*
The source category 5E (Other waste) is a key source of $PM_{2.5}$ and total PAH emissions in both trend (increase) and level assessments.

7.1.2 *Overview of shares and trends in emissions*
An overview of the trends in emissions is shown in Table 7.1. Emissions from the waste sector are low. This is mainly because most emissions from incineration are reported under the Energy sector.

With the exception of NMVOC and Hg, emissions have increased since 1990. With respect to NH_3, this increase was mainly caused by an increase in the industrial composting of household organic waste in the years 1990–1994. For all other pollutants, this increase has been caused by gradual increased activity. The increase is sometimes dampened by the gradual implementation of abatement technology for some sources.

Table 7.1 Overview of emission totals in the Waste sector (NFR 5)

	Main pollutants		Particulate matter			Other	Heavy metals/POPs	
	NMVOC	NH_3	TSP	$PM_{2.5}$	PM_{10}	CO	Hg	DIOX
Year	Gg	Gg	Gg	Gg	Gg	Gg	Mg	g I-Teq
1990	**2.39**	**0.15**	**1.03**	**0.48**	**0.51**	**6.70**	**0.06**	**1.57**
1995	2.28	0.43	1.10	0.51	0.55	7.16	0.07	2.01
2000	2.02	0.44	1.11	0.52	0.56	7.30	0.10	2.02
2005	1.69	0.45	1.07	0.49	0.53	7.00	0.09	1.86
2010	1.62	0.53	1.21	0.56	0.60	8.08	0.05	1.92
2015	1.44	0.56	1.20	0.55	0.59	7.94	0.01	1.88
2016	1.42	0.60	1.21	0.55	0.60	8.01	0.01	1.91
2017	**1.40**	**0.61**	**1.23**	**0.56**	**0.61**	**8.10**	**0.01**	**1.96**
1990–2017 period[1]	-0.99	0.46	0.20	0.09	0.09	1.41	-0.04	0.39
1990–2017 period[2]	-41%	301%	18%	18%	20%	21%	-78%	25%

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

7.1.3 *Methodological issues*
The methodology used to calculate most of the emissions from the source categories under the Waste sector are described in Peek *et al.* (2019). The exceptions are emissions from Cremations, Accidental building and car fires, and Bonfires, whose methodologies are explained in Jansen (2019), and the source Livestock manure digestion, which is explained in Lagerwerf *et al.* (2019).

There are no specific methodological issues.

7.1.4 *Uncertainties and time series consistency*

As explained in Paragraph 1.6.3, the Netherlands implemented an Approach 2 methodology for uncertainty analyses in 2018. This methodology is used for uncertainty analyses 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

NFR source category	**Pollutants uncertainty**					
	NH_3	NO_x	SO_x	NMVOC	PM_{10}	$PM_{2.5}$
5A	NA	NA	NA	NA	NA	NA
5B	55%	102%	103%	NA	NA	NA
5C	336%	359%	317%	359%	351%	358%
5D	NA	NA	NA	NA	NA	NA
5E	237%	199%	205%	199%	195%	194%
Total Waste sector	**66%**	**105%**	**147%**	**187%**	**171%**	**171%**

The Approach 2 uncertainty analysis shows relatively high uncertainties at the level of the source categories. However, since these source categories have no key sources for these pollutants and therefore their contribution to the uncertainty at national level will be relatively small, there is no reason for prioritising methodological improvements.

7.1.5 *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.

7.1.6 *Source-specific recalculations*

In the source category Other waste (5C2), the source Bonfires has been added (see Section 1.4).

7.1.7 *Source-specific planned improvements*

There are no source-specific planned improvements.

7.2 Solid waste disposal on land (5A)

7.2.1 *Source-category description*

The source category of Solid waste disposal on land (5A) comprises the direct emissions from landfills and from captured landfill gas.

Extracted (captured) landfill gas is mainly used as an energy source (combined heat and power production or transferred to the natural gas network) and a relatively small amount is flared. For this reason, emissions from extracted landfill gas are included in the energy sector (source category Other: Stationary (1A1a)). The remaining fraction of the landfill gas emits to the atmosphere.

With regard to the direct emission of landfill gas, only NMVOCs are of relevance. The individual compounds that form NMVOCs mainly originate from volatile organic compounds that were dumped in the past as part of the waste. 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).

Included in this source category are 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 from 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 the waste. From this information, the amount of methane is calculated using a methane conversion factor (Table 7.3).

The amount of captured and combusted landfill gas (mainly for energy purposes) is collected by the Working Group on Waste Registration (WAR). All landfill operators report these data to WAR.

Its assumed that 10% of the non-extracted methane will be oxidised in the top layer of the landfill.

Table 7.3 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; thereafter constant at 0.5	Oonk *et al*. (1994)
Degradable speed constant k	0.094 from 1945 to 1989 (half-life 7.5 yr); from 1990 reducing to 0.0693 in 1995; thereafter constant at 0.0693 (half-life 10 yr); from 2000 reducing to 0.05 in 2005; thereafter constant at 0.05 (half-life 14 yr)	Oonk *et al*. (1994)
$DOC_{(X)}$ = concentration of biodegradable carbon in waste that was dumped in year x	132 kg C/ton dumped waste from 1945 to 1989; from 1990 linear, reducing to 125 kg C/ton in 1995; 120 kg/ton 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 CH4 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	

7.2.2 *Overview of shares and trends in emissions*

NMVOC emission levels related to this source category are relatively low (at 1.47 Gg and 0.32 Gg in 1990 and 2017, respectively).

Landfilling of waste and particularly of combustible waste products and biodegradable material is discouraged in the Netherlands. Due to this, the amount of waste landfilled has dropped considerably, from 13.9 Mton in 1990 to only 2.9 Mton in 2017 (-79%). In addition, due to the separation of biodegradable materials, the amount of biodegradable carbon in the waste has dropped from 130.8 kg C per ton waste in 1990, to 56.0 kg C per ton in 2017 (-57%). These two developments have had a clear effect on methane (and also NMVOC) production by landfill sites, which has decreased by 81% during the same period. This downward trend is expected to continue in the future.

7.2.3 *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 based on the IPCC guidelines. The fractions were based on measurements of the composition of landfill gas. An overview of the emission factors used is provided in Table 7.4.

For each waste site, landfill site operators systematically monitor the amount of waste dumped (weight and composition). Since 1993, monitoring has been conducted by weighing the amount of waste dumped using weighbridges. Since 2005, landfill operators have been obliged to register their waste on the basis of EURAL codes (EC-Directive 75/442/EEG).

Table 7.4 Landfill gas emission factors

Compound	Emission factors and units		
	Combusted landfill gas		Emitted landfill gas
	Flared	Gas engine	
Total hydrocarbons (incl. methane)			0.389803 kg/m³
Hydrocarbons (C_xH_y)	0.27% hydrocarbons	6 g/m^3	
Dioxins	0.9E^{-9} g/m^3	0.3E-9 g/m^3	
SO_x (based on all sulphur)			104 mg/m^3
NO_x (as NO_2)	0.3 g/m^3	3 g/m^3	
CO	2.7% C	3.4 g/m^3	
Soot	0.05% hydrocarbons		
CO_2 (biogenic)	total C minus CO minus soot		
Other aliphatic non-halogenated hydrocarbons			700 mg/m^3
Dichloromethane			20 mg/m^3
Trichloromethane			1 mg/m^3
Chlorodifluormethane (HCFC-22)			10 mg/m^3
Dichlorodifluormethane (CFC-12)			20 mg/m^3
Trichlorofluormethane (CFC-11)			5 mg/m^3
Chloroethene			10 mg/m^3
Cis-1,2-Dichloroethene			1 mg/m^3
1,1,1-Trichloroethene			2 mg/m^3
Trichloroethene (Tri)			10 mg/m^3
Tetrachloroethene (Per)			10 mg/m^3
Chloropentafluorethane			1 mg/m^3
1,2-dichloro-1,1,2,2-tetrafluoroethane (CFC-114)			2 mg/m^3
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)			1 mg/m^3
Mercaptan, non-specified			10 mg/m^3
Benzene			7 mg/m^3
Toluene			120 mg/m^3
H_2S			100 mg/m^3

7.3 Composting and anaerobic digestion (5B)

7.3.1 Source category description

The source category Composting and anaerobic digestion (5B) comprises emissions from the following categories:

- 5B1 Composting;
- 5B2 Anaerobic digestion at biogas facilities.

Emissions from this source category originate from facilities for the composting and/or fermenting of separately collected organic household 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 (biogas production). Additionally, part of the manure produced by pigs and cattle is used in anaerobic digesters (biogas production).

The amounts of biodegradable waste processed by composting and fermentation plants (per year) are taken from the annual report by the Working Group on Waste Registration (WAR). The data from the WAR are based on questionnaires filled in by operators. When an operator does not fill in a questionnaire, the estimated amount processed is based on data from the National Registration Waste Products (Landelijk meldpunt afvalstoffen, LMA). The LMA tracks all waste transport in the Netherlands. Table 7.5 provides an overview of the total amounts of separately collected organic household and horticultural waste for composting and digestion.

Table 7.5 Overview of total separately collected organic waste for composting and digestion.

	Amounts of separate collected organic wastes for composting and digestion. (Gg)	
Year	**Horticulture**	**Household (garden, fruit and vegetable)**
1990	0	228
1995	2,057	1,454
2000	2,475	1,568
2005	2,784	1,367
2010	2,437	1,220
2015	2,077	1,357
2016	2,400	1,431
2017	2,442	1,492

Activity data on the anaerobic digestion of livestock manure are based on registered manure transports (data from the Netherlands Enterprise Agency, RVO) and its N content.

Composting (5B1)

During composting, biodegradable organic waste is converted into compost. This process is carried out in enclosed facilities (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 organic horticulture waste are carried out mostly in the open air, in rows which are regularly turned over to optimise aeration.
Composting generates small emissions of NH_3.

Anaerobic digestion (5B2)
Emissions from anaerobic digestion come 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, which release no 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)).

7.3.2 *Overview of shares and trends in emissions*

Composting
Emissions of NH_3 related to composting are relatively small (0.05 Gg and 0.23 Gg for 1990 and 2017, respectively). Therefore, shares and trends in these emissions are not elaborated here.

Anaerobic digestion
Emissions related to anaerobic digestion date from 1994, when the first digestion plants started operations. NH_3, NO_x and SO_x emission levels related to anaerobic digestion are relatively low (0.03 Mg, 2.2 Mg and 0.13 Mg, respectively, in 1994, and 0.25 Gg, 0.10 Gg and 0.006 Gg, respectively, in 2017). Therefore, shares and trends in these emissions are not elaborated here.

7.3.3 *Emissions, activity data and (implied) emission factors*

Composting
The emission factors used for composting come from the sparse literature on emissions from the composting of separated biodegradable and other organic waste. It appears that hardly any monitoring is conducted at the biobed reactors. The literature cannot be considered relevant due to the clearly diverse operational methods used in the Netherlands. The emission factors 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 NH_3 from composting an emission factor of 200 g/Mg of biodegradable and other organic waste is used.
Most of the separate collected organic waste is used in composting. Table 7.6 provides an overview of the total amounts of organic household and horticultural waste that is treated in composting plants.

Table 7.6 Overview of amounts of composted organic waste

	Amounts of composted organic waste (Gg)	
Year	**Horticulture**	**Household (garden, fruit and vegetable)**
1990	0	228
1995	2,057	1,409
2000	2,473	1,498
2005	2,770	1,326
2010	2,424	1,066
2015	1,992	882
2016	2,321	966
2017	2,335	1,027

Anaerobic digestion
The anaerobic digestion of biodegradable domestic waste (i.e. garden waste, horticulture waste and household waste such as fruits and vegetables) and of livestock manure is done in different specialised plants. These are regarded as different sources of emissions and are therefore calculated separately. Most of the NH_3 emissions come from the digestion of livestock manure.

The emission factors used for the anaerobic digestion of biodegradable domestic waste come 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 the anaerobic digestion of biodegradable domestic waste the following emission factors 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.

Activity data for anaerobic digestion from organic domestic waste are based on the amount declared to the Landelijk Meldpunt Afvalstoffen (LMA), the hotline for national waste transport, as described under composting.

A relatively small amount of the separate collected organic waste is used in digestion. Table 7.7 provides an overview of the total amounts of organic household and horticultural waste that are treated in digestion plants.

Table 7.7 Overview of the amounts of composted organic waste

Year	Amounts of digested organic waste (Gg)	
	Horticulture	Household (garden, fruit and vegetable)
1990	0	0.0
1995	0	44.4
2000	0	70.0
2005	13.9	41.0
2010	13.0	154.1
2015	84.9	474.7
2016	78.4	464,7
2017	106.5	465.0

The emission factors used for the anaerobic digestion of livestock manure come from a literature study carried out by Melse and Groenestein (2016) aimed at compiling the most suitable emission factors for the different manure treatments used under conditions in the Netherlands. For the anaerobic digestion of biodegradable domestic waste the following emission factors have been used:

- NH_3 from anaerobic digestion of pigs manure, 0.02 kg/kg N;
- NH_3 from anaerobic digestion of cattle manure (excl. veal calves), 0.01 kg/kg N.

The emission calculation methodology can be found in Lagerweij *et al.* (2019). The calculations are done with the NEMA model for calculating agricultural emissions (van Bruggen *et al.*, 2019).

Activity data on the amount of manure that has been treated and its N content is estimated based on registered manure transports (data from the RVO).

7.4 Waste incineration (5C)

7.4.1 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 heating. These categories, therefore, are reported under the energy sector (source category Public electricity and heat production (1A1a)) or, if used as fuel, under the specific Industry category in NFR-sector 2.

Emissions from cremations (category 5C1bv) originate from the incineration of human remains (process emissions) and from combustion emissions. The emissions of natural gas used are reported under the energy sector (source category Commercial and institutional services (1A4ai)). Since 2012, all cremation centres have complied with the Dutch Atmospheric Emissions Guideline (NeR) and are equipped with technological measures to reduce emissions.

There is no incineration of carcasses or slaughter waste in the Netherlands. This is processed to reusable products, including biofuels.

Because of a ban on other waste incineration (5C1bvi) and open waste burning (5C2), these emission sources are considered not to occur in the Netherlands.

However, according to tradition a number of holidays are brightened by bonfires. These have a strong cultural and regional background, most such celebrations taking part only 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. Bonfires are reported under Open burning of waste (5C2).

Table 7.8 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.

Table 7.8 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
Saint-Maarten	11 November	The most Northern provinces and the most southern province

7.4.2 *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.

7.4.3 *Emissions, activity data and (implied) emission factors*

Cremations (5C1bv)

Activity data

The number of cremations in the Netherlands is published online by the Dutch National Association of Crematoria (LVC), at www.lvc-online.nl (LVC, 2019).

An overview of the number of cremations in compliance with the NeR is given in Table 7.9.

Table 7.9 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*
2011	135,741	78,594	59	86**
2012	140,813	83,379	59	100
2016	148,898	93,907	63	100
2017	150,027	96,688	64	100

* Interpolation using year 2011.
** Calculation based on an accurate list of crematoria under the NeR (LVC, 2017).

Emission factors

The emission factor for mercury is based on sales of amalgam combined with results from model (KUB) calculations of the emission factor for mercury per age category (Coenen, 1997).

All the mercury in amalgam is assumed to become volatilised during cremation and subsequently emitted, together with the flue gas if no NeR measures are in place. The emission factors used for this situation are:

- 1.15 gHg/cremation for 1995*;
- 1.37 gHg/cremation for 2000*;
- 1.44 gHg/cremation for 2002*;
- 1.73 gHg/cremation from 2010 onwards.

* For the intermediate years, emission factors have been linearly interpolated.

The implementation of NeR measures has been shown to lead to a significant reduction in mercury emissions. Measurements that were taken, when crematoria were in compliance with the NeR, resulted in concentrations of between 0.001 and 0.004 mgHg/m^3 (Elzenga, 1996). Based on these measurements, an emission factor of 0.1 gHg/cremation

(0.05 mgHg/m^3 fume) was assumed for crematoria in compliance with the NeR.

PM_{10} and $PM_{2.5}$ are calculated as a fraction of TSP. Due to the lack of information, the fraction for both was set to 1.
When no emission reduction measures are in place, an emission factor of 100 g TSP/cremation is used (Elzenga, 1996). The NeR measure for emission reduction requires the use of a special filter (cloth or electrostatic). Emission levels with the use of cloth filters were found to be 25 g TSP/cremation or less (Elzenga, 1996). However, measurements carried out at the crematorium in the Dutch city of Geleen showed concentrations of <6 mg TSP/m^3 (~13 g TSP/cremation) and, at the crematorium in Bilthoven, concentrations of less than 0.7 mg TSP/m^3 were measured. For facilities with NeR measures in place, calculations were done under the assumption of an emission level of 10 g TSP/cremation.

For crematoria without NeR measures in place, an emission factor for dioxins of 4 ug I-TEQ/cremation was assumed on the basis of measurements taken at three crematoria in the Netherlands (Bremmer *et al.*, 1993).

The NeR emission reduction measure also reduces dioxin emissions. Measurements taken at the crematoria of Geleen and Bilthoven showed respective concentrations of 0.024 ng I-TEQ/m^3 (0.052 ug I-TEQ/cremation) and 0.013 ng I-TEQ/m^3 (0.028 ug I-TEQ/cremation). However, in Germany, the current limit (Verordnung über Anlagen zur Feuerbestattung; Bundes-Immissionsschutzverordnung 27 (27th BImSchV)) for installations equipped with filters is 0.1 ng I-TEQ/m^3 (or 0.2 ug I-TEQ/cremation).
For installations with NeR measures in place, calculations are done with an emission factor of 0.2 ug I-TEQ/cremation.

7.5 Open burning of waste (5C2)

Activity data

The actual number of bonfires in the Netherlands fluctuates per year mainly depending on how strongly the tradition is respected and the local weather at the time.

The activity data used come largely from specific websites, local newspapers and news articles and sometimes permits. Estimates of the yearly amounts of pallets and pruning wood burned are based on this information and supplemented by expert judgement.

Easter fires

Table 7.10 provides an overview of the total amount (m^3) of pruning burned in the four large Easter fires (see http://www.paasvuurdijkerhoek.nl/wordpress/uitslagen).

Table 7.10 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**	**Beuseberg**	**Holterbroek**
2015	5,308	5,783	2,289	1,634
2016	6,611	5,714	2,384	2,260
2017	7,960	5,767	3,477	2,351

All other Easter fires in the Netherlands are much smaller and the occurrence of these bonfires is very dependent on local initiatives and organisation. In the majority of the Netherlands, no permits are needed if the volume of the bonfire is below 1,000 m^3. Picture 7.1 shows the 2012 Easter fire in Espelo, which has twice been registered as a World Record in the *Guinness Book of World Records*.

Picture 7.1 Espelo's 2012 Easter fire

As a result, the number of (small) Easter fires and volumes can only be estimated from local newspaper reports and the number of inhabitants per province. The average volume of the smaller Easter fires is estimated to be 250m^3, the number of Easter fires is estimated to be roughly 400 and is linked to the number of inhabitants per province.

New Year's Eve fires

The New Year's Eve bonfires at Scheveningen and Duindorp are made of pallets (see Picture 7.2). The volume of pallets burned can be measured accurately because of the fierce competition between the two neighbourhoods. Table 7.11 provides an overview of the amount of pallets burned is these two fires.

Table 7.11 Amount of pallets burned at main New Year's Eve bonfires

	Total amount of pallets per New Year's Eve fire (m^3)	
Year	**Duindorp**	**Scheveningen***
2015	9,453	8,695
2016	9,616	8,848
2017	9,782	9,000

* Like the Easter fire at Espelo, both the Scheveningen and Duindorp bonfires have been officially registered as the largest bonfire by the *Guinness Book of World Records*, in different years.

All other bonfires on New Year's Eve in the Netherlands are much smaller and the occurrence of these bonfires is very dependent on local initiatives and organisation. In the majority of the Netherlands, no permits are needed if the volume of the bonfire is below 1,000 m^3.

Picture 7.2 The piles of pallets at Scheveningen and Duindorp for the 2018 New Year's Eve bonfires.

As a result, the total volume of wood burned in New Year's Eve fires is estimated to be 25,000 m^3 (around 19,000 m^3 for Scheveningen and Duindorp and 6,000 m^3 for the other, smaller non-registered bonfires).

Meierblis

Based on local newspaper reports it is estimated that around 7 large fires and around 65 smaller fires are lit every year. It is estimated the large bonfires together account for about 3,500 m^3 of wood and the smaller bonfires amount to 16,250 m^3 in total.

Luilak

Based on local newspaper reports it is estimated that the number of bonfires is about 10 and the amount of wood burned in each fire is restricted to 16 m^2 max., resulting in a total amount of about 640 m^3.

Saint-Maarten

Based on regional newspaper reports and expert judgement it is estimated that the volume of wood burned is 5,000 m^3.

Christmas tree burning

Based on regional newspaper reports and expert judgement it is estimated that the volume of wood burned is 5,000 m^3.

Emission factors

Wood density

The density of pruning wood is based on a Belgian report from the Flemish government on waste from 2014 (www.lne.be) and is equal to 0.15 ton/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 ton/m^3.

Heating value of pallets

The heating value of pallets has been derived from the kachelmodel Jansen (2010). This is equal to 15.6 MJ/kg.

