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

Informative Inventory *Report 2020*

Emissions of transboundary air pollutants in the Netherlands 1990-2018

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Colophon

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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 (NFR) 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 updating the Approach2 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 2020
Emissions of transboundary air pollutants in the Netherlands 1990–2018

Decrease in ammonia emissions; entire time series adjusted downwards
Mainly as result of the implementation of new emission factors for wood combustion in household fireplaces and for the use of fertiliser in agriculture the entire time series was adjusted downwards with 1.3 Gg in 1990 and 1.0 Gg in 2017.

At 129.3 Gg in 2018, ammonia emissions are 1.3 Gg above the maximum set by the European Union and the UNECE under the Gothenburg Protocol (both 128 Gg).

Compared to 2017 the ammonia emissions decreased by 1.8 Gg. This decrease is mainly due to a decrease in cattle numbers and increased use of low-emission animal housing for swine.

Decrease in non-methane volatile organic compounds, nitrogen oxides and sulphur oxides
Mainly as a result of a decrease in cattle numbers the emissions non-methane volatile organic compounds compared to 2017 decreased with 241.6 Gg – 56.6 Gg above the maximum set by the European Union (185 Gg) and 50.6 Gg above the UNECE maximum under the Gothenburg Protocol (191 Gg).

The emissions of both nitrogen oxides and sulphur oxides decreased with respectively 8.6 and 1.6 Gg. For nitrogen oxides this is mainly a result of decreasing road traffic emissions due to ongoing implementation of the latest European Union regulations and a decrease in coal use for energy purposes.
The decrease of sulphur oxides is mainly a result of refineries using less oil for energy production and better flue gas treatments

Applying for adjustments
For both ammonia and non-methane volatile organic compounds the Netherlands uses the approved adjustments on the emissions for compliance with the ceilings set by the European Union and the UNECE under the Gothenburg Protocol.

The Informative Inventory Report 2020 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 2020

De uitstoot van ammoniak in Nederland is in 2018 met 0,6 kiloton is afgenomen ten opzichte van 2017. Dit komt vooral door ontwikkelingen in de landbouw, waar minder runderen worden gehouden en er steeds meer varkensstallen komen die minder ammoniak uitstoten. Toch ligt de uitstoot van ammoniak in 2018 met 129,3 kiloton boven het maximum van 128 kiloton dat vanuit Europa voor Nederland is bepaald.

De uitstoot van stikstofoxiden en zwaveldioxide is in 2018 licht gedaald, met respectievelijk 8,6 en 1,6 kiloton. Minder stikstofoxiden komt onder andere door de strengere eisen voor de uitstoot door personenauto's en vrachtverkeer, en doordat energiecentrales minder steenkool gebruiken. Minder zwaveloxiden komt vooral doordat raffinaderijen niet meer op olie maar op gas stoken, met een betere rookgasreiniging. De uitstoot van beide stoffen blijft onder de vastgestelde maxima. Ook de emissies van fijnstof zijn iets gedaald. Dat komt door aanpassingen in productie processen en toenemend gebruik van stoffilters in de industrie, en door strengere eisen voor de uitstoot door wegverkeer.

De uitstoot van vluchtige organische stoffen is in 2018 met 13,1 kiloton afgenomen tot 241,6 kiloton, maar ligt wel boven het maximum van 185 kiloton. De afname wordt vooral veroorzaakt doordat in de landbouw minder kuilvoer nodig is. Een andere reden zijn extra milieumaatregelen bij de energieproductie en in de industrie.

Voor Nederland verzorgen het RIVM en diverse partnerinstituten deze zogeheten Informative Inventory Report rapportage (IIR) waarin de uitstoot van in totaal 26 verontreinigende stoffen wordt gerapporteerd. Nederland gebruikt de analyses om beleid te onderbouwen en om te rapporteren in hoeverre de emissies onder de afgesproken maximale hoeveelheden (emissieplafonds) blijven.

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 in 2016 to set national emission reduction commitments for EU Member States (EU, 2016).

Parties to the CLRTAP and European Member States are obligated to report their emission data annually. Under the CLRTAP, 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).
Additionally the emission reduction commitments under both the Gothenburg Protocol (UNECE, 2012) and NECD (EU, 2016) are reported using the Technical guidance (UNECE, 2015)

The Informative Inventory Report 2020 (IIR 2020) 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 (PM_{10}, 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 2020 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 2018, including descriptions of methods, data sources and the annual QA/QC activities (including the trend analysis work shop). 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 2019 (EEA, 2019), 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 University & Research (WUR), Statutory research tasks:
  - Wageningen Environmental Research (WEnR);
  - Wageningen UR Livestock Research (WLR);
  - Wageningen Economic Research (WEcR.
- 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, 2019).

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 the Task Force (relevant sector data) and finally the 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).

1.3.2 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.