A distinction in emission factor is made between the burning of pallets and the burning of pruning wood. The emission factors for the burning of pallets have been derived from EMEP/EEA, 2016 (NFR Category 1A4 - table 3.39 open fireplaces burning wood), the emission factors 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 Waste-water handling (5D)

WWPTs produce methane, among other emissions. About 80% of this methane is captured and used in energy production or is flared. Emissions from WWPTs, therefore, are reported under the source category of Small combustion (1A4).

7.7 Other waste (5E)

7.7.1 Source category description

The source category Other waste (5D) comprises the following emission sources:

- Sludge spreading;
- Waste preparation for recycling;
- Scrap fridges/freezers;
- Accidental building and car fires.

Sludge spreading
WWTPs produce sewage sludge. In the Netherlands, when this sewage sludge meets the legal environmental quality criteria, it can be used as fertiliser in agriculture. In line with the EMEP/EEA Guidebook, emissions from this source are reported under Sewage sludge applied to soils (3Da2b).

The remainder of the sewage sludge is recycled or incinerated. To minimise the cost of transport, the sewage sludge is mechanically dried at the WWTP. The dried sludge is then transported to one of the waste recycling/incineration plants. Emissions from this source are included in Municipal waste incineration (5C1a) and reported in the sector on energy (source category Public electricity and heat production (1A1a)).

The process for the drying of sludge by spreading it in the open air is not applied in the Netherlands. However, in 2013 a survey was done to explore the possibility of drying sewage sludge in specially designed greenhouses using solar energy and/or residual heat from combustion processes.

Waste preparation for recycling
Waste preparation for recycling is done mainly by companies that process waste to turn it into new base materials.

Scrap fridges/freezers
Fridges and freezers that have been written off are collected separately from other waste and sent to specialised recycling centres. During the recycling process, a small amount of NMVOC is emitted from the fridges' and freezers' insulating layer.

Accidental building and car fires
Mainly due to accidents (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 were based on environmental reports by large industrial companies. Where necessary, extrapolations were made to produce emission totals per industry group, using either both IEFs and production data or production data based on environmental reports in combination with specific emission factors (as described in Section 5.1.3 under Methodological issues).

Scrap fridges/freezers
When recycling scrapped fridges/freezers, a small amount of NMVOC (as dichlorodifluoromethane (CFC12), used as blowing agent) is emitted from the insulation material. In the calculations, an emission factor of 105 g CFC12 per recycled fridge/freezer was used.

Since 2010, data on the numbers of scrapped fridges/freezers have been based on the annual Wecycle monitoring report on the collecting and recycling of e-waste (electrical appliances and energy-saving lighting). Wecycle reports the total weight of scrapped fridges/freezers, and its monitoring reports are published online at www.wecycle.eu. In the past, these data were supplied by the NVMP (Dutch Foundation Disposal Metalelectro Products), but the NVMP merged with Wecycle in 2010.

In 2009, the NVMP reported both the collected tonnage and number of fridges/freezers. From this report, the average weight of a single fridge/freezer was calculated. This average weight was used to calculate the number of scrapped fridges/freezers for the years before and from 2009.

Accidental building and car fires
Emissions from accidental building and car fires are relatively small.

Emission factors: Building fires
The emission factor for house fires in the EEA Guidebook (5.E, tables 3.3 to 3.5) is based on a Norwegian study and therefore seems inappropriate for the Dutch situation, as houses built in Norway contain more wood and Norway is more rural.

To estimate the amount of combustible material in an average Dutch house, a study of the Dutch house stock by TNO (2017) was used, omitting the non-combustible materials, such as concrete, bricks and insulation materials, which constitute 90% of the total. Excluding the interior of the house, this results in about 10.3 Mg of combustible material (8.6 Mg wood/triplex and 1.7 Mg plastics). Based on expert judgement the combustible interior material (cabinets, floor coverings, beds, etc.) is estimated to be around 4.5 Mg, making a total of 14.8 Mg.

According to multi-year statistics on the number of fatal house fires in the Netherlands (Fatal house fires 2017), in about 55% of the cases studied, the destruction is limited to a single room, in 17% of cases it is limited to a single floor and in 28% of cases the entire house is burned down. Table 7.12 provides an overview of the estimated amounts of combustible material being burned, based on an average Dutch situation of a one-family home consisting of 3 floors and 4 rooms per floor.

Table 7.12 Overview of the average amount of material burned in accidental house fires in the Netherlands

Destruction by fire (limited to)	Combustible material burned (%)	Combustible material burned (Mg)
One room	10	1.48
One floor	33	4,9
Complete house	100	14.8

When these data on fire destruction are combined, they result in the following amount of combustible materials burned:

1.48 x 55% + 4.9 x 17% + 14.8 x 28% = 5.8 Mg.

It is estimated that half of the interior consists of wood and the other half is believed to consist of a mixture of different plastics.

Emissions from the combustible construction materials and interior materials are calculated using the emission factors from EMEP/EEA (2016: table 3.39 on small combustion in chapter 1A4).

Emission factors: Car fires
For car fires the emission factor has been derived from EMEP/EEA (2016: chapter 5.E, table 3.2).

Activity data: Car and building fires
The number of houses and cars damaged by fire was reported annually by Statistics Netherlands (CBS Statline) until 2013. Those numbers are used for the time series 1990–2013. For the number of indoor fires in the years 2014 and later, new statistics collected via a central emergency system registering the deployment of fire brigades were used. These new data are also reported via Statistics Netherlands.

For the number of car fires in the years 2015 and 2016, a news article was used, giving the number of car fires for these two years. This article refers to 'alarmeringen.nl' and seems to be reliable, based on expert judgement. The year 2014 was interpolated from 2013 and 2015.

On basis of the total amount of cars in the Netherlands and the annual average percentage of fire-damaged cars an estimate was made for 2017.

8 Other

8.1 Overview of the sector

The Other sources sector (NRF 6) includes emissions from sources that cannot be placed under a specific NFR. It therefore consists of just one source category: 6A Other sources.

8.2 Other sources (6A)

8.2.1 Source category description

This source category includes emissions from the following sources:

- Privately owned livestock (horses and ponies, sheep, mules and assess);
- Human transpiration and respiration;
- Manure sold and applied to private properties or nature areas;
- Domestic animals (pets).

Privately owned livestock

Emissions from horses and ponies are split between horses and ponies kept in an agricultural setting and those kept in a non-agricultural setting (animals privately owned or at riding schools). Emissions from horses and ponies in an agricultural setting are reported under the Agricultural sector (3B), while emissions of NH_3, NO_x and PM resulting from the management of horse and pony manure in a non-agricultural setting are reported under Manure management (3B) and calculated using NEMA (see Section 6.2).

Since 2016, privately owned sheep, mules and asses have also been included in sector 6A, following a definition change of agriculture within the Agricultural census.

Human transpiration and respiration

Through the consumption of food, nitrogen (N) is introduced to the human system. Most nitrogen is released through faeces and urine into the sewage system. Part of the ammonia is released through sweating and breathing is calculated within this emission source.

Manure sold and applied to private properties or nature areas

In the Netherlands, a small part of the manure from agriculture is used (and produced) for non-agricultural purposes on privately owned land and in nature areas. Additionally, a small number of cattle are used for nature management (grazing in nature areas). From this non-agricultural source, emissions of NH_3 and NO_x are due to the storage and application of the manure and from grazing.

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*

Table 8.1 Key sources of Other sources (6A)

	Category / Subcategory	Pollutant	Contribution to total of 2016 (%)
6A	Other sources	NH_3	7.3

8.2.3 *Methodological issues*

The methodology used for calculating emissions from the sources Human transpiration and respiration and Domestic animals are described in Jansen *et al.*, (2019). The methodology for calculating emissions from the sources Privately owned livestock and Manure sold and applied to private properties or nature areas can be found in Lagerwerf *et al*. (2019).

There are no specific methodological issues.

8.2.4 *Uncertainties and time series consistency*

No accurate information was available for assessing uncertainties about emissions from sources in this sector.

8.2.5 *Source-specific QA/QC and verification*

Verification for the source Domestic animals (pets) is done using a survey conducted by order of the branch organisation DIBEVO (entrepreneurs in the pet supplies branch). The numbers of cats and dogs from this survey combined with the emission factors for cats and dogs from Sutton et al. (2000) represent 70% of the total emissions (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.

8.2.6 *Source-specific recalculations*

There are no source-specific recalculations.

8.2.7 *Source-specific planned improvements*

There are no source-specific planned improvements.

8.2.8 *Overview of shares and trends in emissions*

An overview of emissions and the trends for this sector is shown in Table 8.2.

Table 8.2 Overview of emission totals in the Other sector (NFR 6)

	Main pollutants		Particulate matter		
	NO_x	NH_3	TSP	$PM_{2.5}$	PM_{10}
Year	Gg	Gg	Gg	Gg	Gg
1990	1.69	12.1	0.07	0.04	0.04
1995	1.93	9.60	0.07	0.04	0.04
2000	1.69	8.31	0.07	0.04	0.04
2005	1.99	9.81	0.07	0.04	0.04
2010	1.76	8.77	0.07	0.04	0.04
2015	1.90	9.58	0.07	0.04	0.04
2106	1.94	9.83	0.07	0.05	0.05
2017	1.83	9.62	0.07	0.05	0.05
1990–2017 period[1]	0.14	-2.45	0.01	0.00	0.00
1990–2017 period[2]	8%	-20%	8%	8%	8%

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

8.2.9 *Emissions, activity data and (implied) emission factors*

Privately owned livestock

For horses and ponies, an estimated 300,000 additional animals were included in the inventory to account for privately owned animals. NH_3 emissions from privately owned horses (in stables and manure storage) decreased gradually from 3.6 Gg in 1990 to 3.0 Gg in 2008 as a result of a lower N excretion rate. Between 2008 and 2015, the N excretion rate stayed at a stable level. Since 2016, NH_3 emissions have increased to 3.3 Gg due to higher N excretion per horse.

Starting in 2016, a number of sheep, mules and asses previously considered within the Agriculture sector have been included in sector 6A following a definition change within the Agricultural census.

The emission factors used can be found in Section 6.2 (Manure management).

Human transpiration and respiration

NH_3 emissions from this source gradually increased over the time series in line with the increase in the human population, from 1.5 Gg in 1990 to 1.7 Gg in 2017.

Population numbers in the Netherlands are derived from CBS Statline (http://statline.cbs.nl/) and increased from 14,893,000 in 1990 to 17,082,000 in 2017.

To avoid underestimation, the high-end emission factor of 0.0826 kg NH_3 per person per year (Sutton *et al.*, 2000) was used to calculate emissions from this source.

Manure sold and applied to private properties or nature areas
NH_3 emissions from this source decreased over the time series from 5.8 Gg in 1990 to 3.1 Gg in 2017, while NO_x emissions from this source increased from 1.6 Gg in 1990 to 1.7 Gg in 2017.

The emission factors used can be found in Section 6.2 (Manure management).

Domestic animals (pets)
NH_3 emissions from this source increased slightly over the time series from 1.2 Gg in 1990 to 1.5 Gg in 2017.

Emissions are calculated using an emission factor per house. The number of houses is derived from Statistics Netherlands. The emission factor used is based on Booij (1995), who calculated a total emission of 1,220 tonnes NH_3 from all domestic animals (cats, dogs, rabbits and birds) for the year 1990. With the total emission in 1990 and the number of houses in 1990, an emission factor of 0.2 kg NH_3 per household was calculated.

9 Response to the Reviews

9.1 Combined CLRTAP and NEC review 2015

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. Based on this decision, since 2008 the national inventories (CLRTAP and NECD) have been subject to a five-year cycle of in-depth technical reviews. 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 data submitted (see http://www.ceip.at/).

The review also seeks to achieve a common approach to prioritising and monitoring inventory improvements under the Convention 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 reviewed in 2015. In the review report, several recommendations were made for improvements to the inventory and inventory reporting. Table A2.1 provides an overview of the status of the recommendations' implementation.

9.2 NEC review 2018

Article 10(3) of the revised NECD introduces a regular annual review of EU Member States' national emission inventory data in order to:

- verify, inter alia, 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 2018 submission by the Netherlands was reviewed under this EU decision. Several recommendations were given to improve the inventory and inventory report. Actions based on these recommendations were given a high priority and added to the work plan in order to ensure a follow-up to the majority of recommendations before the next review in 2019. Table A2.2 shows the status of the implementation of the recommendations from this NEC review.

10 Recalculations and Other Changes

10.1 Recalculations of certain elements of the IIR2019

Compared with the IIR2018 (Wever *et al.*, 2018), only a few methodological changes were implemented in the Pollutant Release and Transfer (PRTR) system:

- Inclusion of one new emission source (annual bonfires) in the inventory;
- Addition of new NMVOC source: Silage of agricultural crops;
- Update of emissions from accidental fires;
- Improved representation of emission from biological treatment of waste;
- New NH_3 source: Woodstoves and fireplaces.

10.2 Improvements

10.2.1 Improvements made

During the compilation of the IIR2018 minor errors were detected, and these have been repaired in the IIR2019. The following significant improvements were carried out during the improvement process of the Dutch PRTR:

- Revision of the use of diesel and biogas based on a revision of the energy statistics;
- Outdated emission factors used to calculate emissions from stationary combustion replaced with emission factors from the EEA Guidebook;
- NH_3 emissions from agriculture changed in line with the update of parameters in the N flow model;
- Use of improved activity data for 2016, resulting in several changes to the figures for that year.

10.2.2 Planned improvements

The remaining actions with respect to content will be prioritised and are planned for implementation in the inventories of 2019 and 2020. Appendix 3 gives an overview of the relevant plans.

10.3 Effects of recalculations and improvements

Table 10.1 to 10.3 show the changes in total national emission levels for the various pollutants, compared with the inventory report of 2018.

Table 10.1 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010 and 2015 (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 2018	**655.6**	**498.0**	**197.4**	**350.1**	**51.6**	**74.9**	**98.3**	**13.3**	**1141.8**
	IIR 2019	**656.6**	**603.9**	**196.3**	**351.3**	**52.7**	**75.1**	**99.1**	**13.5**	**1150.9**
Difference	absolute	**0.9**	**105.9**	**-1.1**	**1.2**	**1.1**	**0.3**	**0.8**	**0.1**	**9.1**
	%	*0.1*	*21.3*	*-0.5*	*0.3*	*2.1*	*0.3*	*0.8*	*1.1*	*0.8*
2000	IIR 2018	**463.7**	**252.2**	**77.9**	**175.1**	**28.9**	**43.5**	**52.0**	**9.9**	**749.5**
	IIR 2019	**464.9**	**332.7**	**78.0**	**176.3**	**29.9**	**44.1**	**53.2**	**9.9**	**761.9**
Difference:	absolute	**1.2**	**80.6**	**0.0**	**1.2**	**1.0**	**0.6**	**1.2**	**0.0**	**12.4**
	%	*0.3*	*31.9*	*0.1*	*0.7*	*3.6*	*1.3*	*2.3*	*0.3*	*1.7*
2010	IIR 2018	**333.8**	**174.7**	**35.2**	**132.7**	**17.0**	**30.5**	**37.3**	**5.4**	**674.5**
	IIR 2019	**332.6**	**267.9**	**35.3**	**134.2**	**18.6**	**31.5**	**38.9**	**5.5**	**685.2**
Difference:	absolute	**-1.2**	**93.3**	**0.1**	**1.4**	**1.6**	**1.0**	**1.6**	**0.1**	**10.7**
	%	*-0.4*	*53.4*	*0.2*	*1.1*	*9.5*	*3.2*	*4.2*	*1.5*	*1.6*
2015	IIR 2018	**267.8**	**149.3**	**30.6**	**125.8**	**13.2**	**26.8**	**34.2**	**3.4**	**568.9**
	IIR 2019	**272.5**	**253.0**	**30.8**	**128.9**	**15.0**	**27.9**	**36.0**	**3.6**	**575.6**
Difference:	absolute	**4.7**	**103.6**	**0.2**	**3.2**	**1.8**	**1.2**	**1.8**	**0.1**	**6.6**
	%	*1.8*	*69.4*	*0.7*	*2.5*	*13.7*	*4.4*	*5.3*	*3.8*	*1.2*
2016	IIR 2018	**254.2**	**141.2**	**27.9**	**127.4**	**12.5**	**26.3**	**33.5**	**3.2**	**558.7**
	IIR 2019	**258.0**	**250.8**	**28.5**	**128.1**	**14.1**	**27.2**	**34.7**	**3.2**	**563.8**
Difference:	absolute	**3.8**	**109.6**	**0.6**	**0.7**	**1.6**	**0.9**	**1.2**	**-0.1**	**5.1**
	%	*1.5*	*77.6*	*2.3*	*0.5*	*12.9*	*3.4*	*3.5*	*-2.1*	*0.9*

From Table 10.1 it is clear that NMVOC and $PM_{2.5}$ emissions changed significantly compared with the 2018 submission. The change in the former is the result of the new emission source Silage of agricultural crops. $PM_{2.5}$ emissions changed mainly due to the introduction of the sources Accidental fires and Bonfires.

The recalculation of the use of windscreen washer fluid (transport) and the new emission source of Scented candles/incense sticks/fragrance oils (consumers), both reported in category 2, also contributed to the increase in the emissions of NMVOC.

The increase in NO_x emissions was mainly caused by the update of emission factors in the transport and non-road mobile machinery sectors.

The increase in NH_3 was caused by the inclusion of the compound in Wood combustion in the residential sector. Emissions in agriculture from manure management also increased as a result of an update of the nitrogen flow model.

The changes in all other pollutants are for the most part due to the changes in bonfire and accidental fire emissions.

Table 10.2 Differences in the total national emission level between the current and previous inventory reports for the years 1990, 2000, 2010 and 2015 (metals).

National total		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
		Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	IIR 2018	331.6	2.1	3.6	1.3	11.8	36.8	72.9	0.4	224.1
	IIR 2019	332.8	2.2	3.6	1.3	11.9	36.3	74.9	0.4	225.1
Difference:	absolute	1.2	0.0	0.0	0.0	0.1	-0.5	2.0	0.0	1.0
	%	*0.4*	*1.1*	*0.1*	*0.7*	*0.8*	*-1.3*	*2.8*	*1.0*	*0.5*
2000	IIR 2018	27.3	1.0	1.1	0.9	5.0	39.2	18.6	0.5	95.4
	IIR 2019	27.4	1.0	1.1	0.9	5.1	37.8	19.5	0.5	96.5
Difference:	absolute	0.1	0.0	0.0	0.0	0.1	-1.4	0.9	0.0	1.1
	%	*0.3*	*2.4*	*0.1*	*2.5*	*1.4*	*-3.5*	*4.9*	*0.8*	*1.1*
2010	IIR 2018	37.5	2.6	0.6	0.6	3.8	45.2	2.1	1.5	102.4
	IIR 2019	37.6	2.6	0.7	0.6	3.9	43.5	2.1	1.5	103.5
Difference:	absolute	0.1	0.0	0.1	0.0	0.0	-1.8	0.0	0.0	1.1
	%	*0.1*	*1.0*	*16.2*	*2.9*	*1.0*	*-3.9*	*-0.4*	*0.2*	*1.1*
2015	IIR 2018	8.6	0.6	0.6	0.6	3.4	45.4	2.0	1.0	103.1
	IIR 2019	8.7	0.7	0.7	0.7	3.5	38.9	2.0	1.0	103.1
Difference:	absolute	0.1	0.0	0.1	0.0	0.1	-6.5	0.0	0.0	0.1
	%	*0.8*	*4.3*	*19.3*	*2.8*	*2.3*	*-14.3*	*0.5*	*0.3*	*0.1*
2016	IIR 2018	8.9	0.7	0.6	0.7	3.7	41.5	2.2	0.6	99.7
	IIR 2019	9.0	0.7	0.7	0.7	3.7	39.8	2.2	0.6	100.9
Difference:	absolute	0.1	0.0	0.1	0.0	0.1	-1.7	0.0	0.0	1.2
	%	*0.6*	*3.7*	*16.9*	*2.8*	*1.6*	*-4.2*	*0.2*	*0.5*	*1.2*

The changes shown in Table 10.2 are mostly the result of the inclusion /update of the emissions from bonfires and accidental fires. The increase in Hg emissions is the result of a recalculation of emissions from the brick and tile industry. Other changes in the 2016 figures are the result of using improved activity data for that year.

All changes shown in Table 10.3 for PCDD/F and PAH are due to the inclusion of bonfires in the inventory. PCDD/F emissions in transport increased compared to the last submission due to revision of the fuel use in Navigation.

Table 10.3 Differences in the total national emission level between the current and previous inventory reports for the years 1990, 2000, 2010 and 2015 (PCDD/F, PAHs and HCB).

National total		PCDD/ PCDF (dioxines/ furanes)	PAHs				
			benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1.2.3 -cd) pyrene	Total 1-4
		g I-Teq	Mg	Mg	Mg	Mg	Mg
1990	IIR 2018	**744.0**	**5.2**	**7.8**	**4.0**	**2.8**	**19.8**
	IIR 2019	**744.0**	**5.5**	**8.1**	**4.1**	**2.9**	**20.6**
Difference	absolute	**0.0**	**0.2**	**0.3**	**0.2**	**0.1**	**0.8**
	%	*0.0*	*4.5*	*3.7*	*4.1*	*3.7*	*4.0*
2000	IIR 2018	**32.8**	**1.8**	**1.7**	**0.9**	**0.8**	**5.1**
	IIR 2019	**32.7**	**2.0**	**2.0**	**1.0**	**0.9**	**6.0**
Difference	absolute	**0.0**	**0.3**	**0.3**	**0.2**	**0.1**	**0.9**
	%	*-0.1*	*14.5*	*19.5*	*18.3*	*16.5*	*17.1*
2010	IIR 2018	**33.2**	**1.6**	**1.6**	**0.8**	**0.8**	**4.8**
	IIR 2019	**33.2**	**1.9**	**1.9**	**1.0**	**0.9**	**5.8**
Difference	absolute	**0.0**	**0.3**	**0.3**	**0.2**	**0.1**	**0.9**
	%	*-0.1*	*17.4*	*21.3*	*23.1*	*15.1*	*19.2*
2016	IIR 2018	**23.2**	**1.7**	**1.5**	**0.8**	**0.8**	**4.8**
	IIR 2019	**23.2**	**1.9**	**1.9**	**1.0**	**0.9**	**5.7**
Difference	absolute	**0.0**	**0.3**	**0.3**	**0.2**	**0.1**	**0.9**
	%	*-0.1*	*16.9*	*22.2*	*23.8*	*15.1*	*19.4*

11 Projections

The emission projections in IIR2019 consist of an update of air pollutant projections as presented in IIR2018 (Wever *et al.*, 2018). Emission projections are recalculated every year by the PBL Netherlands Environmental Assessment Agency.

An overview of the historical and projected total emissions for the Netherlands is given in Table 11.1. These are the emission totals for compliance purposes, according to the definitions in the EU directive 2016/2284 (EU, 2016).

Table 11.1 Historical and projected national emissions (Gg) for the Netherlands for the purpose of compliance, calculated from fuel sold

Pollutant	Historical	Actual	Projected (WM)		Projected (WaM)	
Years	2005	2017	2020	2030	2020	2030
SO_x	67	27	30	31	30	31
NO_x [a]	380	224	173	127	173	125
NH_3	155	132	119	107	119	107
NMVOC [a]	199	154	144	146	143	145
PM_{10}	36.9	26.9	24.8	23.8	24.7	23.6
$PM_{2.5}$	24.0	13.4	10.9	9.9	10.9	9.8

WM = with measures.
WaM = with additional measures.
a. The national emission totals for NO_x and NMVOC exclude agricultural sources 3B (manure management) and 3D (agricultural soils).

In 2018 the non-combustion emissions for ammonia from agriculture projected for 2020 were updated due to new information on the emission factor from air scrubbers, a change in N excretion factor from dairy cows and a new emission source. The effects of the 2017 phosphate regulation programme and the grants on reducing swine numbers were also incorporated. Due to this recalculation, projected ammonia emissions in 2020 have increased by 3.8 Gg. All other emission projections have not changed compared with IIR2018.

Change in agriculture emission projections for 2020
NH_3 emission projections for non-combustion sources in agriculture for 2020 have been adjusted. The most important changes resulting from the recalculations (described in Chapter 6) are:

- Since the emission factor of air scrubbers that combine a biological step and a chemical step appeared to be higher than previously assumed (because these systems turned out to be less effective than expected), NH_3 emission projections for 2020 are circa 2 Gg higher than the previous projections.
- The addition of the new source Manure treatment has resulted in higher NH_3 emissions in the projections (though by less than 1 Gg). In the Netherlands there are several processes in use to treat manure: separation of liquid and solid fraction, nitrification/denitrification, incineration and anaerobic digestion.

Another important change in the projections is probably partly the result of a change in policy but also a result of several other factors, such as changed grassland area (resulting in more grass and less corn in animal feed) and an higher increase in milk production rate per cow, resulting in a higher N excretion rate per cow:

- In IIR2018 N excretion rates per cow were still based on projections created in 2015. However, current N excretion rates per cow are higher than those projected in 2015. Because of this, the projection has been adjusted, resulting in approximately 1 Gg higher NH_3 emissions in the 2020 projection.

Apart from these changes, the projections of the number of young dairy cattle and the number of swine have been adjusted, influencing ammonia emissions from agriculture. These changes are the result of political decisions:

- In 2017 the Netherlands implemented a phosphate reduction regulation. Every farmer is now limited as to the amount of phosphate he is allowed to produce. This has led to a reduction in number of mature and young dairy cattle. The number of dairy cattle projected was still in line with the monitored numbers, but the number of young dairy cattle was less than projected. The projected number of young dairy cattle for 2020 has thus been adjusted in line with recently monitored numbers. It reduces projected NH_3 emissions by approximately 0.5 Gg.
- In 2018 grants were announced in the Netherlands to reduce the number of swine. Projected numbers of swine have been adjusted in line with this policy measure, resulting in approximately 0.4 Gg less NH_3 emission for the 2020 projection.

12 Adjustments

In 2001, the Netherlands, as an EU Member State, adopted the National Emission Ceiling Directive (2001/81/EC), which was replaced in 2016 by the revised NECD (2016/2284/EU), and signed and ratified the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level ozone (UNECE Gothenburg Protocol). The Netherlands was thereby committed to reducing its emissions of NO_x, SO_x, NMVOC and NH_3 to the agreed national emission ceilings by 2010 and to respect these ceilings from 2010 onwards.

12.1 Exceedances

12.1.1 Historical and actual exceedances

In the 2019 submission, the emission totals for NMVOC and NH_3 exceed the emission ceilings as set at the time for these pollutants, for all years since 2010 (Table 12.1). This is mainly due to the implementation of new emission sources and emission factors that were not applicable when the ceilings were set. These include the addition of new default calculation methods for NMVOC emissions from manure and country-specific calculations for NH_3 emissions from crop cultivation and crop residues left behind on soils.

Emissions of NO_x and SO_x in the Netherlands do not exceed the ceilings.

Table 42.1 An overview of the emissions of under the NEC directive and the possible categories eligible for adjustments.

National emission ceilings								
	NMVOC				**NH3**			
Gothenburg	191				128			
NEC	185				128			
Inventory data								
	2010	**2015**	**2016**	**2017**	**2010**	**2015**	**2016**	**2017**
National total for reporting	268	253	251	252	134	129	128	132
Exceedances of set emission ceilings								
Against Gothenburg	77	62	60	61	6	1	0	4
Against NEC	83	68	66	67	6	1	0	4
Adjustments								
National total for reporting	**268**	**253**	**251**	**252**	**134**	**129**	**128**	**132**
3B Manure management	59	67	70	70	-	-	-	-
Of which manure treatment	-	-	-	-	0.2	0.8	0.9	0.8
3D Agricultural soils	23	26	28	28	-	-	-	-
3De Crop cultivation	-	-	-	-	2	2	2	2
3Da4 Crop residues left behind on soils	-	-	-	-	2	2	2	2
National total for compliance	**185**	**160**	**152**	**154**	**130**	**124**	**123**	**127**
Remaining exceedances								
Against Gothenburg	No	No	No	No	2	No	No	No
Against NEC	No	No	No	No	2	No	No	No

12.1.2 *Meeting the reduction commitments without adjustments*

In 2019 the Netherlands emissions projections will be fully updated and recalculated. These will be the basis for the IIR2020 report.

As explained in Chapter 11, there was an update of the 2020 projection for ammonia emissions from agriculture. This update included a new emission source: Manure treatment (see Table 12.1).

The new NMVOC sources are not included in the current projections outlined in Chapter 11. Emissions from these new NMVOC sources are reported in the NFR subsectors 3B and 3D, and are thus excluded for the purpose of NECD compliance checking for 2020 and beyond (EU, 2016: art 4 sub 3D). However, for the Gothenburg protocol there is no specific article which states that 3B and 3D sources should be excluded from compliance checking. This means that these sources should be included in the totals for 2020 compliance checking without adjustment.

When all the NFR 3B and 3D sources are included for 2005, this leads to an NMVOC 2020 Gothenburg ceiling of 243 Gg (Table 12.2).

For a tentative estimate of the NMVOC projection including all 3B and 3D emissions (thus including all sources that were added to the inventory after the setting of the Gothenburg ceilings), it is assumed that there will be no significant changes in the emissions from Manure management (use of silage) and Agricultural soils (animal manure applied to soils, urine and dung deposited by grazing animals, farm-level agricultural operations including storage, handling and transport of agricultural products and cultivated crops). The tentative estimated projection is calculated by using the projected emission of 144 Gg from Table 12.2 and adding the expected emissions from 3B and 3D. This leads to an estimated 2020 projection for NMVOC (including all 3A and 3B sources) of 242 Gg, just under the calculated ceiling of 243 Gg including all 3A and 3B.

Based on the given projections and without adjustment in 2020, the Netherlands will not exceed the ceilings laid down by either the NECD or Gothenburg for NH_3 and NMVOC. Table 12.2 shows that, based on the projections based on 'With measures', both NH_3 and NMVOC will be in compliance in 2020.

Table 12.2 Ceilings versus projected emissions (based on linear interpolation)

Pollutant	**Ceilings**				**Projected emissions (WM)**	
	NECD		**Gothenburg**		**NECD**	**Gothenburg**
Gg	**Until 2019**[1]	**2020**[2]	**Until 2019**[1]	**2020**[3]	**2020**	**2020**
NH_3	128	142	128	142	119[4]	119[1]
NMVOC	185	183	191	243	144[2]	242[5]

1. Emissions from traffic based on fuel used.
2. Under NECD; Based on NFR2019 emission year 2005, fuel sold and exclusion of NFR source sectors 3B and 3D.
3. Based on emission year 2005 in the NFR2019, fuel sold.
4. Projection under NECD.
5. Tentative projection including all 3B and 3D sources; fuel sold.

12.2 (Application for) Adjustments

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

Article 5 of the revised NEC Directive (Directive 2016/2284/EU) lists ‘flexibilities’, one of which is the possibility to establish adjusted emission inventories, where non-compliance with the national emission reduction commitments has resulted from applying improved emission inventory methods updated in accordance with scientific knowledge. The circumstances under which an adjustment may be applied fall into three broad categories:

- Where emission source categories are identified that were not accounted for when emission reduction commitments were set;
- Where emission factors used to determine emission levels for particular source categories for the year in which emission reduction commitments were to be attained are significantly different from the emission factors applied to these categories when the emission reduction commitments were set;
- Where the methodologies used for determining emissions from specific source categories have undergone significant changes between the time when emission reduction commitments were set and the year they are to be attained.

12.2.1 NH3 adjustments

NH_3 emissions from Crop cultivation (3De) and Crop residues left behind on soils (3Da4) were both included in the emission inventory in 2013 with an country-specific calculation method, as first published in van Bruggen *et al.* (2015a). NH_3 emissions from cultivated crops are acknowledged in the EMEP/EEA Guidebook, but no default emission factor is provided.

NH_3 emissions from manure treatment were included in 2017, as described in Chapter 6. In the current EMEP/EEA Guidebook there is no default calculation method included for this emission source. Since there were no calculation methods for these sources, they were not included in the considerations when the emission ceilings were set.

With these proposed adjustments, the Netherlands will not exceed the emission ceilings under the revised NECD and Gothenburg Protocol, as shown in Table 12.1.

Activity data 3B3 manure treatment

The activity data for manure treatment for 2017 has not been published yet; therefore these are included into the IIR (Table 12.3).

Table 12.3 Activity data and emission factors for the calculation of the emissions of manure treatment of swine manure

	Treated manure (million kg) 2017	Emission factor (kg-N/kg-N in manure)
Manure separation		
N-supply of meat pigs	6.174	3.2
N-supply of breeding pigs	3.04	3.2
Mineral concentrate		
N-supply of meat pigs	2.876	3.2
N-supply of breeding pigs	0.552	3.2

Activity data 3Da4 Crop residues left behind on soils
The activity data for Crop residues left behind on soils (3Da4) for 2017 have not been published yet; therefore these are included into the IIR (Table 12.4 and Table 12.5), for convenience sake the data from 2014 to 2016 are also included (CBS 2011 through 2018). The total area used for the calculation of crop residues is a summation of the area of cultivated crop and the mowed and destroyed grassland.

Table 12.4 Activity data (excluding area) of agricultural crops for the calculation of Crop residues left behind on soils (3Da4)

	Field residue fraction[1]	N in crop residue above ground (kg N/ha)[2]	N in crop residue below ground (kg N/ha)[2]	NH_3-N (% N in crop residue above ground)[2]
Winter wheat	0.1	45	23	0
Spring wheat	0.1	45	23	0
Winter barley	0.1	19	20	0
Spring barley	0.1	19	20	0
Rye	0.1	16	17	0
Oats	0.1	19	20	0
Triticale	0.1	24	17	0
Dried and green peas	1	47	13	4.92
Peas	1	170	13	1.63
Marrowfats	1	40	13	3.72
Kidney beans	1	16	13	0
Broad and field beans	1	19	13	0
Grass seed	1	28	14	0
Oilseed rape incl. rape seed	1	40	21	0
Caraway seed	1	27	21	0
Pop seed	1	21	21	0.92
Flax	1	1	3	0
Seed potatoes	1	85	19	5.79
Potatoes	1	31.5	19	0.84
Industrial potatoes	1	31.5	19	0.84
Sugar beets	1	110	11	0.43
Fodder beets	1	92	11	1.44
Lucerne	1	23	67	6.92
Green maize incl. energy maize	0.1	22	21	0
Green manure crops	1	51.5	14	1.56

	Field residue fraction[1]	N in crop residue above ground (kg N/ha)[2]	N in crop residue below ground (kg N/ha)[2]	NH_3-N (% N in crop residue above ground)[2]
Grain maize	1	56	21	0
Corn Cob Mix	1	56	21	0
Chicory	1	59	0	0.93
Hemp	1	23	3	0.92
Onions	1	19	4	0
Other horticultural crops	1	40	13	0
Strawberry	1	19	6	0
Endive	1	40	6	1.63
Asparagus	1	27	6	6.52
Gherkin	1	78	6	2
Cauliflower	1	132	14	5.59
Broccoli	1	156	14	5.83
Cabbage	1	122	14	3.15
Celeriac	1	75	14	1.13
Beetroot	1	95	14	1.23
Lettuce	1	37	6	2.2
Leeks	1	82	4	7.32
Scorzonera	1	46	14	0.53
Spinach	1	30	6	1.21
Brussels sprouts	1	170	14	3.32
Industrial French beans	1	77	13	1.76
Runner beans	1	61	13	1.76
Broad beans green	1	16	13	0
Carrot	1	9	0	0.14
Winter Carrot (Danvers)	1	65	0	0.5
Chicory	1	59	0	0.93
Other vegetables	1	78	6	2.7
Green manure following arable crop	1	51.5	14	1.56
Green manure following maize	1	19.5	5	2

1. Source: Van der Hoek et al. (2007).
2. Source: De Ruijter et al. (2013) and De Ruijter & Huijsmans (2016).
3. Update of: De Ruijter et al. (2013).

Table 12.5 Activity data (only the area used [ha]) of agricultural crops for the calculation of Crop residues left behind on soils (3Da4)

	Crop area (ha)			
	2014	2015	2016	2017
Winter wheat	122,290	127,467	117,014	108,015
Spring wheat	19,922	15,001	11,051	8,414
Winter barley	5,558	7,648	9,818	9,299
Spring barley	22,055	25,173	24,980	20,905
Rye	1,720	1,628	1,612	1,496
Oats	1,751	1,528	1,484	1,495
Triticale	1,520	1,361	1,047	1,227
Dried and green peas	189	273	201	263
Peas	3,709	3,492	3,312	3,042

	Crop area (ha)			
	2014	2015	2016	2017
Marrowfats	266	343	468	596
Kidney beans	1,829	1,574	822	1,347
Broad and field beans	280	360	427	573
Grass seed	12,014	10,789	9,974	10,084
Oilseed rape incl. rape seed	3,086	2,269	1,696	1,947
Caraway seed	22	25	30	14
Pop seed	501	774	584	330
Flax	1,983	2,405	2,415	2,564
Seed potatoes	4,238	44,604	44,531	45,403
Potatoes	25,148	71,736	73,321	76,304
Industrial potatoes	42,310	40,171	40,048	40,964
Sugar beets	75,094	58,436	70,722	85,352
Fodder beets	279	424	708	1,535
Lucerne	5,257	7,172	7,593	7,495
Green maize incl. energy maize	226,151	224,214	206,868	205,249
Green manure crops	3,703	7,321	8,411	9,513
Grain maize	12,594	11,188	9,123	8,690
Corn Cob Mix	4,930	4,615	3,930	3,589
Chicory	3,555	3,903	3,884	3,235
Hemp	1,633	2,041	2,262	2,272
Onions	30,199	32,157	33,431	34,917
Other horticultural crops	8,338	8,316	7,540	7,933
Strawberry	3,167	2,391	2,377	2,273
Endive	207	216	220	217
Asparagus	3,316	3,566	3,795	3,807
Gherkin	605	1,018	1,053	1,176
Cauliflower	2,103	2,198	2,114	2,097
Broccoli	1,554	1,678	1,790	1,884
Cabbage	2,727	2,593	2,798	2,891
Celeriac	1,579	1,561	1,723	1,923
Beetroot	620	650	737	945
Lettuce	2,027	2,110	2,210	2,055
Leeks	2,593	2,200	2,167	2,279
Scorzonera	1,038	775	460	667
Spinach	1,720	1,693	1,661	2,057
Brussels sprouts	2,730	2,757	2,606	2,635
Industrial French beans	2,133	2,241	2,386	2,419
Runner beans	55	22	20	34
Broad beans green	1,417	1,043	1,081	1,107
Carrot	2,671	2,708	3,063	2,774
Winter Carrot (Danvers)	6,126	5,959	6,644	6,479
Chicory	2,961	2,950	2,898	3,211
Other vegetables	3,261	3,385	3,525	3,843
Green manure following arable crop	85,350	85,350	85,350	85,350
Green manure following maize	182,207	179,349	164,274	162,627

Next to the emissions from crops are also the NH_3 emissions from the mowing and destroying of grass included into Crop residues left behind on soils (3Da4). This is calculated differently from the other crops, therefore described in the next paragraph (Table 12.6).

Table 12.6 Activity data (crop area), the data needed to calculate the emission factor (N in grass, N losses mowing and emission percentage) and the emission factor (kg/ha mowed land)

	Grassland				**Destroying of grassland**			
	2014	**2015**	**2016**	**2017**	**2014**	**2015**	**2016**	**2017**
Crop area (ha)	2,760,000	2,714,000	2,671,000	2,645,000	41,632	38,948	34,386	40,215
N in grass (g)	29.73	27.52	28.96	31.20	23.78	22.02	23.17	24.96
N losses mowing (kg N/ha)	5.95	5.50	5.79	6.24	71.35	66.05	69.50	74.88
Emission percentage	6.81	5.93	6.50	7.40	4.43	3.73	4.19	4.90
NH3-N emission from mowing losses (kg/ha mowed land)	0.40	0.33	0.38	0.46	3.16	2.46	2.91	3.67

The amount of N in grass is measured yearly in the Netherlands to be able to use this data to calculate the N-excretion (CBS (2018b), table 2.1.1). Per hectare of land that is mowed 200 kg gram of dry matter (DM) is emitted for normal mowing, if the grass is completely destroyed 3,000 kg DM per hectare is emitted. If the amount of N available per ha of land (N losses in mowing) is multiplied with the emission percentage results this in the EF of NH_3-N per ha. The emission percentage is calculated with the regression formula 0.4*N in grass -5.08 as described in De Ruijter and Huijsmans (2012).

Activity data 3De Cultivated crops
For the calculation of the 3De NH_3 emissions no activity data was used, as described in the methodological report, since the output of the model was not certain enough to make a yearly estimation. Therefore a 1 was put in the activity data in the adjustment application table “Annex_II” (see Appendix 4), since a 0 will give errors.

12.2.2 NMVOC adjustments

The 2013 EMEP/EEA Guidebook implemented a default methodology and default emission factors for NMVOC from animal husbandry and manure management. This resulted into the inclusion of the NMVOC emissions from agriculture into the emission inventory in 2017 as described in chapter 6.

The NMVOC emissions from agriculture are a large contributor to the national total (Table 12.1), resulting in an exceedance of the emission ceiling. With the proposed adjustment of in Table 12.1, the Netherlands will be in compliance again.

Activity data 3B3 animal numbers
The animal numbers as presented in the NFR and thus the the adjustment application table “Annex_II” (see Appendix 4) are based on

the amount of animals used for the calculation of NH_3 emissions. However for the calculations of NMVOC emission not all the same animal numbers are used. For the calculation of NH_3 the piglets are not included in the calculations, this is done because there N-excretion is included with their mothers. For the calculations the default emissions VS excretions are used and there the piglets are not included with their mothers and therefore are included in the calculations (Table 12.7).

Table 12.7 Animal numbers of swine, were the swine numbers are used for the calculation of NH3 emissions and the summation of swine and piglets for the NMVOC emissions

Animal type	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Swine	7,131	7,132	7,054	6,939	6,856	7,005	6,883	6,789
Piglets	5,124	5,297	5,180	5,274	5,382	5,598	5,595	5,612

Table 12.8 Implied emission factor of 3B3 swine for NMVOC with the animal numbers used for NMVOC

IEF (kg NMVOC/animal)	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Swine	0,29	0,28	0,27	0,27	0,27	0,27	0,26	0,29

Activity data 3B manure management and 3D Animal manure applied to soils

The activity data for NMVOC calculations have not been published yet; therefore these are included into the IIR (Table 12.9 and Table 12.10).