1.3.3 Data storage

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

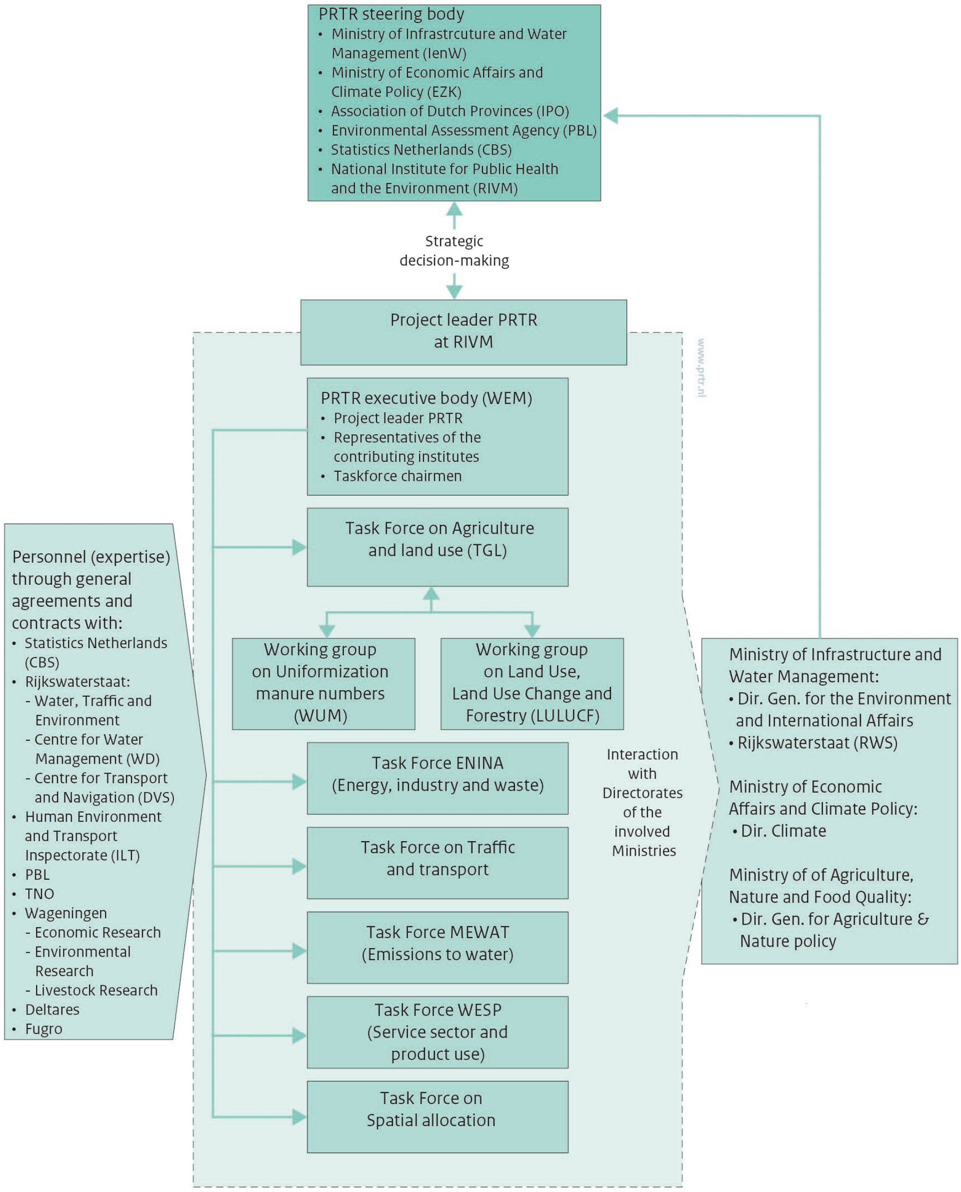

Figure 1.1 The organisational structure of the Netherlands Pollutant Release and Transfer Register (PRTR)

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.

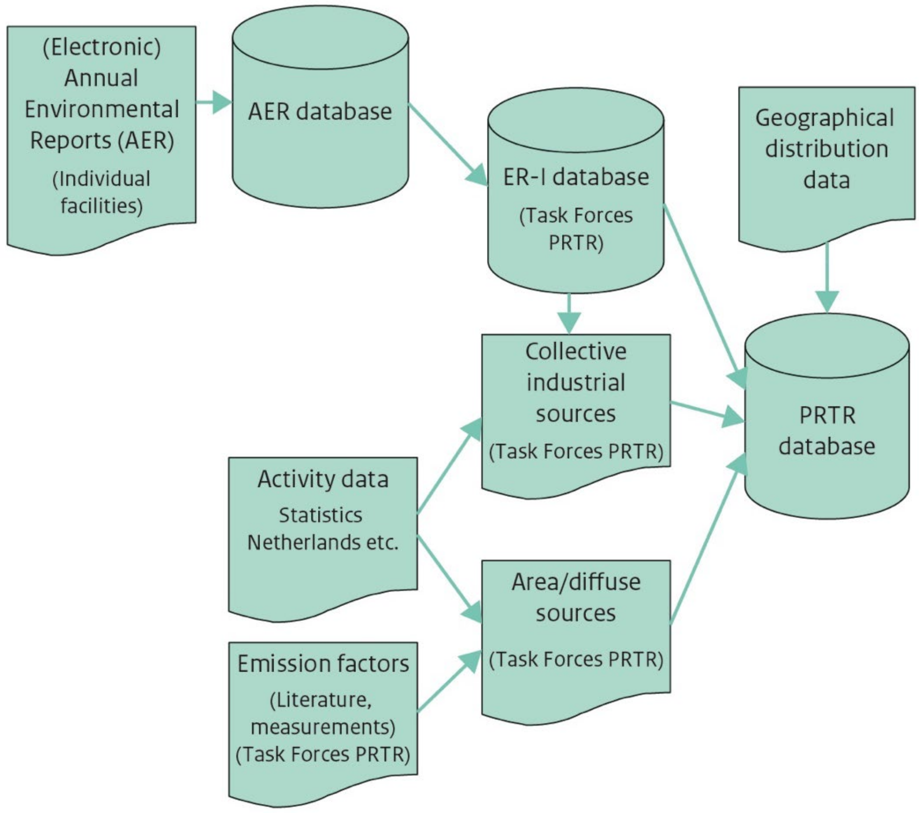

Figure 1.2 The data flow in the Netherlands Pollutant Release and Transfer Register (PRTR)

1.3.4 *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 issues 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'.