Table 12.9 Fractions of NH3 emissions from outside storage divided by the NH3 from animal housing

NH_3 emissions outside storage / NH_3 emissions animal housing	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Dairy cattle	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
Non-dairy cattle	0.05	0.04	0.04	0.04	0.05	0.05	0.04	0.04
Sheep	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Swine	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Goats	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Horses	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Mules and asses	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04
Laying hens	0.22	0.19	0.21	0.27	0.27	0.33	0.33	0.33
Broilers	0.05	0.07	0.07	0.11	0.12	0.07	0.12	0.13
Turkeys	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
Other poultry	0.08	0.08	0.08	0.09	0.08	0.07	0.06	0.07
Other animals	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16

Table 12.10 Fractions of NH3 emissions from manure application divided by the NH3 from animal housing

NH_3 manure application / NH_3 animal housing	2010	2011	2012	2013	2014	2015	2016	2017
Dairy cattle	1.05	1.13	1.14	1.11	1.08	1.06	1.07	1.04
Non-dairy cattle	1.35	1.14	1.17	1.08	1.08	1.09	1.13	1.15
Sheep	1.30	1.38	1.37	1.39	1.39	1.42	1.44	1.37
Swine	0.30	0.36	0.38	0.52	0.51	0.43	0.44	0.46
Goats	2.16	2.27	2.17	2.32	2.33	2.39	2.43	2.36
Horses	1.44	1.64	1.52	1.40	1.33	1.56	1.65	1.65
Mules and asses	1.24	1.31	1.29	1.32	1.31	1.37	1.40	1.32
Laying hens	0.06	0.09	0.02	0.10	0.08	0.05	0.05	0.07
Broilers	0.32	0.64	0.31	0.52	0.56	0.23	0.58	0.49
Turkeys	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.01
Other poultry	0.99	0.99	1.03	1.08	0.89	0.80	0.76	0.88
Other animals	0.38	0.51	0.67	1.02	1.14	0.98	0.97	1.05

Activity data 3Da2a Animal manure applied to soils

As for 3De and 3B3 the activity data used to calculate the NMVOC emissions are not the same to calculate the NH_3 emissions for animal manure applied to soil. For the calculations of NH_3 emissions the N applied on the field is the activity data, but for NMVOC it is the animal numbers (Table 12.11).

Table 12.11 Animal numbers used for the calculation of the 3Da2a NMVOC emissions (1,000 heads)

Animal numbers	2010	2011	2012	2013	2014	2015	2016	2017
Total of animals	116,401	111,861	109,943	112,307	117,585	121,702	120,236	118,390

Activity data 3Da3 Urine and dung deposited by grazing animals

As for 3De, 3B3 and 3Da2a the activity data used to calculate the NMVOC emissions are not the same to calculate the NH_3 emissions for Urine and dung deposited by grazing animals (3Da3). For the calculations of NH_3 emissions the N excreted during grazing is the activity data, but for NMVOC it is the animal numbers (Table 12.12).

Table 12.12 Animal numbers used for the calculation of the 3Da3 NMVOC emissions (1,000 heads)

Animal numbers grazing	2010	2011	2012	2013	2014	2015	2016	2017
Total number of grazing animals	3,593	3,516	3,499	3,602	3,650	3,714	3,668	3,449

Activity data 3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products

The activity data for farm-level agricultural operations including storage, handling and transport of agricultural products (3Dc) have not been published yet; therefore these are included into the IIR (Table 12.13 and Table 12.14). Note that in de methodological report is stated that if an animal category is fed more than 0.5 silage, it is assumed that the fraction of silage is 1. However for some categories a fraction of higher than 0.5 is reported, this is because there are more underlying animal categories of which the weighted average (on animal numbers) is taken.

Table 12.13 Fraction of time that the farm animals spent inside the animal house

Fraction time spend inside	2010	2011	2012	2013	2014	2015	2016	2017
Dairy cattle	0.84	0.85	0.86	0.86	0.86	0.88	0.89	0.89
Non-dairy cattle	0.68	0.68	0.68	0.70	0.71	0.71	0.73	0.69
Sheep	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Swine	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Goats	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Horses	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Mules and asses	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Laying hens	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Broilers	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turkeys	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Other poultry	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Other animals	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 12.14 Animal categories that are fed silage and the fraction of feed that is silage

Fraction of silage fed	2010	2011	2012	2013	2014	2015	2016	2017
Dairy cattle	1.00	1.00	1.00	1.00	0.79	1.00	1.00	1.00
Non-dairy cattle	0.59	0.55	0.53	0.55	0.54	0.56	0.54	0.50
Sheep	0.07	0.02	0.02	0.02	0.02	0.08	0.08	0.08
Goats	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

13 Spatial Distributions

13.1 Background for reporting

In 2017, the Netherlands reported geographically distributed emissions and LPS data to the UNECE LRTAP Convention for the years 1990, 1995, 2000, 2005, 2010 and 2015. Emission data were disaggregated to the standard EMEP grid with a resolution of 7 km x 7 km. Reporting was mandatory for the following air pollutants: SO_x, NO_x, NH_3, NMVOC, CO, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, DIOX, PAH and HCB. Guidelines for reporting air emissions on grid level are given in EMEP/EEA (2016). Gridded emission data are 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 (EMEP/EEA (2016)). These aggregations can be achieved through the aggregation of the spatially resolved (mapped), detailed NFR sectors.

The gridded emission data of the 2017 report is available at the Central Data Repository (CDR) on the EIONET website (https://cdr.eionet.europa.eu).

13.2 Methodology for disaggregation of emission data

All emissions in the Dutch PRTR are linked with a spatial allocation. For every spatial allocation category, a factsheet is available at http://www.prtr.nl.

Each factsheet contains a brief description of the method used, an example of the relevant distribution map, references to background documents and a list of the relevant institutes. An Excel sheet is also provided, which can be used to link emissions, emission source, allocation and factsheet.

Three methods are used for the spatial allocation of emission sources:
- Direct linkage to location;
- Model calculation;
- Estimation through proxy data.

The first category applies only to large point sources, for which both the location and the emissions are known. This includes all companies that are required by Dutch law to report their air and water emissions by means of Annual Environmental Reports (AERs), combined with data concerning waste-water treatment plants (WWTPs). Altogether, this category encompasses almost 3,000 sources.

Some examples of the second method, spatial distributions based on model calculations, are:
- Ammonia (NH_3) from agriculture;
- Particulate matter (PM_{10} and $PM_{2.5}$) from agriculture;
- Deposition on surface water;

- Leaching and run-off to surface water (heavy metals and nutrients);
- Emissions of crop protection chemicals to air and surface water.

Finally 'Estimation through proxy data', the third and largest group of emissions is spatially allocated by proxy data. Examples of these allocation keys are population and housing density, vehicle kilometres (cars, ships and trains), land cover and the number of employees per facility.

13.3 Maps with geographically distributed emission data

Examples of combinations of the three methods can be seen in the maps below, based on the latest reporting data (2015) from the Netherlands Pollutants Release and Transfer Register (http://www.prtr.nl). The selected air pollutants are ammonia (NH_3), sulphur dioxide (SO_x), nitrogen dioxide (NO_x) and fine particulates ($PM_{2.5}$). Figure 13.1–Figure 13.4 show the geographically distributed emissions for these air pollutants. Even from the spatial allocation at national level, specific patterns of the major sectors are recognisable.

On a national scale, the agricultural sector is the major contributor to NH_3 emissions. Emissions of NH_3 are mainly related to livestock farming and especially to the handling of manure. Emissions of NH_3 are therefore related to the storage and spreading of manure, as well as emissions from stables (van Bruggen *et al.*, 2017a). Some inland shipping routes and fishing grounds are visible because the burning of fossil fuels also releases NH_3. There are no other large aquatic sources. Compared with other sectors, however, the emission quantities from inland shipping and fisheries are small.

Both SO_x and NO_x are predominantly emitted by transport; cities, main roads, airports and shipping routes are therefore clearly visible. Inland shipping routes stand out more on the SO_x emission map because more reduction measures were taken in other sectors than in inland shipping.

Finally, on the map of fine particulate matter, cities, airports, agriculture, main roads and shipping routes can all be recognised. This is due to the fact that residential heating, agricultural animal housing, traffic and shipping are all main sources of PM emissions.

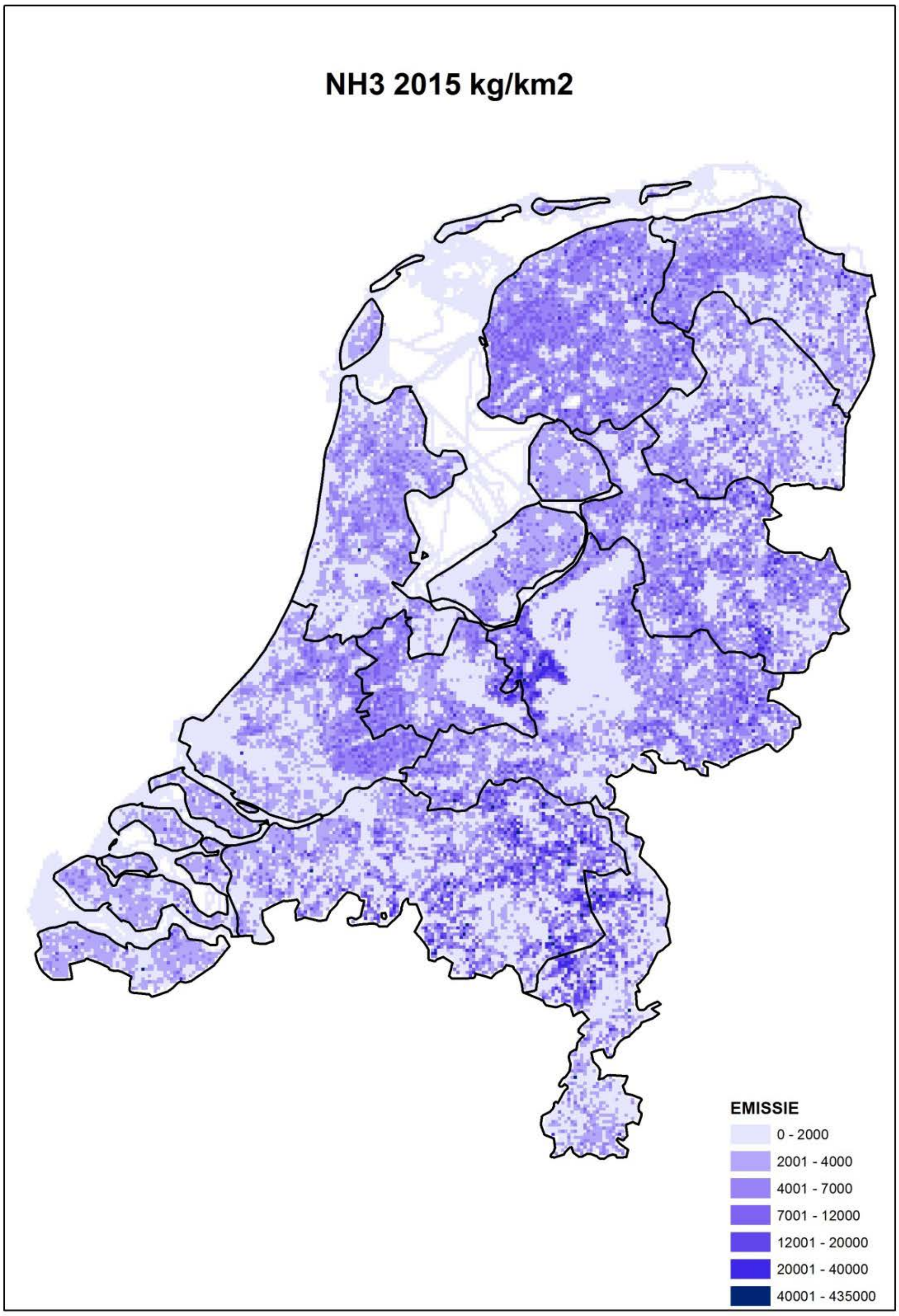

Figure 13.1 Geographical distribution of NH_3 emissions in the Netherlands in 2015

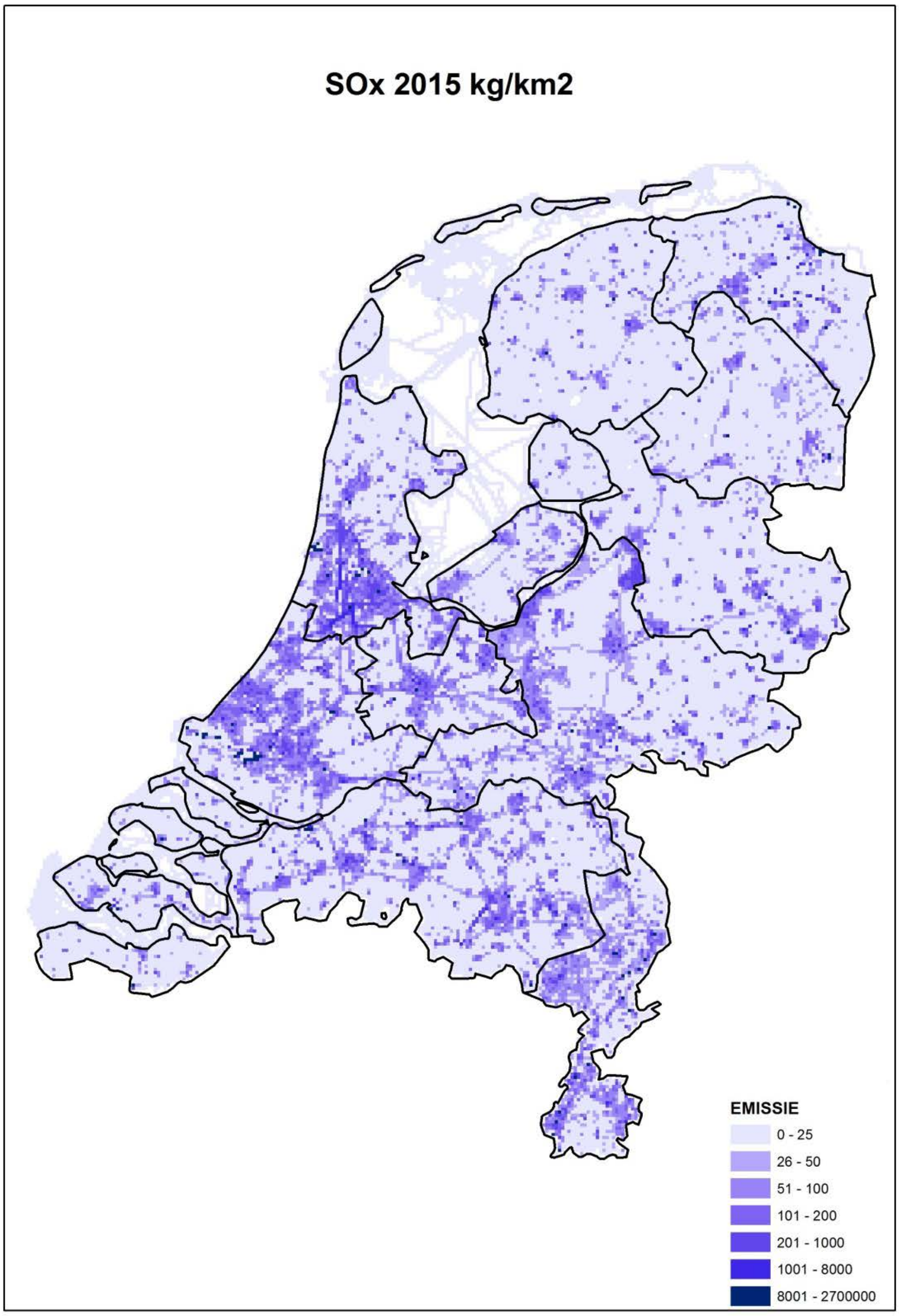

Figure 13.2 Geographical distribution of SO_x emissions in the Netherlands in 2015

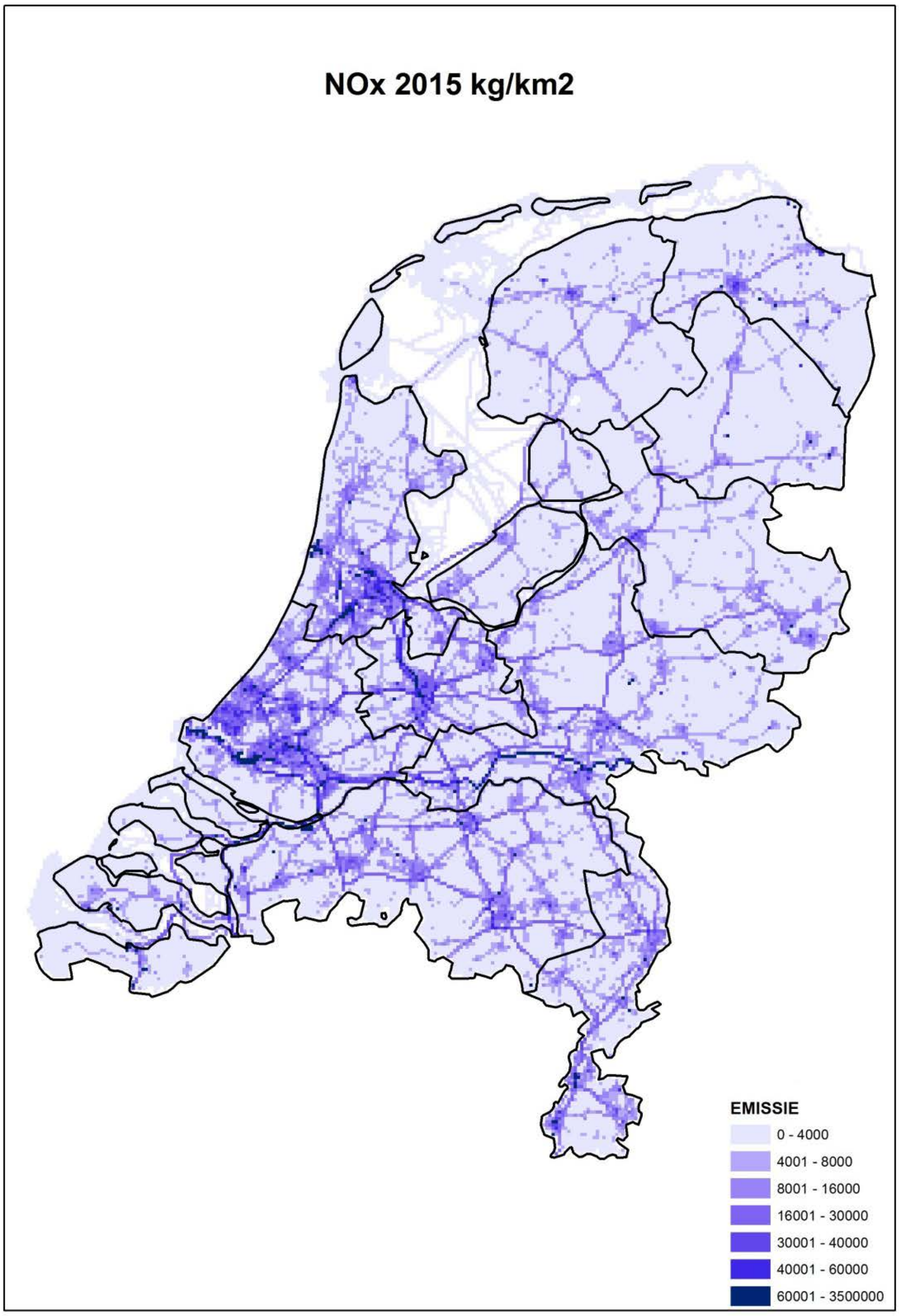

Figure 13.3 Geographical distribution of NO_x emissions in the Netherlands in 2015

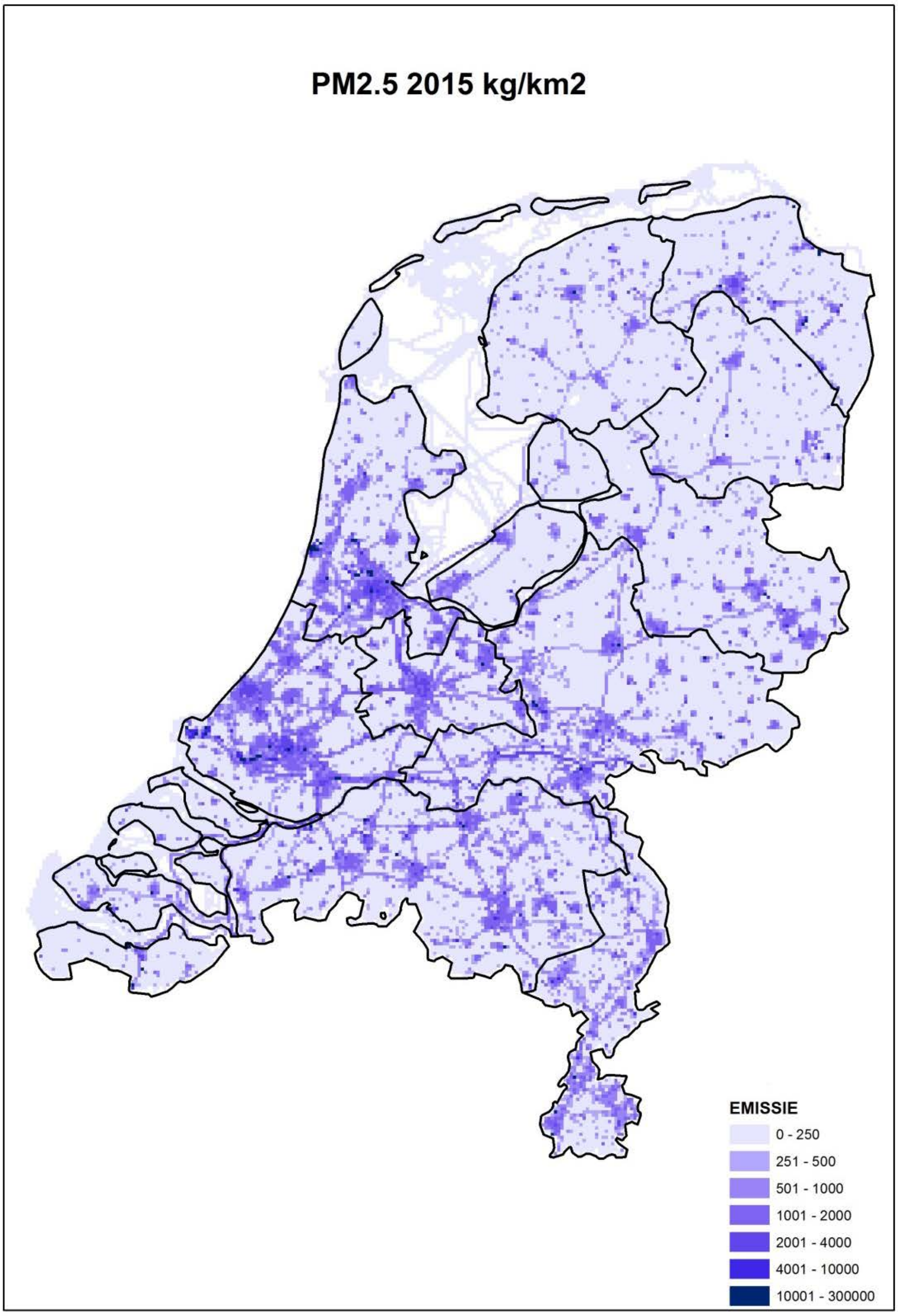

Figure 13.4 Geographical distribution of $PM_{2.5}$ emissions in the Netherlands in 2015

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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	NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs, HCBs and PCBs	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 1A1c.
1A2f	All	1A2gviii	Whether splitting these emission sources is possible is under evaluation by the specific task force.
1A3aii(i)	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins and PAHs	1A3ai(i)	Not possible to split the fuels between the two source categories.
1A3ei	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins and PAHs	1A2f, 1A4cii, 1B2b	Combustion and process emissions from pipeline transport cannot be split due to lack of detailed activity data.
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	NO_x, NMVOC, SO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	1A2c	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 1A1c.
1B2aiv	Cd, Hg and Dioxins	1A1b	
1B2c	NO_x, NMVOC, SO_x, TSP, PM_{10}, BC, CO	NMVOC included in 1B2b; NO_x and SO_x include in 1A1c	Combustion and process emissions cannot be split due to lack of detailed activity data.
2A2	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, HCBs and PCBs	2A6	Because of allocation problems, emissions from 2A2 are reported in the category Other mineral products (2A6).

NFR code	Substance(s)	Included in NFR code	Explanation
2A5a	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, HCBs and PCBs	2A6	Because of allocation problems, emissions from 2A5a are reported in the category Other mineral products (2A6).
2A5b	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, HCBs and PCBs	2A6	Because of allocation problems, emissions from 2A5b are reported in the category Other mineral products (2A6).
2A5c	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, HCBs and PCBs	2H3	Because only emissions from the storage and handling of bulk products companies are available, emissions from 2A5c are reported in the category Other industrial processes (2H3). The 2H3 subcategory in the Dutch PRTR includes 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.
2B1	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, HCBs and PCBs	2B10a	Because of allocation problems and for confidential reasons, emissions from 2B1 are included in Chemical industry: Other (2B10a).
2B2	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, HCBs and PCBs	2B10a	Because of allocation problems and for confidential reasons, emissions from 2B2 are included in Chemical industry: Other (2B10a).
2B5	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, HCBs and PCBs	2B10a	Because of allocation problems and for confidential reasons, emissions from Silicon carbide (2B5) are included in Chemical industry: Other (2B10a).
2B6	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, HCBs and PCBs	2B10a	Because of allocation problems and for confidential reasons, emissions from 2B6 are included in Chemical industry: Other (2B10a).
2B7	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, HCBs and PCBs	2B10a	Because of allocation problems and for confidential reasons, emissions from 2B7 are included in Chemical industry: Other (2B10a).

NFR code	Substance(s)	Included in NFR code	Explanation
2B10b	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, HCBs and PCBs	2H3	Because only emissions from the storage and handling of bulk products companies are available, emissions from 2B10b are reported in the category Other industrial processes (2H3). The 2H3 subcategory in the Dutch PRTR includes 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.
2C3	NO_x and SO_x	1A2b	Because it is not possible to split the SOx and NOx from Aluminium production, all SOx and NOx emissions are reported in 1A2b.
2C4	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, HCBs and PCBs	2H3	For confidential reasons, emissions from 2C4 are included in 2H3.
2C7d	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, HCBs and PCBs	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 IIR2019, 5.3.1.
2G	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, HCBs and PCBs	2D3i	Because the 2016 Guidebook is not clear about which sources belong to 2G, 2G is included in 2D3i (Other solvent and product use).
2L	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, HCBs and PCBs	2H3	Because the 2016 Guidebook is not clear about which sources belong to 2L, 2L is included in 2H3 (Other industrial processes).
5A	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A1a	Emissions from heat and power production and flaring are included in the sector Energy.
5B2	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A4ai	Emissions from heat and power production and flaring are included in the sector Energy.

NFR code	Substance(s)	Included in NFR code	Explanation
5C1a	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, HCBs and PCBs	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	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, HCBs and PCBs	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	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, HCBs and PCBs	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	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, HCBs and PCBs	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	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, HCBs and PCBs	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	1A4ai	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, 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, 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
All	PCBs	assumed negligible
1A1b	Pb, Cd, Hg, As, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible; no method available
1A2a	NH_3, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible
1A2b	BC and HCBs	assumed negligible
1A2c	BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, PAHs and HCBs	assumed negligible
1A2d	BC, Pb, Cd, As, Cr, Cu, Ni, Se, Dioxins, PAHs and HCBs	assumed negligible
1A2e	Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn and Dioxins	assumed negligible; no method available
1A2gvii	HCBs	assumed negligible
1A3ai(i)	NH3 and Hg	assumed negligible
1A3b till 1A3biv	HCBs	assumed negligible
1A3bv	Dioxins, PAHs and HCBs	assumed negligible
1A3bvi	Hg, Dioxins and HCBs	assumed negligible
1A3bvii	Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible
1A3c, 1A3di(ii) and 1A3dii	HCBs	assumed negligible
1A4aii	HCBs	assumed negligible
1A4bii	HCBs	assumed negligible
1A4ci	Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn	assumed negligible
1A4cii	HCBs	assumed negligible
1A4ciii	Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible
1A5a	NH_3, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn and HCBs	assumed negligible
1A5b	HCBs	assumed negligible
1B1a	NMVOC, SO_x, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible

NFR code	Substance(s)	Reason for non-estimation
1B2ai	NMVOC, SO_x, Dioxins, PAHs and HCBs	assumed negligible
1B2aiv	SO_x, PAHs and HCBs	assumed negligible
1B2av	SO_x, Dioxins, PAHs and HCBs	assumed negligible
1B2b	SO_x, Dioxins, PAHs and HCBs	assumed negligible
1B2c	$PM_{2.5}$, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible
1B2d	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	assumed negligible
2A3	BC	assumed negligible
2A6	BC	assumed negligible
2B10a	BC	assumed negligible
2C1	NO_x, SO_x and HCBs	assumed negligible
2C3	BC, Hg, Se and HCBs	assumed negligible
2C5	BC	assumed negligible
2C6	BC	assumed negligible
2D3b and 2D3c	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	assumed negligible
2D3i, 2H1, 2H2, 2H3 and 2I	BC	assumed negligible
3Da2a, 3Da2b, 3Da2c, 3Da3 and 2Da4	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
3De	NO_x, SO_x, BC, CO, , Pb, Cd, Hg, As, Cr, Cu, Ni and Se	assumed negligible
3Df	NO_x, NMVOC, SO_x, NH_3, BC, Pb, Cd, Hg, As, Cr, Cu, Ni and Se	assumed negligible
3I	All	assumed negligible
6A	SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible

Appendix 2 Key category analysis results

Results from the key (source) category analysis have been calculated and sorted for every component. In addition to a 2017 and 1990 level assessment, a trend assessment was performed. In both approaches, key source categories are identified using a cumulative threshold of 80%.

SO_x key sources

Table A2.1.a SO_x key source categories identified by 2017 level assessment (emissions in Gg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
1A1b	Petroleum refining	11.1	41%	41%
1A1a	Public electricity and heat production	4.9	18%	60%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	3.2	12%	72%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	2.4	8.8%	81%

Table A2.1.b SO_x key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A1b	Petroleum refining	67	34%	34%
1A1a	Public electricity and heat production	48	25%	59%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	20	10%	69%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	9.1	4.7%	74%
1A3biii	Road transport: Heavy duty vehicles and buses	7.7	3.9%	78%
2A6	Other mineral products	5.5	2.8%	81%

Table A2.1.c SO_x key source categories identified by 1990–2017 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	0.9%	13%	13%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	1.0%	15%	29%
1A1b	Petroleum refining	1.0%	15.3%	44%
1A1a	Public electricity and heat production	0.9%	13%	58%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.6%	9%	66%
1A3biii	Road transport: Heavy-duty vehicles and buses	0.5%	7.9%	74%
1A3bi	Road transport: Passenger cars	0.3%	4.9%	79%
1A4ciii	Agriculture/Forestry/ Fishing: National fishing	0.2%	3.1%	82%
1A3bii	Road transport: Light-duty vehicles	0.1%	2.2%	84%

NO_x key sources

Table A2.2.a NOx key source categories identified by 2017 level assessment (emissions in Gg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy-duty vehicles and buses	32	13%	13%
1A3bi	Road transport: Passenger cars	31	12%	25%
1A3bii	Road transport: Light-duty vehicles	19	7.6%	33%
1A1a	Public electricity and heat production	17	6.8%	39%
1A3di(ii)	International inland waterways	16	6.5%	46%
3Da2a	Animal manure applied to soils	12	4.9%	51%
3Da1	Inorganic N-fertilisers (includes also urea application)	9.7	3.8%	55%
1A2gvii	Mobile combustion in manufacturing industries and construction	9.6	3.8%	58%
1A3dii	National navigation (shipping)	9.2	3.7%	62%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	9.1	3.6%	66%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	7.8	3.1%	69%
1A4ci	Agriculture/Forestry/Fishing: Stationary	7.8	3.1%	72%
1A4bi	Residential: Stationary	7.3	2.9%	75%
1A4ciii	Agriculture/Forestry/Fishing: National fishing	7.2	2.8%	78%
1A4ai	Commercial/institutional: Stationary	6.6	2.6%	80%

Table A2.2.b NO_x key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	145	22%	22%
1A3biii	Road transport: Heavy-duty vehicles and buses	113	17%	39%
1A1a	Public electricity and heat production	83	13%	52%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	36	5.5%	57%
1A3bii	Road transport: Light-duty vehicles	24	3.6%	61%
1A3di(ii)	International inland waterways	22	3.4%	64%
1A4bi	Residential: Stationary	22	3.3%	68%
1A4ciii	Agriculture/Forestry/ Fishing: National fishing	21	3.1%	71%
1A2gvii	Mobile Combustion in manufacturing industries and construction	21	3.1%	74%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	20	3.0%	77%
1A1b	Petroleum refining	19	2.9%	80%
3Da1	Inorganic N-fertilisers (includes also urea application)	16	2.4%	82%

Table A2.2.c NO_x key source categories identified by 1990–2017 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	3.8%	20%	20%
1A1a	Public electricity and heat production	2.2%	11%	31%
1A3biii	Road transport: Heavy-duty vehicles and buses	1.7%	8.6%	40%
1A3bii	Road transport: Light-duty vehicles	1.6%	8.0%	48%
1A3di(ii)	International inland waterways	1.2%	6.0%	54%
1A3dii	National navigation (shipping)	1.0%	5.3%	59%
3Da2a	Animal manure applied to soils	1.0%	5.05%	64%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.7%	3.7%	68%
1A4ci	Agriculture/Forestry/ Fishing: Stationary	0.7%	3.5%	71%
3Da1	Inorganic N-fertilisers (includes also urea application)	0.6%	2.89%	74%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.5%	2.3%	76%
1A3ai(i)	International aviation LTO (civil)	0.5%	2.3%	79%
3I	Agriculture other	0.5%	2.33%	81%

NH_3 key sources

Table A2.3.a NH_3 key source categories identified by 2017 level assessment (emissions in Gg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	40	30%	30%
3B1a	Manure management – Dairy cattle	23	17%	47%
3B3	Manure management – Swine	14	10.4%	58%
3B1b	Manure management – Non-dairy cattle	10.6	8.0%	66%
3Da1	Inorganic N-fertilisers (includes also urea application)	10	7.7%	73%
6A	Other (included in national total for entire territory)	9.6	7.3%	80.6%

Table A2.3.b NH_3 key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	197	56%	56%
3B3	Manure management – Swine	49	14%	70%
3B1a	Manure management – Dairy cattle	22	6.3%	76%
3Da3	Urine and dung deposited by grazing animals	15	4.3%	81%

Table A2.3.c NH_3 key source categories identified by 1990–2017 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
3Da2a	Animal manure applied to soils	10%	38%	38%
3B1a	Manure management – Dairy cattle	4.1%	16%	54%
3B1b	Manure management – Non-dairy cattle	1.8%	7.0%	61%
6A	Other (included in national total for entire territory)	1.4%	5.6%	66.7%
3Da1	Inorganic N-fertilizers (incl. also urea application)	1.4%	5.5%	72%
3B3	Manure management – Swine	1.3%	5.2%	77%
3B4gi	Manure management – Laying hens	1.2%	4.8%	82%

NMVOC key sources

Table A2.4.a NMVOC key source categories identified by 2017 level assessment (emissions in Gg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
3B1a	Manure management – Dairy cattle	45.2	18%	18%
2D3a	Domestic solvent use including fungicides	34	13%	31%
2D3i	Other solvent use	16	6%	38%
2D3d	Coating applications	15	6%	43%
3Da2a	Animal manure applied to soils	14.4	5.7%	49%
1A3bi	Road transport: Passenger cars	12	4.9%	54%
3B1b	Manure management – Non-dairy cattle	12.3	4.9%	59%
3Dc	Farm-level agricultural operations including storage. handling and transport of agricultural products	12.1	4.8%	64%
1A4bi	Residential: Stationary	11	4.4%	68%
1A3biv	Road transport: Mopeds & motorcycles	10.7	4.2%	73%
2H3	Other industrial processes	10.5	4.2%	77%
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	4.8	1.9%	79%
2B10a	Chemical industry: Other	4.7	1.9%	80%

Table A2.4.b NMVOC key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	101	17%	17%
2D3d	Coating applications	93	15%	32%
3Da2a	Animal manure applied to soils	49.5	8.2%	40 %
1A3bv	Road transport: Gasoline evaporation	36	5.9%	46%
2B10a	Chemical industry: Other	33	5.5%	52%
2H3	Other industrial processes	25	4.2%	56%
1A3biv	Road transport: Mopeds & motorcycles	25	4.1%	60%
2D3a	Domestic solvent use including fungicides	23.8	3.9%	64%
2D3i	Other solvent use	18	3.0%	67%
1B2av	Distribution of oil products	16.9	2.8%	70%
1A3biii	Road transport: Heavy duty vehicles and buses	16	2.6%	73%
3B1a	Manure management – Dairy cattle	15.3	2.5%	75%
1B2aiv	Fugitive emissions oil: Refining/storage	15	2.4%	77%
2D3h	Printing	14	2.4%	80%
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	14.2	2.4%	82%

Table A2.4.c NMVOC key source categories identified by 1990–2017 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
3B1a	Manure management – Dairy cattle	6.4%	18.2%	18%
1A3bi	Road transport: Passenger cars	4.9%	14%	32%
2D3d	Coating applications	4.0%	11.3%	43%
2D3a	Domestic solvent use including fungicides	4.0%	11%	55%
1A3bv	Road transport: Gasoline evaporation	2.2%	6.2%	61%
3Dc	Farm-level agricultural operations including storage. handling and transport of agricultural products	1.6%	4.7%	66%
2B10a	Chemical industry: Other	1.5%	4.3%	70%
2D3i	Other solvent use	1.4%	3.8%	74%
3B1b	Manure management – Non-dairy cattle	1.1%	3.0%	77%
3Da2a	Animal manure applied to soils	1.1%	3.0%	80%
1A4bi	Residential: Stationary	0.9%	2.7%	82%

CO key sources

Table A2.5.a CO key source categories identified by 2017 level assessment (emissions in Gg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	229	41%	41%
1A4bi	Residential: Stationary	81	14%	55%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	56	10%	65%
1A3biv	Road transport: Mopeds & motorcycles	50	9%	74%
1A4bii	Residential: Household and gardening (mobile)	28	5.0%	79%
1A5b	Other: Mobile (including military, land based and recreational boats)	21	3.7%	83%

Table A2.5.b CO key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	588	51%	51%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	187	16%	67%
1A4bi	Residential: Stationary	79	6.8%	74%
1A3bii	Road transport: Light-duty vehicles	48	4.2%	78%
1A3biv	Road transport: Mopeds & motorcycles	45	3.9%	82%

Table A2.5.c CO key source categories identified by 1990–2017 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	5.1%	22%	22%
1A4bi	Residential: Stationary	3.7%	16%	38%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	3.1%	14%	52%
1A3biv	Road transport: Mopeds & motorcycles	2.5%	11%	63%
1A4bii	Residential: Household and gardening (mobile)	1.8%	7.9%	71%
1A3bii	Road transport: Light-duty vehicles	1.8%	7.7%	78%
1A5b	Other: Mobile (including military, land based and recreational boats)	1.2%	5.2%	84%

PM_{10} key sources

Table A2.6.a PM_{10} key source categories identified by 2017 level assessment (emissions in Gg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
3B4gi	Manure management – Laying hens	2.8	10%	10%
2H3	Other industrial processes	2.6	9.7%	20%
1A4bi	Residential: Stationary	2.1	7.7%	28%
2H2	Food and beverages industry	1.9	6.9%	35%
1A3bvi	Road transport: Automobile tyre and brake wear	1.5	5.5%	40%
2D3i	Other solvent use	1.4	5.1%	45%
2B10a	Chemical industry: Other	1.4	5.1%	50%
3B4gii	Manure management – Broilers	1.3	4.7%	55%
2C1	Iron and steel production	1.2	4.5%	60%
1A3bvii	Road transport: Automobile road abrasion	1.2	4.4%	64%
2A6	Other mineral products	1.1	4.0%	68%
3B3	Manure management – Swine	0.9	3.3%	71%
1A3bii	Road transport: Light-duty vehicles	0.7	2.6%	74%
1A3bi	Road transport: Passenger cars	0.7	2.6%	76%
1A2gvii	Mobile combustion in manufacturing industries and construction	0.51	1.9%	78%
1A3di(ii)	International inland waterways	0.50	1.9%	80%

Table A2.6.b PM_{10} key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
2C1	Iron and steel production	9.1	12%	12%
1A3biii	Road transport: Heavy-duty vehicles and buses	7.0	9.3%	22%
1A3bi	Road transport: Passenger cars	6.4	8.6%	30%
1A1b	Petroleum refining	6.4	8.5%	39%
2H3	Other industrial processes	5.4	7.2%	46%
1A3bii	Road transport: Light-duty vehicles	4.6	6.1%	52%
2H2	Food and beverages industry	4.3	5.8%	58%
2B10a	Chemical industry: Other	4.1	5.5%	63%
1A4bi	Residential: Stationary	2.5	3.3%	66%
1A2gvii	Mobile combustion in manufacturing industries and construction	2.2	2.9%	69%
1A1a	Public electricity and heat production	2.2	2.9%	72%
2A6	Other mineral products	2.0	2.7%	75%
2D3i	Other solvent use	2.0	2.7%	78%
3B3	Manure management – Swine	1.6	2.1%	80%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.3	1.8%	82%