1.3.5 *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, 2019). The level assessments were performed for both the latest inventory year (2018) 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.

1.3.6 *Reporting, QA/QC and archiving*

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

1.3.7 *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 (Wanders, 2019). 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, 2019).

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 2018. 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 2018 and NFR/IIR 2020

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	08-07-2019	RIVM-PRTR	List of remaining issues/actions from last inventory	Actiepunten Voorlopige cijfers 2018 v 8 juli 2019.xls
Input for checking allocations from the PRTR database to the NFR tables	29-11-2019	RIVM-NIC	List of allocations	NFR-ER-Koppellijst-2019-11-29.xlsx
Comparison sheets with concept data	20-11-2019	RIVM	Input for data checks	Verschiltabel_LuchtIPCC_18-11-2019.xls
Comparison sheets with final data	26-11-2019	RIVM	Input for trend analyses	Verschiltabel_LuchtIPCC_26-11-2019.xls
Trend analysis workshops	05-12-2019	Sector specialists, RIVM-PRTR	Explanations for observed trends and actions to resolve before finalising the PRTR dataset	– Landbouw Trendanalyse 2019.pptx; – Trendanalyse ENINA.pptx; – Trendanalyse verkeer 2019.pptx; – WESP trendanalyse - 5-12-2019.pptx; – Grootschalige luchtverontreiniging irt plafondsTrendanalysedag 2019 v1.pptx.
Input for resolving the final actions before finalising the PRTR dataset	05-12-2019	Task Forces	Updated action list	Actiepunten Definitieve cijfers 1990-2018 v 10 december 2019.xls

QC item/action	Date	Who	Result	Documentation*
Request to the individual task force chairs to approve the data produced by the task force	24-01-2020	RIVM-PRTR	Updated action list	– Email (24-01-2020 15:35) with the request to endorse the PRTR database; – Actiepunten Definitieve cijfers 1990-2018 v 15 januari 2020.xls
Request to the contributing institutes to approve the PRTR database	28-01-2020	PRTR project secretary, representatives of the contributing institutes	Reactions of the contributing institutes to the PRTR project leader	– Email (28-01-2020 15:21) with the request to endorse the PRTR database; – Actiepunten Definitieve cijfers 1990-2018 v 28 januari 2020.xls; Emails with consent from PBL, Deltares and CBS (CBS 31-01-2020 16:42; PBL 31-01-2020 20:00; Deltares 28-01-2020 15:35).
Input for compiling the NEC report (in NFR format)	13-01-2020	RIVM-NIC	List of allocations for compiling from the PRTR database to the NFR tables	NFR-ER-Koppellijst-2020-01-13.xlsx
List of allocations for compiling from the PRTR database to the NFR tables	06-02-2020	RIVM	Input for compiling the EMEP/LRTAP report (NFR format)	NFR-ER-Koppellijst-2020-01-13 DW-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 dataset. 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 2017 from the new time series were compared with those of last year’s inventory; and (2) the data for 2018 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.

1.4 Archiving and documentation

Internal procedures are agreed on (e.g. in the PRTR work plan) for general data collection and the storage of fixed datasets in the PRTR database, including the documentation/archiving of QC checks. As of 2010, sector experts can store related documents (i.e. interim results, model runs, 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.

1.5 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.

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

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 2018 (%)

NFR category	NH_3	NO_x	SO_x	NMVOC	PM_{10}	$PM_{2.5}$
1	128	14	22	85	36	34
2	51	44	43	35	35	43
3	34	115	-	128	24	39
5	61	104	147	149	169	169
6	91	28	-	239	68	67
Total	**31**	**17**	**20**	**54**	**20**	**25**

The uncertainty estimates from the Approach2 method used in 2018 are different from the uncertainty estimates from this method in 2017 (as presented in the IIR 2019). This can be explained by the following:

- Small changes in the total uncertainty of a sector/pollutant are caused by changes in absolute emissions.
- Updated uncertainty estimates of:
  - Industry emission factors (resulting in lower NO_x and SO_x uncertainties)
  - Traffic (degassing of inland shipping, mobile machinery, aviation)
  - Residential wood combustion (emission factors)
  - Energy statistics (activity data)
  - Waste incineration, landfills and composting

Approach1 method

Uncertainty estimates from earlier studies (Van Gijlswijk *et al.*, 2004; RIVM, 2001) are presented in Table 1.3. The uncertainty estimate of NO_x is similar to the NO_x uncertainty calculated for 2018. The uncertainty for NH_3 and SO_x in 2018 increased compared with the studies of Van Gijlswijk *et al.* (2004) and RIVM (2001). For SO_x, this can be explained by the fact that the uncertainty of the SO_x emission factor from chemical waste gas, coal and cokes is assumed to be more uncertain.