Table A2.6.c PM_{10} key source categories identified by 1990–2017 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
3B4gi	Manure management – Laying hens	3.3%	12%	12%
1A3biii	Road transport: Heavy-duty vehicles and buses	2.8%	9.8%	21%
2C1	Iron and steel production	2.8%	9.6%	31%
1A1b	Petroleum refining	2.7%	9.5%	40%
1A3bi	Road transport: Passenger cars	2.2%	7.5%	48%
1A4bi	Residential: Stationary	1.6%	5.4%	53%
1A3bvi	Road transport: Automobile tyre and brake wear	1.4%	4.8%	58%
1A3bii	Road transport: Light-duty vehicles	1.3%	4.4%	63%
1A3bvii	Road transport: Automobile road abrasion	1.2%	4.0%	67%
3B4gii	Manure management – Broilers	1.1%	4.0%	71%
2H3	Other industrial processes	0.9%	3.1%	74%
2D3i	Other solvent use	0.9%	3.0%	77%
1A1a	Public electricity and heat production	0.7%	2.5%	79%
2A6	Other mineral products	0.5%	1.6%	81%

$PM_{2.5}$ key sources

Table A2.7.a $PM_{2.5}$ key source categories identified by 2017 level assessment (emissions in Gg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	2.0	14%	14%
2D3i	Other solvent use	1.4	9.9%	24%
2A6	Other mineral products	1.0	6.8%	31%
2B10a	Chemical industry: Other	0.9	6.6%	37%
2C1	Iron and steel production	0.8	5.5%	43%
2H3	Other industrial processes	0.8	5.4%	48%
1A3bii	Road transport: Light-duty vehicles	0.7	5.0%	53%
1A3bi	Road transport: Passenger cars	0.7	4.9%	58%
2H2	Food and beverages industry	0.5	3.6%	61.8%
1A2gvii	Mobile combustion in manufacturing industries and construction	0.5	3.5%	65%
1A3di(ii)	International inland waterways	0.5	3.4%	69%
5E	Other waste	0.41	2.95%	71.57%
1A3biii	Road transport: Heavy-duty vehicles and buses	0.4	2.9%	74%
1A3dii	National navigation (shipping)	0.4	2.5%	77%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.4	2.5%	79%
1A3bvi	Road transport: Automobile tyre and brake wear	0.27	1.9%	81%

Table A2.7.b PM2.5 key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy-duty vehicles and buses	7.0	13%	13%
1A3bi	Road transport: Passenger cars	6.4	12%	26%
2C1	Iron and steel production	5.9	11%	37%
1A1b	Petroleum refining	4.9	9%	46%
1A3bii	Road transport: Light-duty vehicles	4.6	8.7%	55%
2B10a	Chemical industry: Other	2.6	4.9%	60%
1A4bi	Residential: Stationary	2.4	4.5%	64%
1A2gvii	Mobile combustion in manufacturing industries and construction	2.1	4.0%	68%
2D3i	Other solvent use	2.0	3.8%	72%
1A1a	Public electricity and heat production	1.8	3.4%	75%
2H3	Other industrial processes	1.7	3.1%	79%
2A6	Other mineral products	1.6	3.0%	81%

Table A2.7.c $PM_{2.5}$ key source categories identified by 1990–2017 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A4bi	Residential: Stationary	2.5%	12%	12%
1A3biii	Road transport: Heavy-duty vehicles and buses	2.8%	13%	25%
1A1b	Petroleum refining	2.1%	10%	34%
1A3bi	Road transport: Passenger cars	1.9%	9.0%	43%
2D3i	Other solvent use	1.6%	7.4%	51%
2C1	Iron and steel production	1.5%	7.0%	58%
2A6	Other mineral products	1.0%	4.7%	62%
1A3bii	Road transport: Light-duty vehicles	1.0%	4.6%	67%
5E	Other waste	0.6%	2.8%	70%
1A1a	Public electricity and heat production	0.6%	2.8%	73%
2H3	Other industrial processes	0.6%	2.8%	75%
1A3dii	National navigation (shipping)	0.5%	2.3%	78%
2B10a	Chemical industry: Other	0.5%	2.1%	80%
1A3di(ii)	International inland waterways	0.4%	2.0%	82%

Black Carbon key sources

Table A2.8.a Black carbon key source categories identified by 2017 level assessment (emissions in Gg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
1A3bii	Road transport: Light-duty vehicles	0.52	17%	17%
1A4bi	Residential: Stationary	0.67	22%	39%
1A3bi	Road transport: Passenger cars	0.36	12%	51%
1A3di(ii)	International inland waterways	0.27	8.8%	60%
1A2gvii	Mobile combustion in manufacturing industries and construction	0.24709	8.1%	68%
1A3biii	Road transport: Heavy-duty vehicles and buses	0.21	7%	74.6%
1A3dii	National navigation (shipping)	0.2	6.1%	81%

Table A2.8.b Black carbon key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy-duty vehicles and buses	3.5	26%	26%
1A3bi	Road transport: Passenger cars	3.0	22%	48%
1A3bii	Road transport: Light-duty vehicles	2.5	19%	67%
1A2gvii	Mobile combustion in manufacturing industries and construction	1.08	8.0%	75%
1A4bi	Residential: Stationary	0.95	7.1%	82%

Table A2.8.c Black carbon key source categories identified by 1990–2017 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3biii	Road transport: Heavy-duty vehicles and buses	4.4%	28%	28%
1A4bi	Residential: Stationary	3.4%	22%	50%
1A3bi	Road transport: Passenger cars	2.4%	15%	65%
1A3di(ii)	International inland waterways	1.3%	8.4%	74%
1A3dii	National navigation (shipping)	1.1%	7.3%	81%

Pb key sources

Table A2.9.a Pb key source categories identified by 2017 level assessment (emissions in Mg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
2C1	Iron and steel production	3.5	41%	41%
2A3	Glass production	1.6	18.4%	59.1%
2C6	Zinc production	1.0	12%	71%
1A3ai(i)	International aviation LTO (civil)	0.7	8.3%	79%
1A3bi	Road transport: Passenger cars	0.46	5.4%	84.8%

Table A2.9.b Pb key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	230	69%	69%
2C1	Iron and steel production	56	17%	86%

Table A2.9.c Pb key source categories identified by 1990–2017 trend assessment (emissions in Mg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	1.7%	45%	45%
2C1	Iron and steel production	0.6%	17%	62%
2A3	Glass production	0.4%	11%	73%
2C6	Zinc production	0.3%	8%	81%

Hg key sources

Table A2.10.a Hg key source categories identified by 2017 level assessment (emissions in Mg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	0.17	29%	29%
2A6	Other mineral products	0.10	17.7%	46%
2C1	Iron and steel production	0.09	15%	62%
1A3bi	Road transport: Passenger cars	0.06	11%	73%
2C5	Lead production	0.04	7%	80%

Table A2.10.b Hg key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	1.9	54%	54%
2B10a	Chemical industry: Other	0.7	20%	73%
2C1	Iron and steel production	0.4	11%	84%

Table A2.10.c Hg key source categories identified by 1990–2017 trend assessment (emissions in Mg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2B10a	Chemical industry: Other	3.2%	20%	20%
1A1a	Public electricity and heat production	4.1%	26%	46%
2A6	Other mineral products	2.9%	18.2%	64%
1A3bi	Road transport: Passenger cars	1.6%	10%	74%
1A4bi	Residential: Stationary	0.9%	5.7%	80%

Cd key sources

Table A2.11.a Cd key source categories identified by 2017 level assessment (emissions in Mg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
2C6	Zinc production	0.21	27%	27%
2C1	Iron and steel production	0.15	20%	47%
1A3bi	Road transport: Passenger cars	0.10	13%	59%
2B10a	Chemical industry: Other	0.09	12%	71%
2A3	Glass production	0.07	8.66%	80%

Table A2.11.b Cd key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	0.9	44%	44%
2C1	Iron and steel production	0.7	32%	75%
1A1b	Petroleum refining	0.1	5.1%	80%

Table A2.11.c Cd key source categories identified by 1990–2017 trend assessment (emissions in Mg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	14%	37%	37%
2C6	Zinc production	7.8%	20%	57%
2B10a	Chemical industry: Other	4.3%	11%	68%
2C1	Iron and steel production	4%	11%	79%
1A3bi	Road transport: Passenger cars	3.3%	9%	88%

Dioxin key sources

Table A2.12.a Dioxin key source categories identified by 2017 level assessment (emissions in g I-Teq)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
2D3i	Other solvent use	12	50%	50%
1A4bi	Residential: Stationary	7.0	30%	80%

Table A2.12.b Dioxin key source categories identified by 1990 level assessment (emissions in g I-Teq)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	583	78%	78%
1A4ai	Commercial/institutional: Stationary	100	13%	92%

Table A2.12.c Dioxin key source categories identified by 1990–2017 trend assessment (emissions in g I-Teq)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	2.2%	41%	41%
2D3i	Other solvent use	1.4%	27%	68%
1A4bi	Residential: Stationary	0.9%	17%	85%

PAH key sources

Table A2.13.a PAH key source categories identified by 2017 level assessment (emissions in Mg)

NFR14 Code	Long name	2017	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	4.22	73%	72.9%
5E	Other waste	0.57	9.91%	82.85%

Table A2.13.b PAH key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
2C3	Aluminium production	6.9	34%	34%
1A4bi	Residential: Stationary	3.8	18%	52%
2D3d	Coating applications	2.4	12%	63%
2C1	Iron and steel production	1.6	8.0%	71%
2H3	Other industrial processes	1.4	6.6%	78%
1A3bi	Road transport: Passenger cars	0.8	4.0%	82%

Table A2.13.c PAH key source categories identified by 1990–2017 trend assessment (emissions in Mg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A4bi	Residential: Stationary	15%	46%	46%
2C3	Aluminium production	9.3%	28%	74%
5E	Other waste	2.1%	6.4%	80%

Appendix 3 Status of review recommendations implementation

EMEP/CLRTAP stage 3 review

As a result of the EMEP/CLRTAP stage 3 review on the IIR2015 and the 2015 NFR tables, a plan was drafted on the implementation of actions regarding the issues found. Table A3.1 provides an overview of the plan for the implementation of actions from the stage 3 review. As countries are only reviewed under the EMEP/CLRTAP every 5 years, the same table will appear in this report until the next review, planned for 2020.

Table A3.1 Overview of the implementation of actions as result of the 2015 stage 3 review

Issue in review report	Implemented in	Issue in review report	Implemented in
1	See from issue 43 onwards	71	No action necessary
2	See from issue 43 onwards	72	No action necessary
3	See from issue 43 onwards	73	No action necessary
4	See from issue 43 onwards	74	No action necessary
5	See from issue 43 onwards	75	In IIR2016
6	See from issue 43 onwards	76	progressively in IIR2016–2018
7	See from issue 43 onwards	77	In IIR2016
8	See from issue 43 onwards	78	No action necessary
9	See from issue 43 onwards	79	In IIR2016
10	See from issue 43 onwards	80	In IIR2016
11	See from issue 43 onwards	81	progressively in IIR2016–2018
12	See from issue 43 onwards	82	progressively in IIR2016–2018
13	See from issue 43 onwards	83	No action necessary
14	See from issue 43 onwards	84	In IIR2016
15	See from issue 43 onwards	85	No action necessary
16	See from issue 43 onwards	86	No action necessary
17	See from issue 43 onwards	87	No action necessary
18	See from issue 43 onwards	88	No action necessary
19	See from issue 43 onwards	89	In IIR2016
20	See from issue 43 onwards	90	In IIR2016
21	See from issue 43 onwards	91	In IIR2016
22	See from issue 43 onwards	92	progressively in IIR2016–2018
23	See from issue 43 onwards	93	In IIR2016
24	See from issue 43 onwards	94	No action necessary
25	See from issue 43 onwards	95	In IIR2016
26	See from issue 43 onwards	96	In IIR2016
27	See from issue 43 onwards	97	In IIR2016
28	See from issue 43 onwards	98	In IIR2016
29	See from issue 43 onwards	99	In IIR2016

Issue in review report	Implemented in	Issue in review report	Implemented in
30	See from issue 43 onwards	100	IIR2017
31	See from issue 43 onwards	101	IIR2017
32	See from issue 43 onwards	102	In IIR2016
33	See from issue 43 onwards	103	IIR2017
34	See from issue 43 onwards	104	No action necessary
35	See from issue 43 onwards	105	No action necessary
36	See from issue 43 onwards	106	In IIR2017/2018
37	See from issue 43 onwards	107	No action necessary
38	See from issue 43 onwards	108	In IIR2017
39	See from issue 43 onwards	109	No action necessary
40	See from issue 43 onwards	110	No action necessary
41	See from issue 43 onwards	111	In IIR2016
42	See from issue 43 onwards	112	In IIR2016
43	Not yet implemented	113	In IIR2016
44	Not yet implemented	114	In IIR2017
45	No action necessary	115	In IIR2016
46	Not yet implemented	116	In IIR2016
47	Not yet implemented	117	In IIR2016
48	In IIR2016	118	In IIR2017
49	In IIR2016	119	In IIR2016
50	In IIR2016	120	In IIR2016
51	In IIR2016	121	See Issue 127
52	In IIR2017	122	In IIR2017
53	In IIR2018	123	In IIR2017
54	In IIR2018	124	No action necessary
55	In IIR2018	125	No action necessary
56	In IIR2016	126	In IIR2017
57	In IIR2018	127	In IIR2017
58	In IIR2018	128	In IIR2017
59	In IIR2016	129	In IIR2017
60	No action necessary	130	In IIR2017
61	In IIR2016	131	In IIR2017
62	In IIR2017	132	No action necessary
63	In IIR2018	133	In IIR2016
64	No action necessary	134	In IIR2016
65	In IIR2016	135	In IIR2016
66	In IIR2016	136	In IIR2016
67	In IIR2017	137	In IIR2017
68	In IIR2016	138	In IIR2017
69	In IIR2016	139	In IIR2017
70	In IIR2017		

NECD stage 3 review
The inventory is reviewed annually by an NECD review team, and improvements in line with the recommendations from these reviews are planned.
Table A3.2 gives an overview of the recommendations from the NECD-review 2017. Some actions were not completed before the 2018 IIR and are repeated in the 2018 NECD-review.

A3.3 gives an overview of the recommendations from the 2018 NECD review and the actions taken or planned since.

Table A3.2 Overview of the implementation of actions as result of the 2017 NECD review

Observation	**NFR, Pollutant(s), Year(s)**	**Recommendation (shortened text)**	**Action taken**
NL-1A1-2017-0001	1A1 Energy industries, $PM_{2.5}$, 2000–2015	The TERT recommends indicating more clearly in the IIR of the definition of these two pollutants and adding to the section Energy in the IIR that $PM_{2.5}$ emissions are estimated on the basis of the standard fractions presented in Visschedijk (2007) and and presenting these shares in the IIR.	To avoid confusion, the emission factors for coarse particulates are no longer shown. Instead, we have included emission factors for PM_{10} and for TSP in the relevant tables in Chapter 3. The $PM_{2.5}$ fractions have not yet been included in the IIR. This recommendation will be subject to further consideration in 2018.
NL-1A1-2017-0002	1A1 Energy Industries, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT recommends that the Netherlands checks the relevance of the country-specific emission factors to have justifiable references for SO_X and NO_X.	This recommendation is subject to further consideration in 2018.
NL-1A1-2017-0003	1A1 Energy Industries, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT recommends that the Netherlands conducts a survey among operators to identify which ones are reporting emissions on the basis of the validated average values and try to derive a methodology to adjust the national emissions over the time series in order to compensate for the fact that national emissions are estimated on the basis of data reported by operators using validated average values.	Performing the suggested survey involves the cooperation of the companies and the competent authorities. There was not enough time to organise these parties to perform the recommended survey before this submission. This will be taken up further during 2018.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A1a-2017-0001	1A1a Public Electricity and Heat Production, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT recommends that in the next submission, the Netherlands adds to category 1A1a the methodology used for waste incineration with energy recovery.	In Paragraph 3.2.1, we have included a sentence that emissions from all waste incineration plants are included in 1A1a. All the plants report their emissions in an environmental report and therefore the methodology described in 3.2.5 is also valid for waste incineration.
NL-1A1b-2017-0001	1A1 Energy Industries, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT recommends that for the next submission the Netherlands corrects the NFR tables with the appropriate value for fuel consumption for the different years.	The activity data are now included in the NFR table.
NL-1A1c-2017-0001	1A1c Manufacture of solid fuels and other energy industries, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT notes that the issue does not relate to an over- or under-estimate. First, for the next submission, the TERT recommends that the Netherlands use the appropriate notation key. Second, the TERT recommends that the Netherlands develop a methodology which allows to consider an installation in the same category throughout the time series (if the main activity remains the same) in order to ensure consistency.	We were not able to conclude in time on the discussion of the use of the correct notation key. This recommendation is subject to further consideration in 2018.
NL-1A2b-2017-0001	1A2b Stationary combustion in manufacturing industries and construction: Non-ferrous metals, NH_3, 2000–2015	The TERT recommends that the Netherlands investigate this issue. First, the Netherlands could verify the relevance of NH_3 emissions declared by companies since emissions are not declared every year. Second, if these data are validated by operators, the Netherlands could estimate for the entire time series NH_3 emissions by using an average EF determined from data declared or an emission factor taken from the literature. The TERT further recommends that the Netherlands ensure time-series consistency by estimating these emissions for all years and include them in the report.	This recommendation is subject to further consideration in 2018.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A2f-2017-0001	1A2f Stationary combustion in manufacturing industries and construction: Non-metallic minerals, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT recommends that the Netherlands use the correct notation keys in its NFR tables regarding the methodology used and consider reallocating emissions from mineral production to category 1A2f instead of category 1A2gviii to improve comparability.	In the IIR, it is now stated that emissions from non-metallic minerals are allocated to 1A2gviii.
NL-1A2gvii-2017-0001	1A2gvii Mobile Combustion in Manufacturing Industries and Construction, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	The TERT recommends providing these data in the NFR tables and the IIR as well.	In this year's inventory the notation key has been replaced by IE for relevant years. Due to limited resources, adding biomass activity data to the inventory will be done in next year's inventory (2020 submission).
NL-1A3ai(i)-2017-0001	1A3ai(i) International aviation LTO (civil), NH_3, 1990–2015	The TERT welcomes this planned correction and recommends that the Netherlands implement it.	Notation key has been revised.
NL-1A3aii(i)-2017-0001	1A3aii(i) Domestic aviation LTO (civil), SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT acknowledges the answer provided by the Netherlands, understanding that this is not an issue of completeness. However, to improve the inventory's transparency and comparability, the TERT recommends that the Netherlands look into this issue when resources allow.	None. Emissions from domestic flights are very small and are included in the inventory, see Section 4.2.5. The issue is on the long list of improvements.
NL-1A3b-2017-0001	1A3b Road transport, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that the Netherlands include biomass activity data in its next submission.	In this year's inventory the notation key has been changed to IE for relevant years. In next year's inventory the activity data for biomass will be included.
NL-1A3b-2017-0002	1A3b Road transport, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that the Netherlands explain clearly in the IIR where the lubricant consumption for different engines is reported and report the figures in NFR tables its next submission.	Explanation included in Section 4.3.4 (Lubricant oil).
NL-1A3b-2017-0003	1A3b Road transport, $PM_{2.5}$, 2000–2015	The TERT recommends that the Netherlands includes emission factors with references in its next submission.	Explanation and reference included in Section 4.3.4 (PM emission factors).

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A3biii-2017-0001	1A3biii Road transport: Heavy-duty vehicles and buses, NH_3, 2007-2015	The TERT recommends that the Netherlands includes the explanation in its next submission.	The explanation is included in Section 4.3.3.
NL-1A3bvi-2017-0001	1A3bvi Road transport: Automobile tyre and brake wear, $PM_{2.5}$, 2000, 2005, 2010	The TERT recommends that the Netherlands includes the correct data in its next submission.	Correct data are included in NFR.
NL-1A3bvii-2017-0001	1A3bvii Road Transport: Automobile road abrasion, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that the Netherlands include the correct data in its next submission.	Correct data are included in NFR.
NL-1A3c-2017-0001	1A3c Railways, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2012-2014	The TERT recommends providing sufficient information on trends of both activity data and emissions in the next submission.	The explanation is included in section 4.4.7. Due to limited resources, adding biomass activity data to the inventory will be done in next year's inventory (2020 submission).
NL-1A3c-2017-0002	1A3c Railways, SO_2, NO_X, NH_3, $PM_{2.5}$, 1990–2015	The TERT agreed with the answer provided by the Netherlands. However, as the Netherlands further stated that separate activity data are available for biofuels and fossil fuels, especially from the CRF tables used for GHG reporting, the TERT recommends providing these separate data in the NFR tables and the IIR as well.	In this year's inventory the notation key has been changed to IE for relevant years. In next year's inventory the activity data for biomass will be included.
NL-1A3di(ii)-2017-0001	1A3di(ii) International inland waterways, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT recommends that the Netherlands check that no biofuels are used for navigation, even as part of blended liquid fuels, and change the notation key accordingly.	Notation key has been changed to IE.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A3ei-2017-0001	1A3ei Pipeline transport, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT acknowledges the answer provided by the Netherlands, warmly welcoming the intention to correct the inventory and recommends that this is done for the next submission. However, as the Netherlands also stated that NMVOC emissions were rightly allocated to category 1B2b, the TERT notes that this allocation would be correct for fugitive NMVOC emissions but not for NMVOC from the fuel combustion in pipeline compressors, recommending the Netherlands to document the nature of NMVOC emissions in the next submission.	This recommendation is subject to further consideration in 2018.
NL-1A4ai-2017-0001	1A4ai Commercial/ institutional: Stationary, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT recommends that Netherlands correct these errors in the next submission.	The references have been updated and errors corrected (See Paragraph 3.4.4).

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A5a-2017-0001	1A5a Other stationary (including military), NH_3, 2000–2015	The TERT recommends that the Netherlands change the allocation of these emissions because it does not follow the 2016 EMEP/EEA Guidebook. Concerning landfill gas, three cases are possible: (1) the gas is not collected or it is collected and not combusted, in which case emissions should be reported in NFR 5A Solid waste disposal on land; (2) The gas is collected and flared, in which case emissions should be reported in 5A Solid waste disposal on land; (3) The gas is collected and combusted in stationary or mobile equipment, in which case emissions should be reported in either NFR 1A1a Public electricity and heat production, if there is a local plant for public electricity and heat production or if the biogas is transferred to another plant (domestic, commercial or industrial combustion plant) under the appropriate NFR code. In all cases, these emissions should not be included in category 1A5a unless the gas is used for military purposes.	This recommendation is subject to further consideration in 2018.
NL-1B1a-2017-0001	1B1a Fugitive emissions from solid fuels: Coal mining and handling, $PM_{2.5}$, 1990–2015	The TERT accepts the explanation and recommends that the information on IE notation keys in the IIR be modified. As a result of the question, the TERT found out that the implementation of quality controls for the emission reports was constrained by the lack of any other data in the inventory besides emissions. The TERT strongly recommends that the Netherlands collect proxy variables, such as production data, which would enable internal quality controls to be developed.	An explanation were the emissions from coal storage and handling in plants whose main activity is not the coal storage and handling (e.g. power plants) are reported is included in Paragraph 5.6.3. The reason why it is not possible to provide activity data and determine/calculate IEFs is given in Paragraph 5.6.3.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1B1b-2017-0001	1B1b Fugitive emissions from solid fuels: Solid fuel transformation, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT agrees with the explanation provided by the Netherlands and recommends that the Netherlands include it in the IIR.	See Paragraph 3.5.1.
NL-1B2av-2017-0001	1B2av Distribution of oil products, NMVOC, 1990–2015	For category 1B2av Distribution of oil products and NMVOC, the TERT noted that the 'NE' notation key had been used and that emission sources such as dissipation losses from gasoline service stations and leakage losses during vehicle and airplane refuelling had been included in the category 1B2aiv Fugitive emissions oil: Refining/ storage. In response to a question raised during the review, the Netherlands stated that the aforementioned emission sources would be reallocated for the next submission.	Emissions are now allocated to 1B2av.
NL-1B2b-2017-0001	1B2b Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other), SO_2, NMVOC, 1990–2015	The TERT recommends that the IIR be updated with this information in the next submission, including all emission sources and a brief methodological description.	See Paragraph 3.5.5.
NL-2A-2017-0001	2A Mineral industry, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT notes that this issue does not relate to an over- or under-estimate. However, the TERT strongly recommends that the Netherlands collect background information on the activity levels and process characteristics in order to validate the data consistency or repetitiveness, estimate emissions from non-reporting plants or fill gaps in the time series related to one reporting plant.	The reason why it is not possible to provide activity data and determine/calculate IEFs is given in Paragraph 5.2.1.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-2B-2017-0001	2B Chemical industry, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2005–2015	The TERT notes that this issue does not relate to an over- or under-estimate and recommends that the Netherlands include these indices in its next IIR to improve transparency.	The Chemical production indices are included in Paragraph 5.3.4.
NL-2C-2017-0001	2C Metal industry, SO_2, 2005–2015	The TERT recommends that the Netherlands investigate the possibility of estimating emissions on the basis of production data, which are reported as confidential in the NFR tables and a default emission factor from the 2016 EMEP/EEA Guidebook.	An explanation of why the Netherlands does not report SO_2 and $PM_{2.5}$ emissions for 2005–2015 is included in Paragraph 5.4.1.
NL-2C3-2017-0001	2C3 Aluminium production, SO_2, NO_X, 2005-2015	The TERT notes that this issue does not relate to an over- or under-estimate and recommends that the Netherlands include this in its next submission.	The reason why the Netherlands does not report SO_2 and NO_x emissions for 2C3 is given in Paragraph 5.4.1.
NL-2D-2017-0001	2D Non-energy products from fuels and solvent uses, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT recommends that the Netherlands improve the transparency of the reporting by including descriptions of the methodology, the activity data used including references, and the emission factors used including references. The TERT further recommends that the Netherlands, in cases when data are used that stem from plant reporting, provide a thorough description of the data quality (e.g. frequency of measurements) and describe in detail the steps in the validation process performed by the competent authority.	A reference to the WESP report, where detailed information on methodologies, activity data, etc. can be found, is included in Paragraph 5.5.5.
NL-2D3g-2017-0001	2D3g Chemical products, NMVOC, 1990–2015	The TERT recommends that the Netherlands make an effort to distinguish between emissions from the use of solvents, to be reported in this category, and emissions from other processes, to be reported under 2B10.	The reason why disaggregation of the reported emissions under 2B10a is not possible is given in Paragraph 5.3.1.
NL-2D3i-2017-0001	2D3i Other solvent use, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT recommends that the Netherlands include information on the activities covered, the activity data including the data sources and the emission factors used including references in its next submission.	The activities which belong to 2D3i are listed in Paragraph 5.5.3 on Other solvent use.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-2H2-2017-0001	2H2 Food and beverages industry, NMVOC, 2005, 2010, 2015	The TERT recommends that in its next submission the Netherlands provide information on the activities covered and make the utmost effort to obtain statistical data for as many of the activities as possible to allow for an estimation of the emissions following the methodology in the 2016 EMEP/EEA Guidebook.	The activities which belong to 2H2 are listed in Paragraph 5.6.1. The explanation why no activity data or emission factors are available can be found in Paragraph 5.6.1.
NL-3B-2017-0002	3B Manure management, NMVOC, 1990–2015	The TERT recommends that the Netherlands include these estimates in the next submission, in accordance with the 2016 EMEP/EEA Guidebook methodology.	This improvement is planned for the next submission; see also Paragraph 6.2.7.
NL-3B-2017-0003	3B Manure management, NH_3, 1990–2015	The TERT recommends that the Netherlands enhance the transparency of its next submission by including, apart from the references in the text, the most relevant parameters/ factors that affect the estimates: such as consistent livestock numbers, N excretion rates and use of MMS, and a detailed justification of any reduction in EFs caused by mitigation measures/national policies. All country-specific EFs should also be documented, including references, and all assumptions should be accompanied by a clear justification of the applicability.	Improved text has been included in Chapter 6 (Agriculture) and the methodology report (Vonk *et al.*, 2018).
NL-3B2-2017-0001	3B2 Manure management – Sheep, $PM_{2.5}$, 1990–2015	The TERT notes that the issue is below the threshold of significance for a technical correction and recommends that emission figures or an explanation of the current reporting (NE) are included in the next submission.	The issue is on the NEMA working group agenda.
NL-3D-2017-0002	3D Crop production and agricultural soils, NO_X, 1990–2015	The TERT recommends that the Netherlands report the emissions in the correct NFR category in the next submission.	NO_x emissions from category 3D are now allocated to the respective subcategories 3Da1 Inorganic N-fertilisers, 3Da2a Animal manure applied to soils and 3Da3 Urine and dung deposited by grazing animals instead of 11C.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-3D-2017-0003	3D Crop production and agricultural soils, $PM_{2.5}$, 1990–2015	The TERT recommends that the Netherlands enhance the transparency of its next submission by including in the IIR the main variables and assumptions made, such as activity data and explanations on how the EFs in Table 6.8 were derived, information on management practices and other parameters supporting the estimates.	The activity data and the assumptions made are included in the new methodology report (Vonk *et al.*, 2018).
NL-3D-2017-0004	3D Crop production and agricultural soils, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT agrees with this and recommends the Netherlands modify the text in the IIR, saying that emissions are not estimated because there is no methodology available in the 2016 EMEP/EEA Guidebook.	The issue is on the NEMA working group agenda.
NL-3Da1-2017-0001	3Da1 Inorganic N-fertilisers (includes urea application), NH_3, 2000–2015	The TERT recommends that the Netherlands include further information in its next IIR, such the amount of N applied to soils by fertiliser type, the EF used for each fertiliser and assumptions, accompanied by a clear justification of their applicability.	This has been included in the new methodology report (Vonk *et al.*, 2018).
NL-3F-2017-0001	3F Field burning of agricultural residues, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2005	The TERT recommends that further explanations supporting the lack of estimates (e.g. that sent to the TERT) be included in the next submission.	See Section 6.1.
NL-5E-2017-0001	5E Other waste, SO_2, NO_X, NMVOC, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that the Netherlands include the revised estimate in its next submission.	IIR2018 describes the methodology, activity data and emission factors used to calculate the emissions from this source
NL-6A-2017-0002	6A Other sources, NH_3, 2005-2015	Considering that this is a key category, the TERT recommends that the Netherlands include a methodological description in the IIR and include activity data and emission factors for the different emission sources covered by category 6A.	In IIR2018 the methodology used for the sources in this sector is described and activity data and emission factors used are reported.

Table A3.3 Overview of the implementation of actions as result of the 2018 NEC-review

Observation	**NFR, Pollutant(s), Year(s)**	**Recommendation (shortened text)**	**Action taken**
NL-1A1-2018-0001	1A1 Energy industries, $PM_{2.5}$, 2000–2015	The TERT reiterates recommendation NL-1A1-2017-0001 from the 2017 NECD Review, to present the $PM_{2.5}$ fractions used for 1A1, 1A2, 1A4, 1A5 in the IIR. During the 2018 NECD Review, the Netherlands confirmed that the recommendation would be addressed by the 2019 submission.	New $PM_{2.5}$ fractions were derived in 2018. The table is too large to include in the IIR, but it has been included in a separate report (see Visschedijk & Dröge, 2019).
NL-1A1-2018-0002	1A1 Energy industries, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT recommends that the Netherlands continue with the research and use the revised emission factors when available in the next submission, and transparently document the research in the IIR. If the results are not available for use in the 2019 submission, the TERT recommends that the Netherlands include a schedule for implementation in its next IIR.	This recommendation has been partly implemented. The emission factors of several fuels have been updated to the default emission factors from the EMEP/EEA Guidebook. EFs for the other fuels are planned to be revised in 2019.
NL-1A1-2018-0003	1A1 Energy industries, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT notes that in response to a question raised during the review, the Netherlands obtained sufficient evidence of the guidance for operator reporting and the verification of emissions by competent authorities to be satisfied that these emissions are not under-estimated (no subtraction of the confidence interval). The TERT recommends that the Netherlands include this transparency information in the 2019 submission.	A description of the guidance on stack measurements has been included in Paragraph 3.2.4.of the IIR2019
NL-1A1c-2018-0002	1A1c Manufacture of solid fuels and other energy industries, NH_3, NMVOC, $PM_{2.5}$, 2000–2015	The TERT reiterates recommendation NL-1A1c-2017-0001 from the 2017 NECD Review, that the Netherlands use the appropriate notation key for NMVOC in 1A1c, i.e. 'IE' if the emissions are included in 1B2b. The TERT also recommends that the Netherlands include transparent information regarding the use of 'NE' for other pollutants.	These emissions are included in 1A2a. The notation key has been changed to IE.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A2b-2018-0002	1A2b Stationary combustion in manufacturing industries and construction: Non-ferrous metals, NH_3, 2000–2015	The TERT reiterates recommendation NL-1A2b-2017-0001 from the 2017 NECD Review that the Netherlands ensures time series consistency of NH_3 emissions in 1A2b, 1A4ai, 1A4bi, 1A4ci. The TERT also recommends that the Netherlands investigate the relevance of the NH_3 emissions from the companies and provide this explanatory information in the 2019 submission, as well as transparently documenting any revisions to the time series based on the outcomes of the investigation.	The AERs from individual companies are not complete. In the coming years, a few sectors will be studied and AERs will be completed as far as possible. It still needs to be decided which sector will be studied in which year.
NL-1A2gvii-2018-0001	1A2gvii Mobile combustion in manufacturing industries and construction, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT recommend that the Netherlands provide separate activity data for biofuels and fossil fuels in the NFR tables for 1A2gvii in its 2019 submission or includes a schedule for implementation in its next IIR.	Due to limited resources, exploring the possibility of splitting the activity data was started in December 2018, too late to implement it in the inventory for the 2019 submission. It is expected that it will be implemented in time for the 2020 submission.
NL-1A3aii(i)-2018-0001	1A3aii(i) Domestic aviation LTO (civil), SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT recommends that Netherlands try to separate domestic and international LTO emissions for inclusion in the next submission or for the 2020 submission.	Emissions from domestic flights are very small and are included in the inventory (see Paragraph 4.2.5 of the 2019 IIR). The issue is on the long list of improvements. Due to limited resources, it is necessary to prioritise improvements annually at the start of the year (RIVM, 2018).

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A3b-2018-0002	1A3b Road transport, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that Netherlands provide separate activity data for biofuels and fossil fuels in the NFR tables for 1A3b in its next 2019 submission.	Due to limited resources, it is necessary to prioritise improvements annually at the start of the year (RIVM, 2018). Exploring the possibility of reporting activity data from biofuels separately started in December 2018, too late to implement the results in the inventory for the 2019 submission. It is expected that it will be implemented in time for the 2020 submission.
NL-1A3c-2018-0001	1A3c Railways, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2012–2014	The TERT recommends that Netherlands provide separate activity data for biofuels and fossil fuels in the NFR tables for 1A3c in its next 2019 submission.	Due to limited resources, it is necessary to prioritise improvements annually at the start of the year (RIVM, 2018). Exploring the possibility of reporting activity data from biofuels separately started in December 2018, too late to implement the results in the inventory for the 2019 submission. It is expected that it will be implemented in time for the 2020 submission.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A3ei-2018-0001	1A3ei Pipeline transport, SO2, NOX, NH3, NMVOC, PM2.5, 1990–2015	The TERT continues to recommend that the Netherlands correctly allocate the combustion emissions from pipeline compressors to 1A3ei in its 2019 submission.	There are several problems with making this improvement: • Emissions from this source are very small. • The combustion part is just a few percent of the total. • We are unable to split the historic emissions, so only the future emissions will be split. • As the split will be somewhat arbitrary, it is expected that it will increase the uncertainty of the combined sources. Due to limited resources, it is necessary to prioritise improvements annually at the start of the year (RIVM, 2018). The split will be put on the long list of improvements and annually prioritised with other improvements.
NL-1A5a-2018-0001	1A5a Other stationary (including military), NH_3, 2000–2015	The TERT recommends that the Netherlands review the notation key for NH_3, and implement the re-allocation of landfill gas across 1A5a/1A1a/5A following the investigation, and transparently document the changes and allocations in the 2019 submission.	Due to limited resources, it is necessary to prioritise improvements annually at the start of the year (RIVM, 2018). The work on splitting the emissions started late in 2018. As result, no new emission factors were available for the NFR/IIR2019 submission. This recommendation is subject for further consideration in 2019.
NL-1B1a-2018-0001	1B1b Fugitive emission from solid fuels: Solid fuel transformation, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT recommends that the Netherlands explicitly include the information regarding the inclusion of coal in Paragraph 5.6.3 of the IIR, as well as including the methodology information in the 2019 submission.	See Section 3.3of the IIR2019