Table 1.3 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%

1.6 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 have 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.

1.7 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 these source categories are named starting with ‘Other’. In Table 1.4 is explained which source sectors 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 1.3 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, NH_3, CO, $PM_{2.5}$, PM_{10}, 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	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, 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	NO_x, SO_x, NH_3, $PM_{2.5}$, PM_{10}, 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 2018 (and some 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. The adjustments were approved in 2019 and several emission sources in the agricultural sector are now 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, 1990–2018

	Main pollutants				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	**657**	**609**	**196**	**350**	**52**	**73**	**97**	**13**
1995	557	437	136	223	39	54	73	11
2000	465	337	78	175	29	42	51	10
2005	407	269	67	153	23	34	43	8
2010	340	270	36	133	18	28	36	5
2015	277	255	31	128	14	25	32	3
2017	252	253	26	131	13	24	30	3
2018	**244**	**240**	**25**	**129**	**12**	**23**	**30**	**2**
1990–2018 period[1]	-413	-368	-172	-221	-40	-50	-67	-11
1990–2018 period[2]	-63%	-61%	-87%	-63%	-76%	-69%	-70%	-82%

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

Table 2.2 Total national emissions of priority heavy metals and POPs, 1990–2018

	Other	Priority heavy metals			POPs	
	CO	Pb	Cd	Hg	DIOX	PAH
Year	Tg	Mg	Mg	Mg	g I-Teq	Mg
1990	**1.2**	**90**	**2.1**	**3.5**	**752**	**19**
1995	0.9	75	1.1	1.4	78	10
2000	0.8	27	0.9	1.0	44	5
2005	0.7	29	1.7	0.9	42	5
2010	0.7	37	2.5	0.6	47	5
2015	0.6	8	0.5	0.6	36	5
2017	0.6	8	0.6	0.5	36	5
2018	**0.6**	**5**	**2.3**	**0.5**	**35**	**5**
1990–2018 period[1]	-0.6	-85	0.3	-3.0	-717	-14
1990–2018 period[2]	-52%	-94%	12%	-85%	-95%	-76%

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

Table 2.3 Total national emissions of other heavy metals, 1990–2018

	Other heavy metals					
	As	Cr	Cu	Ni	Se	Zn
Year	Mg	Mg	Mg	Mg	Mg	Mg
1990	**1.3**	**9.8**	**16**	**74**	**0.4**	**192**
1995	0.9	6.5	18	85	0.3	113
2000	0.9	3.0	19	19	0.5	59
2005	1.3	2.1	19	10	2.6	49
2010	0.6	1.5	22	2	1.5	62
2015	0.7	1.1	17	1	1.0	62
2016	0.5	1.1	19	1	0.2	50
2018	**0.3**	**1.0**	**17**	**1**	**0.2**	**311**
1990–2018 period[1]	-0.9	-8.8	0.9	-73	-0.2	119
1990–2018 period[2]	-73%	-90%	6%	-99%	-54%	62%

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 413 Gg in the 1990–2018 period, corresponding to 63% of the national total in 1990 (Figure 2.1). Although all sectors show a decrease over this period, the main contributors to this decrease were road transport and the Energy sector. In road transport the 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 2018 the sector Transport is still the main contributor to NO_x emissions, with a share of 58% of the national total. The individual shares in the national total of the sectors Energy, Industry (combustion) and Transport show a decrease over the time period 1990-2018, while the share of Agriculture increased from 9% to 13%, respectively.

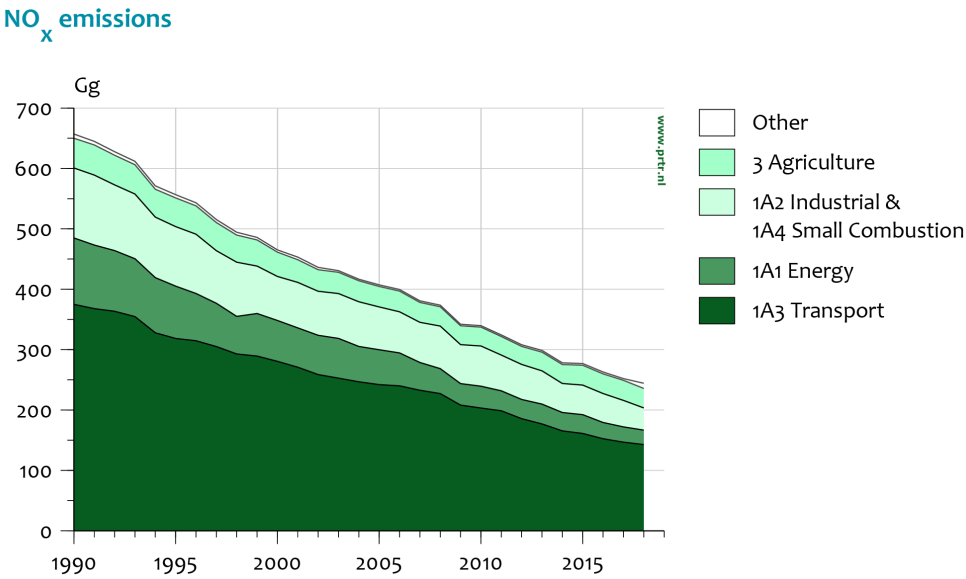

Figure 2.1 NO_x emission trends, 1990–2018

2.3 Trends in sulphur oxides (SO_x)

Dutch SO_x emissions (reported as SO_2) decreased by 172 Gg in the 1990–2018 period, corresponding to 87% 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 1990–2018 refining was the main contributor to total SO_x emissions, with shares of 42% and 40% in 1990 and 2018, respectively. In 2018, the source sectors Industry, and Energy and Refining (IER) were responsible for 81% of national SO_x emissions.