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-2A-2018-0001	2A Mineral industry, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990–2015	The TERT recommends that the Netherlands provide further information on the estimation methods and make sure that estimates of emissions from making cement from clinker are included.	The reason why it is not possible to provide activity data and determine/calculate IEFs is given in Paragraph 5.2.1.of the IIR2019
NL-2C-2018-0001	2C Metal industry, SO_2, 2005–2015	The TERT recommends that the Netherlands provide this explanation in the IIR and explore opportunities to gather activity data from national aggregated statistics where possible.	An explanation of why the Netherlands does not report SO_2 and $PM_{2.5}$ emissions for 2005–2015 is included in Paragraph 5.4.1.of the IIR2019
NL-2D-2018-0001	2C3 Aluminium production, SO_2, NO_X, 2005–2015	The TERT recommends that the notation key be updated to 'IE' and the transparency information regarding the emissions allocation be included in the 2019 submission.	The reason why the Netherlands does not report SO_2 and NO_x emissions for 2C3 is given in Paragraph 5.4.1.of the IIR2019 The notation key has been updated from ‘NA’ to ‘IE’.
NL-2D3g-2018-0002	2D3g Chemical products, NMVOC, 1990–2015	The TERT recommends that the Netherlands continue to explore options for disaggregating 2D3g to provide further transparency to the estimates in its future submissions.	The reason why disaggregation of the reported emissions under 2B10a is not possible is given in Paragraph 5.3.1.of the IIR2019
NL-2H2-2018-0001	2H2 Food and beverages industry, NMVOC, 2005, 2010, 2015	The TERT recommends that the Netherlands update the chapter reference in the IIR, include the transparency information regarding the competency authority validations, and include an update on progress towards obtaining the relevant confidential data for review, if not include these in its 2019 submission.	The activities which belong to 2H2 are listed in Paragraph 5.6.1. The explanation why no activity data or emission factors are available can also be found in Paragraph 5.6.1.of the IIR2019
NL-3B-2018-0001	3B Manure management, NH_3, 1990–2015	The TERT recommends that the Netherlands endeavour to conclude the work of the NEMA working group and include estimates of emissions of NMVOC for all livestock species present in the country and include these emission estimates in the NFR of its 2019 submission. The TERT further recommends that appropriate explanatory text be provided in the IIR.	NMVOC emissions have been added to the inventory and reported in the NFR2019. The emissions are explained in the IIR2019 under Agriculture.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-3B2-2018-0001	3B2 Manure management – Sheep, $PM_{2.5}$, 1990–2015	The TERT recommends that the Netherlands endeavour to develop a country-specific emission factor, as suggested in its response to the observation, and include the emission factor and methodological approach in its 2019 submission.	Emissions from sheep have been added to the inventory and reported in the NFR2019. The emissions and methodology are explained in the IIR2019 under Agriculture.
NL-5E-2018-0001	5E Other waste, SO_2, NO_X, NMVOC, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that the Netherlands increase the transparency of the IIR by including all this information (especially the hypothesis). In addition, in order to justify the use of the $PM_{2.5}$ EF from wood combustion, the TERT recommends that the Netherlands investigate further the composition of combustible house/building material.	After consideration and evaluation of the available information, the Guidebook emission factors were used for the construction and interiors of buildings (EMEP/EEA, 2016: table 3.39 on small combustion in chapter 1A4of the IIR2019).
NL-0B-2018-0001	National Total for Compliance Assessment, SO_2, NOX, NH_3, NMVOC, $PM_{2.5}$, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F, 1990–2016	The TERT recommends that the Netherlands ensure that the National Total for Compliance row includes relevant values. Notation keys, blanks or ‘0’s should not be used.	This has been corrected in NFR2019.
NL-1B2ai-2018-0001	1B2ai Fugitive emissions oil: Exploration, production, transport, NMVOC, 2005, 2010, 2015	The TERT recommends that the Netherlands review the allocation of NMVOCs in the 2019 submission and transparently document the allocations and any category recalculations.	The allocation has been corrected.
NL-2B10a-2018-0002	2B10a Chemical industry: Other, Cd, 1990–2016	The TERT recommends that the Netherlands allocate resources to review the time series for completeness and estimate Cd emissions in the 2019 submission or include an implementation plan in the 2019 submission of when the issue is planned to be addressed.	As mentioned in Paragraph 5.1.1. of the 2019 IIR, incomplete time series will be completed, as far as possible, in future submissions.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-2C7a-2018-0003	2C7a Copper production, Cd, 2005, 2016	The TERT recommends that the Netherlands explore opportunities to collect data and make an estimate or update the notation key to 'NE' and include this and any evidence/justification that this source is not significant and low priority in the 2019 submission.	The notation key has been updated from ‘NA’ to ‘NE’.
NL-2D3g-2018-0001	2D3g Chemical products, PAHs, 1990, 2005, 2016	The TERT recommends that the Netherlands collect activity data for this emission source, calculate PAH emissions and document the methodology as soon as the corrected EF becomes available.	The reason why it is not possible to provide activity data is given in Paragraph 5.3.1.of the IIR2019
NL-1A1a-2018-0001	1A1a Public electricity and heat production, PCBs, 1990, 2016	The TERT recommends that the Netherlands develop a method for PCB emissions from these categories as soon as resources allow and include an update on progress on this in the 2019 IIR.	Emissions of PCBs will be calculated in 2019.
NL-1A1a-2018-0003	1A1a Public electricity and heat production, PCDD/F, PAHs, 1990–2016	The TERT recommends that the Netherlands include this transparency information in the next submission.	In Paragraph 3.2.3of the IIR2019 it is stated that dioxin emissions decreased due to technological improvements.
NL-1A1b-2018-0001	1A1b Petroleum refining, Cd, Hg, Pb, 2016	The TERT recommends that the Netherlands develop a methodology to ensure time series consistency for years when emissions are likely to occur but may be below the E-PRTR thresholds.	The AERs from individual companies are not complete. In the coming years, a few sectors will be studied and AERs will be completed as far as possible. It is yet to be decided which sector will be studied in which year.
NL-1A1c-2018-0001	1A1c Manufacture of solid fuels and other energy industries, Hg, 2016	The TERT recommends that the Netherlands develop a methodology to ensure time series consistency for years when emissions are likely to occur but may be below the E-PRTR thresholds.	The AERs from individual companies are not complete. In the coming years, a few sectors will be studied and AERs will be completed as far as possible. It is yet to be decided which sector will be studied in which year.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A2b-2018-0001	1A2b Stationary combustion in manufacturing industries and construction: Non-ferrous metals, Pb, PCDD/F, 1990–2016	The TERT recommends that the Netherlands develop a methodology to ensure time series consistency for years when emissions are likely to occur but may be below the E-PRTR thresholds.	The AERs from individual companies are not complete. In the coming years, a few sectors will be studied and AERs will be completed as far as possible. It is yet to be decided which sector will be studied in which year.
NL-1A2gviii-2018-0001	1A2gviii Stationary combustion in manufacturing industries and construction: Other, Cd, Hg, Pb, 2005	For category 1A2gviii the TERT recommends that the Netherlands include this transparency information in the 2019 submission.	Planned for 2019.
NL-1A2gviii-2018-0002	1A2gviii Stationary combustion in manufacturing industries and construction: Other, Hg, PAHs, 1990–2016	The TERT recommends that the Netherlands include this transparency information in the next submission.	Explained in IIR2019.
NL-1A3ai(i)-2018-0001	1A3ai(i) International aviation LTO (Civil), Pb, 1990–2016	The TERT recommends that, as this source is a key category for Pb in 2016, the Netherlands undertake an improvement programme to determine the current Pb content on AvGAS accounting for the introduction of unleaded fuels and provide greater transparency in the IIR on the source of Pb emissions and trends in the consumption of AvGAS.	We shall consider starting an improvement programme to determine the current Pb content on AvGAS for the next submission. This point is on the long list that will be prioritised in 2019.
NL-1A3biii-2018-0001	1A3biii Road transport: Heavy-duty vehicles and buses, PCDD/F, 1990–2016	The TERT recommends that the Netherlands explain transparently the dioxin trends and provide details of emission factors with associated sources in its next submission.	This year the same trend is visible for PCDD/F in category 1A3biii. An explanation has not yet been included.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A3biv-2018-0001	1A3biv Road transport: Mopeds & motorcycles, PCDD/F, 1990–2016	The TERT recommends that the Netherlands consider implementing this improvement for its next submission.	Due to limited time, it was not possible to address this point this year. Possibilities for including this in the improvements for the next submission (2020) are currently being investigated.
NL-1A3bvi-2018-0002	1A3bvi Road transport: Automobile tyre and brake wear, PAHs, 1990–2016	The TERT notes that this issue does not relate to an over- or under-estimate and recommends that the Netherlands explain transparently the trends in its next IIR submission.	Answer was provided in the review.
NL-1A3dii-2018-0001	1A3dii National navigation (Shipping), PCBs, HCB, Cd, Hg, Pb, 1990–2016	The TERT recommends that for completeness and for a consistent time series the Netherlands include these emissions in the NFR tables for 1A3dii for all years in the next 2019 NECD submission.	These emissions have not been included. It is planned to include these emissions in the NFR tables for the 2020 submission.
NL-1A4ai-2018-0002	1A4ai Commercial/ Institutional: Stationary, Hg, Pb, HCB, 1990–2016	The TERT recommends that the Netherlands include this transparency information in the next submission.	Planned for 2019.
NL-1A4ci-2018-0001	1A4ci Agriculture/ Forestry/ Fishing: Stationary, Cd, Pb, 1990, 2005, 2016	The TERT recommends that the Netherlands add the calculation of heavy metal emissions from 1A4ci to the inventory improvement plan.	Because the emissions are assumed to be negligible, this improvement will not be implemented in 2019.
NL-1A4ciii-2018-0001	1A4ciii Agriculture/ Forestry/ Fishing: National fishing, PCBs, HCB, Cd, Hg, Pb, PCDD/F, 1990–2016	The TERT notes that this issue may relate to an under-estimate and recommends that for completeness and for a consistent time series the Netherlands make an effort to calculate emissions of these pollutants from this source for all years in the next 2019 NECD submission.	These emissions have not been included. It will be investigated whether it is possible to calculate these emissions.
NL-1B2aiv-2018-0001	1B2aiv Fugitive emissions oil: Refining/ Storage, Cd, Hg, 1990, 2005, 2016	The TERT recommends that the Netherlands use the correct notation key for 1B2aiv ('IE') and transparently document their allocation in the 2019 submission.	The notation keys for all pollutants have been corrected to 'IE'.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1B2aiv-2018-0002	1B2aiv Fugitive emissions oil: Refining/ Storage, PCDD/F, 1990, 2005, 2016	The TERT recommends that the Netherlands use the appropriate notation key ('IE') and provide this information transparently in the IIR for the next submission.	The notation keys for all pollutants have been corrected to ‘IE’.
NL-2A3-2018-0001	2A3 Glass production, Cd, 1990	The TERT recommends that the Netherlands develop a methodology to enable the AER activity data to be used to estimate Hg and Cd emissions in the 2019 submission or include an implementation plan in the 2019 submission of when the issue is planned to be addressed.	Hg and Cd emissions from this category are obtained from AERs (Tier 3). If no AERs are available, ‘NA’ is reported, because there were no activity data available to calculate emissions.
NL-2B10a-2018-0001	2B10a Chemical industry: Other, Hg, 2016	The TERT recommends that the Netherlands use the appropriate notation key ('NO') for years when the activity is not occurring in the 2019 submission, and include a transparent description of the activities/processes (ideally including SNAP codes) reported under 2B10a.	Not all plants had ceased activity by 2016. Because the emissions were far below the reporting threshold in 2016, the notation key has been updated from ‘0’ to ‘NA’.
NL-2C1-2018-0001	2C1 Iron and steel production, HCB, PCBs, 1990, 2005, 2016	The TERT recommends that the Netherlands explore opportunities to collect data and make an estimate or update the notation key to 'NE' and include this and any evidence/justification that this source is not significant and low priority in the 2019 submission.	The notation key has been updated from ‘NA’ to ‘NE’.
NL-2C1-2018-0002	2C1 Iron and Steel Production, PAHs, 1990–2016	The TERT recommends that the Netherlands review the time series data and transparently document any resulting recalculations in the 2019 submission.	Recalculations for PAHs have been made.
NL-2C3-2018-0001	2C3 Aluminium production, HCB, 1990, 2005, 2016	The TERT recommends that the Netherlands explore opportunities to collect data and make an estimate or update the notation key to 'NE' and include this and any evidence/justification that this source is not significant and low priority in the 2019 submission.	The notation key has been updated from ‘NA’ to ‘NE’.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-2C3-2018-0004	2C3 Aluminium production, PCDD/F, 2005, 2016	The TERT recommends that the Netherlands explore opportunities to collect data and make an estimate or update the notation key to 'NE' and include this and any evidence/justification that this source is not significant and low priority in the 2019 submission.	The notation key has been updated from 'NA' to 'NE'.
NL-2C5-2018-0001	2C5 Lead Production, PCBs, 1990, 2005, 2016	The TERT recommends that the Netherlands explore opportunities to collect data and make an estimate or update the notation key to 'NE' and include this and any evidence/justification that this source is not significant and low priority in the 2019 submission.	The notation key has been updated from 'NA' to 'NE'.
NL-2C7a-2018-0001	2C7a Copper production, Pb, 1990	The TERT recommends that the Netherlands explore opportunities to collect data and make an estimate or update the notation key to 'NE' and include this and any evidence/justification that this source is not significant and low priority in the 2019 submission.	For 1990 and 1995 the notation key has been updated from '0' to 'NE'.
NL-2C7a-2018-0002	2C7a Copper production, Pb, 2005, 2016	The TERT recommends that the Netherlands explore opportunities to collect data and make an estimate or update the notation key to 'NE' and include this and any evidence/justification that this source is not significant and low priority in the 2019 submission.	The notation key has been updated from 'NA' to 'NE'.
NL-2D3a-2018-0001	2D3a Domestic solvent use including Fungicides, Hg, 1990, 2005, 2016	The TERT recommends that the Netherlands include the emission estimates and a transparent methodology description in the 2019 submission.	No resources were available to do this in the 2019 submission. This will be done in the 2020 submission.
NL-3Df-2018-0001	3Df Use of pesticides, HCB, 1990–2016	The TERT recommends that the Netherlands include a methodological description with respect to Zn emissions from 3Df in the IIR of its next submission.	The explanation has been included in Paragraph 6.3.4.of the IIR2019

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-5C1a-2018-0001	5C1a Municipal waste incineration, Cd, Hg, Pb, 1990, 2005, 2016	The TERT notes that this issue does not relate to an over- or under-estimate and recommends that the Netherlands report the appropriate notation key in its next submission.	The notation keys for all pollutants have been corrected to ‘IE’.
NL-5C1bi-2018-0001	5C1bi Industrial waste incineration, PCDD/F, 1990, 2005, 2016	The TERT notes that this issue does not relate to an over- or under-estimate and recommends that the Netherlands report the appropriate notation keys in its next submission.	The notation keys for all pollutants have been corrected to ‘IE’.
NL-5C1biii-2018-0001	5C1biii Clinical waste incineration, Hg, PCDD/F, HCB, 1990, 2005, 2016	The TERT notes that this issue does not relate to an over- or under-estimate and recommends that the Netherlands report the appropriate notation keys in its next submission.	The notation keys for all pollutants have been corrected to ‘IE’.
NL-5C1biv-2018-0001	5C1biv Sewage sludge incineration, NH_3, NMVOC, PAHs, PCBs, HCB, Cd, Hg, Pb, PCDD/F, 1990, 2005, 2016	The TERT notes that this issue does not relate to an over or under-estimate and recommends that the Netherlands report the appropriate notation key in its next submission.	The notation keys for all pollutants have been corrected to ‘IE’.

Appendix 4 Adjustment application tables from ANNEX_II

Table A4.1 Summary of new adjustments application by the Netherlands (by NFR, year and pollutant)

Ref. No	Poll.	NFR Code	unit	2010	2011	2012	2013	2014	2015	2016	2017
1	NMVOC	3B1a	Gg	-35.6746	-36.1301	-36.8525	-38.4629	-31.9928	-41.6433	-45.2255	-45.1737
2	NMVOC	3B1b	Gg	-12.5925	-12.6091	-12.5727	-12.8958	-13.0105	-13.2550	-13.0489	-12.3417
3	NMVOC	3Da2a	Gg	-11.0902	-12.3776	-11.6699	-13.4549	-13.4549	-12.6620	-14.4170	-14.3486
4	NMVOC	3Dc	Gg	-10.1573	-10.2498	-10.3975	-10.8087	-9.1993	-11.5626		
5	NMVOC	3B3	Gg	-3.5678	-3.5081	-3.3540					
6	NMVOC	3B4gii	Gg	-3.4169	-3.4173	-3.4224					
7	NMVOC	3B4gi	Gg	-3.2128	-3.0022	-2.9642					
8	NMVOC	3De	Gg	-1.5878							
9	NMVOC	3Da3	Gg	-0.3486							
10	NMVOC	3B4h	Gg	-0.3278							
11	NMVOC	3B4d	Gg	-0.3082							
12	NMVOC	3B4e	Gg	-0.0834							
13	NMVOC	3B4giii	Gg	-0.0727							
14	NMVOC	3B4giv	Gg	-0.0531							
15	NMVOC	3B2	Gg	-0.0202							
16	NMVOC	3B4h	Gg	-0.0024							
17	NMVOC	3B4f	Gg	-0.0003							
18	NH_3	3Da4	Gg					-2.1527	-1.8513	-2.0065	-2.3451
19	NH_3	3De	Gg								-1.8214
20	NH_3	3B3	Gg								-0.4874

Table A4.2 Quantification of new adjustments application by the Netherlands (by NFR, year and pollutant)

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
1	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1a	Manure management - Dairy cattle	2017	1,671,711	2.70E-05	45.1737	-45.1737	Gg	0%
2	new source - NMVOC from animal manure applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da2a	Animal manure applied to soils	2017	118,390,423	1.21E-07	14.3486	-14.3486	Gg	0%
3	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1b	Manure management - Non-dairy cattle	2017	2,351,300	5.25E-06	12.3417	-12.3417	Gg	0%
4	new source - NH_3 from crop residues applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da4	Crop residues applied to soils	2017	3,684,029	6.37E-07	2.3451	-2.3451	Gg	0%
5	new source - NH_3 from cultivated crops	See detailed information in Chapter 6 and 12 of IIR (2019)	3De	Cultivated crops	2017	1	1.82E+00	1.8214	-1.8214	Gg	0%
6	new process in this source sector- NH3 from manure treatment	See detailed information in Chapter 6 and 12 of IIR (2019)	3B3	Manure management - Swine	2017	6,789,135	7.18E-08	0.4874	-0.4874	Gg	0%
7	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1a	Manure management - Dairy cattle	2016	1,744,827	2.59E-05	45.2255	-45.2255	Gg	0%

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
8	new source - NMVOC from animal manure applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da2a	Animal manure applied to soils	2016	120,236,494	1.20E-07	14.4170	-14.4170	Gg	0%
9	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1b	Manure management - Non-dairy cattle	2016	2,506,629	5.21E-06	13.0489	-13.0489	Gg	0%
10	new source - NH_3 from crop residues applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da4	Crop residues applied to soils	2016	3,699,643	5.42E-07	2.0065	-2.0065	Gg	0%
11	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1a	Manure management - Dairy cattle	2015	1,621,767	2.57E-05	41.6433	-41.6433	Gg	0%
12	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1b	Manure management - Non-dairy cattle	2015	2,512,087	5.28E-06	13.2550	-13.2550	Gg	0%
13	new source - NMVOC from animal manure applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da2a	Animal manure applied to soils	2015	121,701,822	1.04E-07	12.6620	-12.6620	Gg	0%

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
14	new source - NMVOC from Farm-level agricultural operations including storage, handling and transport of agricultural products	See detailed information in Chapter 6 and 12 of IIR (2019)	3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	2015	5,067,393	2.28E-06	11.5626	-11.5626	Gg	0%
15	new source - NH_3 from crop residues applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da4	Crop residues applied to soils	2015	3,779,768	4.90E-07	1.8513	-1.8513	Gg	0%
16	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1a	Manure management - Dairy cattle	2014	1,572,287	2.03E-05	31.9928	-31.9928	Gg	0%
17	new source - NMVOC from animal manure applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da2a	Animal manure applied to soils	2014	117,585,146	1.14E-07	13.4549	-13.4549	Gg	0%
18	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1b	Manure management - Non-dairy cattle	2014	2,496,044	5.21E-06	13.0105	-13.0105	Gg	0%

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
19	new source - NMVOC from Farm-level agricultural operations including storage, handling and transport of agricultural products	See detailed information in Chapter 6 and 12 of IIR (2019)	3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	2014	4,997,877	1.84E-06	9.1993	-9.1993	Gg	0%
20	new source - NH_3 from crop residues applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da4	Crop residues applied to soils	2014	3,755,922	5.73E-07	2.1527	-2.1527	Gg	0%
21	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1a	Manure management - Dairy cattle	2013	1,552,919	2.48E-05	38.4629	-38.4629	Gg	0%
22	new source - NMVOC from animal manure applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da2a	Animal manure applied to soils	2013	112,307,183	1.17E-07	13.1958	-13.1958	Gg	0%
23	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1b	Manure management - Non-dairy cattle	2013	2,446,302	5.27E-06	12.8958	-12.8958	Gg	0%

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
24	new source - NMVOC from Farm-level agricultural operations including storage, handling and transport of agricultural products	See detailed information in Chapter 6 and 12 of IIR (2019)	3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	2013	4,926,231	2.19E-06	10.8087	-10.8087	Gg	0%
25	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1a	Manure management - Dairy cattle	2012	1,483,991	2.48E-05	36.8525	-36.8525	Gg	0%
26	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1b	Manure management - Non-dairy cattle	2012	2,395,261	5.25E-06	12.5727	-12.5727	Gg	0%
27	new source - NMVOC from animal manure applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da2a	Animal manure applied to soils	2012	109,943,445	1.06E-07	11.6699	-11.6699	Gg	0%

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
28	new source - NMVOC from Farm-level agricultural operations including storage, handling and transport of agricultural products	See detailed information in Chapter 6 and 12 of IIR (2019)	3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	2012	4,799,590	2.17E-06	10.3975	-10.3975	Gg	0%
29	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4gii	Manure management - Broilers	2012	43,846,343	7.81E-08	3.4224	-3.4224	Gg	0%
30	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B3	Manure management - Swine	2012	7,053,836	4.75E-07	3.3540	-3.3540	Gg	0%
31	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4gi	Manure management - Laying hens	2012	51,426,926	5.76E-08	2.9642	-2.9642	Gg	0%
32	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1a	Manure management - Dairy cattle	2011	1,469,720	2.46E-05	36.1301	-36.1301	Gg	0%
33	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1b	Manure management - Non-dairy cattle	2011	2,415,625	5.22E-06	12.6091	-12.6091	Gg	0%

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
34	new source - NMVOC from animal manure applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da2a	Animal manure applied to soils	2011	111,861,337	1.11E-07	12.3776	-12.3776	Gg	0%
35	new source - NMVOC from Farm-level agricultural operations including storage, handling and transport of agricultural products	See detailed information in Chapter 6 and 12 of IIR (2019)	3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	2011	4,789,004	2.14E-06	10.2498	-10.2498	Gg	0%
36	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B3	Manure management - Swine	2011	7,131,669	4.92E-07	3.5081	-3.5081	Gg	0%
37	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4gii	Manure management - Broilers	2011	43,911,647	7.78E-08	3.4173	-3.4173	Gg	0%
38	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4gi	Manure management - Laying hens	2011	53,006,964	5.66E-08	3.0022	-3.0022	Gg	0%
39	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1a	Manure management - Dairy cattle	2010	1,478,635	2.41E-05	35.6746	-35.6746	Gg	0%

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
40	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B1b	Manure management - Non-dairy cattle	2010	2,496,559	5.04E-06	12.5925	-12.5925	Gg	0%
41	new source - NMVOC from animal manure applied to soils	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da2a	Animal manure applied to soils	2010	116,400,950	9.53E-08	11.0902	-11.0902	Gg	0%
42	new source - NMVOC from Farm-level agricultural operations including storage, handling and transport of agricultural products	See detailed information in Chapter 6 and 12 of IIR (2019)	3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	2010	4,897,886	2.07E-06	10.1573	-10.1573	Gg	0%
43	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B3	Manure management - Swine	2010	7,131,165	5.00E-07	3.5678	-3.5678	Gg	0%
44	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4gii	Manure management - Broilers	2010	44,747,893	7.64E-08	3.4169	-3.4169	Gg	0%
45	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4gi	Manure management - Laying hens	2010	56,499,818	5.69E-08	3.2128	-3.2128	Gg	0%

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
46	new process in this source sector- NMVOC from Cultivated crops	See detailed information in Chapter 6 and 12 of IIR (2019)	3De	Cultivated crops	2010	18,462,451,675	8.60E-11	1.5878	-1.5878	Gg	0%
47	new source - NMVOC from urine and dung deposited by grazing animals	See detailed information in Chapter 6 and 12 of IIR (2019)	3Da3	Urine and dung deposited by grazing animals	2010	3,593,146	9.70E-08	0.3486	-0.3486	Gg	0%
48	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4h	Manure management - Other animals Fur-bearing	2010	962,409	3.38E-07	0.3254	-0.3254	Gg	0%
49	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4d	Manure management - Goats	2010	221,977	1.39E-06	0.3082	-0.3082	Gg	0%
50	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4e	Manure management - Horses	2010	141,481	5.90E-07	0.0834	-0.0834	Gg	0%
51	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4giii	Manure management - Turkeys	2010	1,036,277	7.01E-08	0.0727	-0.0727	Gg	0%
52	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4giv	Manure management - Other poultry	2010	1,086,990	4.88E-08	0.0531	-0.0531	Gg	0%

No.	Title	Comment	NFR Code	NFR Long name	Year	Adjusted activity data	Adjusted EF	Adjusted emissions (kt)	Adjust-ment (kt)	Units	Diff. in %
53	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B2	Manure management - Sheep	2010	558,184	3.61E-08	0.0202	-0.0202	Gg	0%
54	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4h	Manure management - Other animals Rabbits	2010	298,834	7.95E-09	0.0024	-0.0024	Gg	0%
55	new source - NMVOC from agriculture	See detailed information in Chapter 6 and 12 of IIR (2019)	3B4f	Manure management - Mules and asses	2010	1,050	2.54E-07	0.0003	-0.0003	Gg	0%

Table A4.3 Units of the activity data used in the new adjustments application by the Netherlands

Pollutant	NFR Code	Units activity data
NMVOC	3B1a	Animals
NMVOC	3B1b	Animals
NMVOC	3Da2a	Animals
NMVOC	3Dc	Animals
NMVOC	3B3	Animals
NMVOC	3B4gii	Animals
NMVOC	3B4gi	Animals
NMVOC	3De	Grondgebruik (m^2)
NMVOC	3Da3	Animals
NMVOC	3B4h	Animals
NMVOC	3B4d	Animals
NMVOC	3B4e	Animals
NMVOC	3B4giii	Animals
NMVOC	3B4giv	Animals
NMVOC	3B2	Animals
NMVOC	3B4h	Animals
NMVOC	3B4f	Animals
NH_3	3Da4	Grondgebruik (m^2)
NH_3	3De	
NH_3	3B3	Animals

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