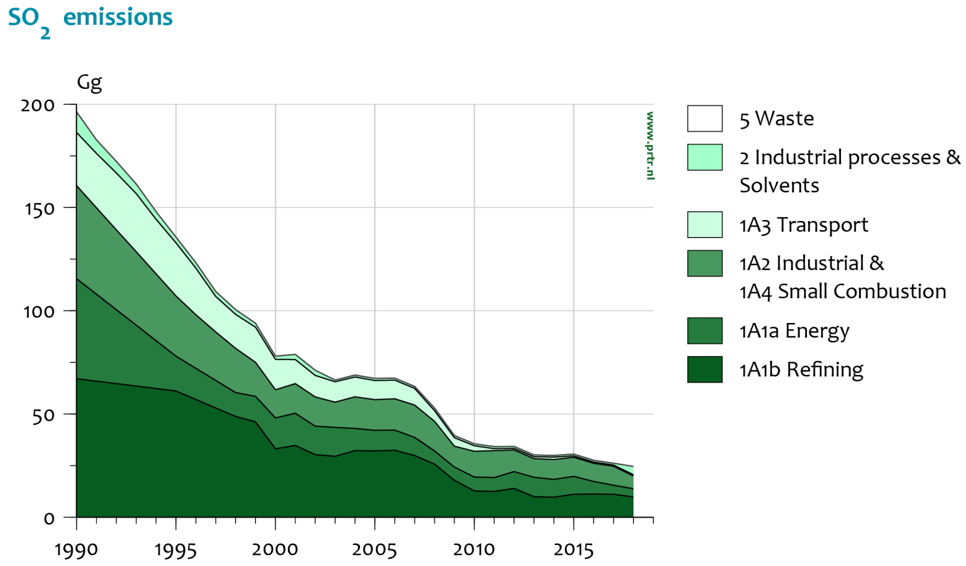

Figure 2.2 SO_x emission trends, 1990–2018

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 2018) come from agricultural sources. The share of agricultural sources in the national total is constant over the period 2004-2018. The sector Other has in 2018 a share of 8% and the sectors Industry and Transport each 3%. The shares of the sectors Industry and Waste are negligible (less than 1% each). Main sources in de sector Other are emissions from privately held horses and ponies and manure from agricultural sources used in nature reserves and by the public. However, for reporting under the CLRTAP and the NECD these sources should be allocated under agriculture (EC, 2019b), which will bring the share of the sector Agriculture over the period 1990-2018 under NECD and CLRTAP at a relative constant range of 95% to 93%, respectively.
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 131 Gg in 2018. 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). Further decreasing cattle numbers lead in 2018 to an decrease of 1 Gg NH_3-emissions from this source. A further emission decrease of 1 Gg NH_3 comes from ongoing implementation of low emission housing for swine.

Due to the above-mentioned developments, in 2018 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 justified the application for adjustments, as applied for and approved on by the EC and the EMEP-steering body in 2019, in order to achieve compliance (see Chapter 12).

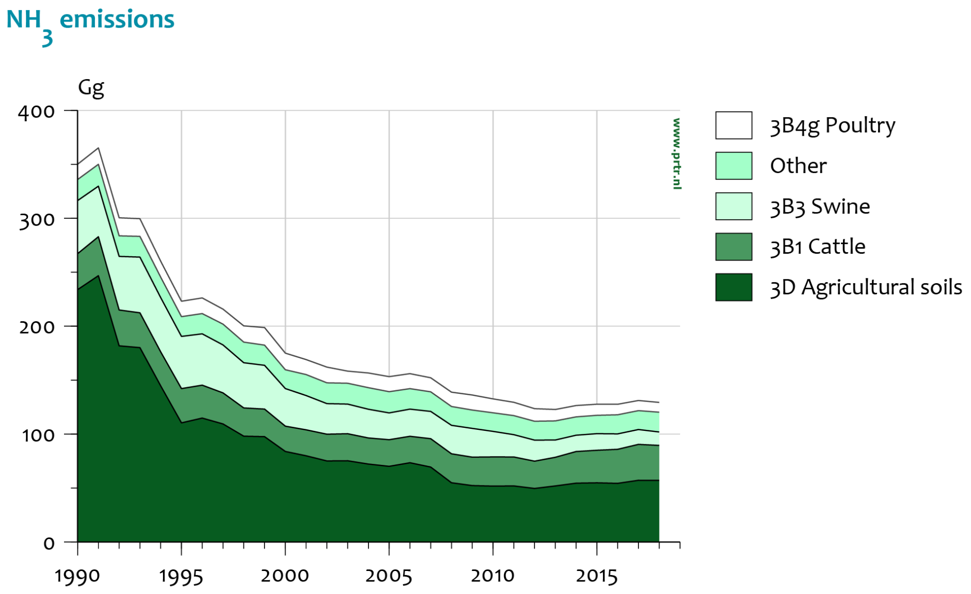

Figure 2.3 NH_3 emission trends 1990–2018

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 1990–2018, NMVOC emissions decreased by 368 Gg, corresponding to 61% 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 2018 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 justified the application for adjustments, as applied for and approved on by the EC and the EMEP-steering body in 2019, in order to achieve compliance (see Chapter 12).

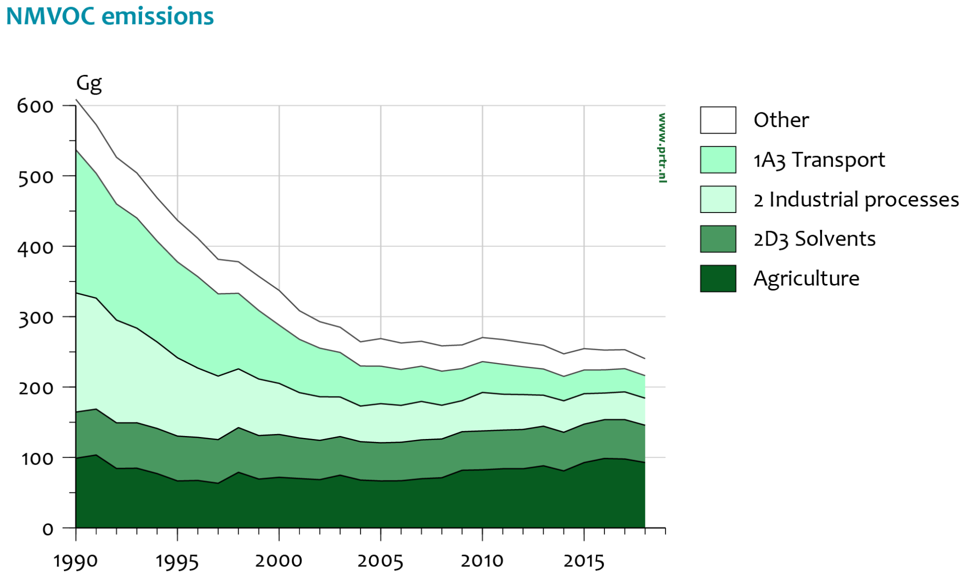

Figure 2.4 NMVOC emission trends, 1990–2018

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 40 Gg in the 1990–2018 period, corresponding to 76% 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.

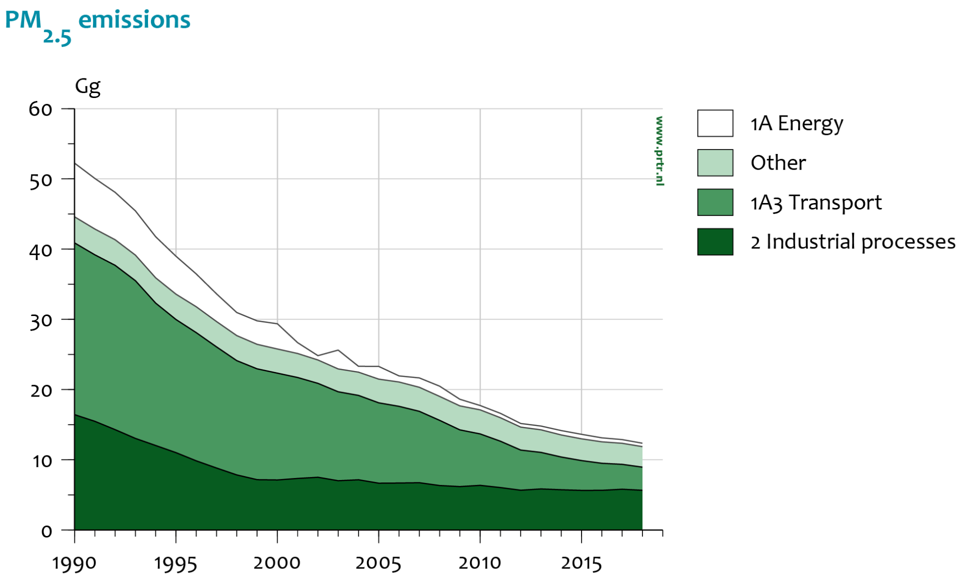

Figure 2.5 $PM_{2.5}$ emission trends, 1990–2018

2.7 Trends in PM_{10}

Dutch PM_{10} emissions decreased by 50 Gg in the 1990–2018 period, corresponding to 69% 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, and decreased again to 5.8 Gg in 2018. These increasing emissions were mainly caused by a change in housing systems (a shift from liquid manure to solid manure systems) for especially laying hens. The decrease in 2018 is mainly caused by an decrease in animal numbers in poultry.

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

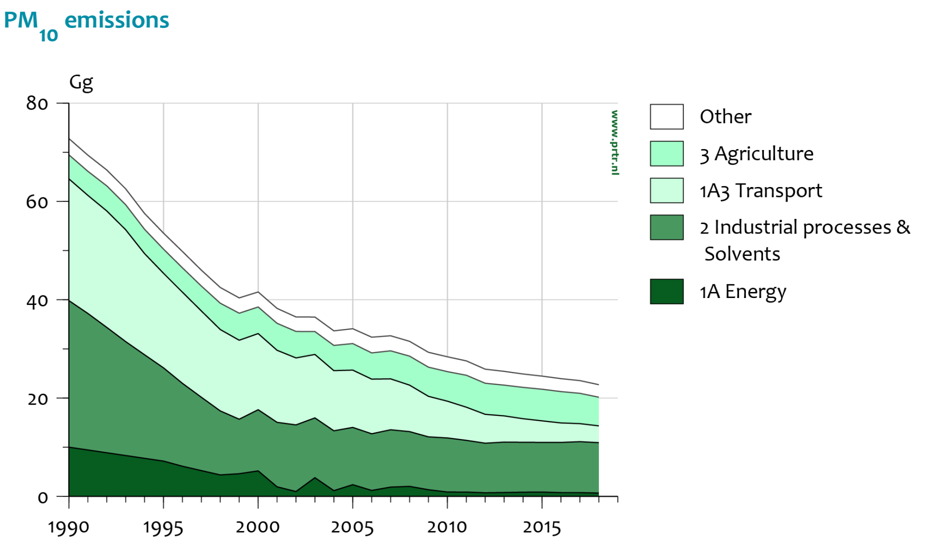

Figure 2.6 PM_{10} emission trends, 1990–2018

2.8 Trends in lead (Pb)

Lead (Pb) emissions in the Netherlands decreased by 332 Mg in the 1990–2018 period, corresponding to 98% 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).

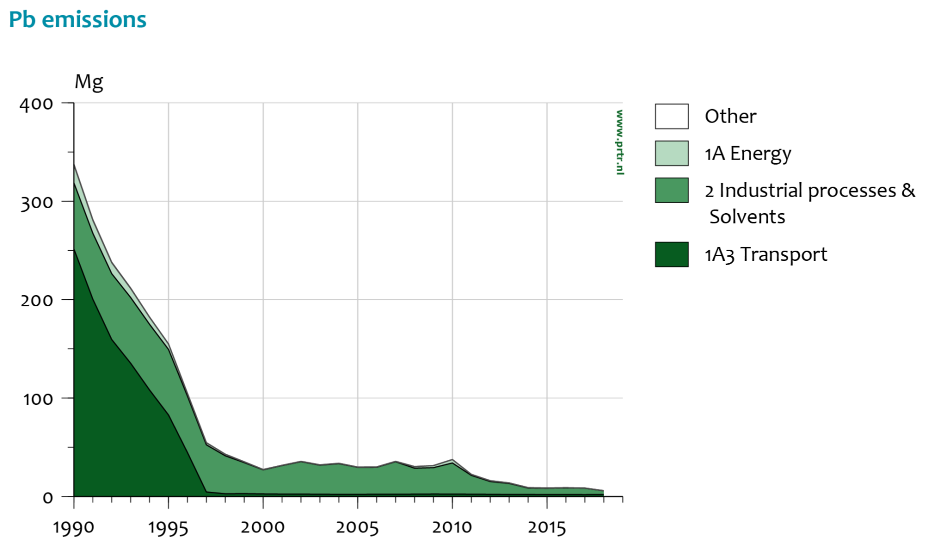

Figure 2.7 Pb emission trends, 1990–2018

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 84% (NH_3), 63% (NMVOC), 69% (NO_x) and 49% (PM_{10}) in 2018. 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 2018, natural gas supplied about 42% of the total primary fuels used in the Netherlands, followed by liquid fuels (37%) and solid fossil fuels (11%). The contribution of non-fossil fuels, including renewables and waste streams, is small (9%). 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 2018. Using the button 'Change selection' on the website, it is possible to select the data for another year.

Energy statistics of 2018: https://opendata.cbs.nl/

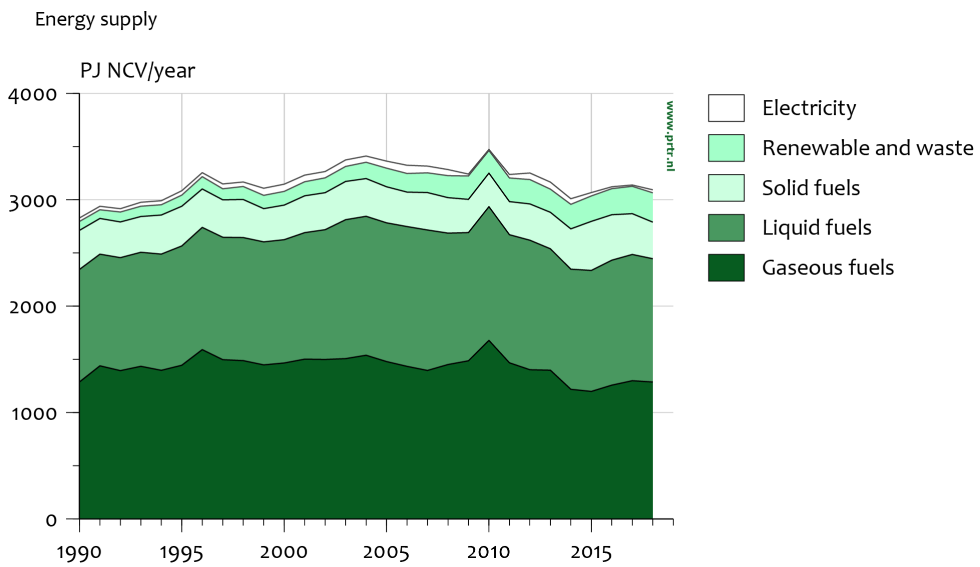

Figure 3.1 Energy supply in the Netherlands, 1990–2018 ('Electricity' refers to imported electricity only)

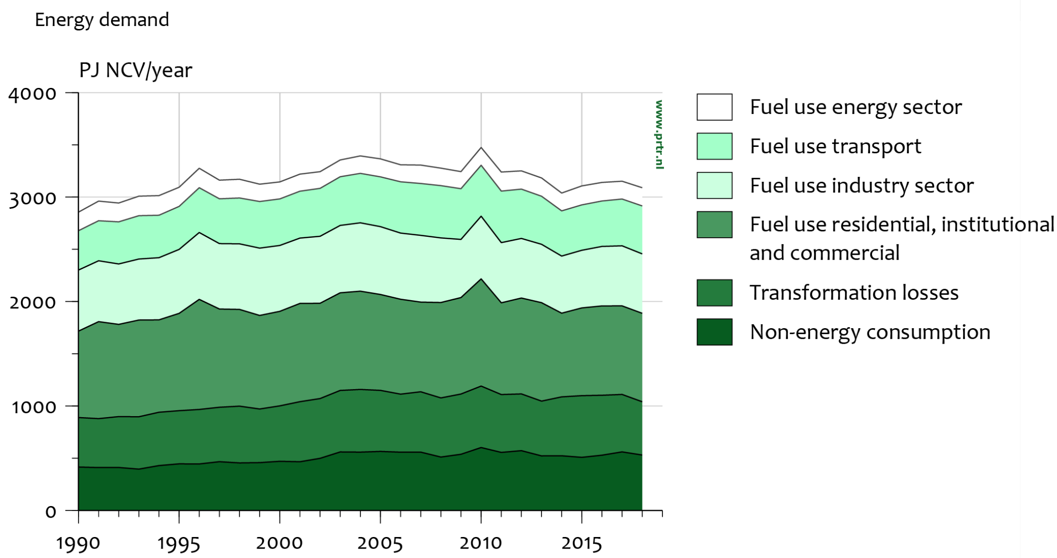

Figure 3.2 Energy demand in the Netherlands, 1990–2018

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 2018 (%)**
1A1a	Public electricity and heat production	SO_x	16
		NO_x	6.4
		Hg	31

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 2018, while fuel consumption increased over the same period.

NO_x and SO_x emissions decreased by 81% and 92%, respectively. Other pollutant emissions decreased by at least 48%. 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

Year	Main pollutants				Particulate matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**82.9**	**0.89**	**48.5**	**0.00**	**1.81**	**2.21**	**2.46**	**0.00**	**8.35**
1995	61.7	1.07	16.8	0.04	0.38	0.63	0.98	0.00	7.39
2000	51.5	2.12	14.9	0.04	0.25	0.33	0.33	0.00	15.4
2005	43.4	0.91	9.93	0.26	0.40	0.54	0.82	0.00	8.27
2010	25.8	0.67	6.75	0.07	0.21	0.29	0.60	0.00	4.75
2015	20.3	0.69	8.65	0.12	0.30	0.40	0.78	0.00	4.40
2017	16.8	0.67	4.36	0.13	0.17	0.26	0.38	0.00	4.01
2018	**16.8**	**0.67**	**4.36**	**0.13**	**0.17**	**0.26**	**0.38**	**0.00**	**4.01**
1990–2018 period[1]	-66.1	-0.22	-44.1	0.13	-1.64	-1.95	-2.09	0.00	-4.33
1990–2018 period[2]	-80%	-25%	-91%		-91%	-88%	-85%		-52%

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**	**0.18**	**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	0.13	0.01	0.08	0.19	0.17	0.08	0.45	0.26
2005	0.24	0.09	0.38	0.76	0.01	0.16	0.33	0.28	1.91	1.68	0.52
2010	0.34	0.18	0.22	1.18	0.02	0.11	0.14	0.15	0.16	1.33	3.91
2015	0.16	0.03	0.22	1.01	0.03	0.06	0.16	0.18	0.17	0.91	4.07
2017	0.09	0.03	0.17	1.55	0.04	0.04	0.14	0.12	0.06	0.13	3.73
2018	**0.09**	**0.03**	**0.17**	**1.55**	**0.04**	**0.04**	**0.14**	**0.12**	**0.06**	**0.13**	**3.73**
1990–2018 period[1]	-16.2	-0.92	-1.75	-581	-0.14	-0.46	-0.54	-1.94	-2.44	0.11	-36.9
1990–2018 period[2]	-99%	-97%	-91%	-100%	-78%	-91%	-79%	-94%	-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, a large part of the emission figures are based on AERs: NO_x (99%), NMVOC (85%), SO_x (99.5%), NH_3 (63.5%) and $PM_{2.5}$ (91%). 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), only used for fuel consumption and emissions that were not reported by individual companies

Substance name	Natural gas	Biogas	Coal	Fuel oil	Wood
NMVOC	2.6 [1)]	8.45 [4)]	5 [5)]	4 [6)]	48 [8)]
Sulphur dioxide	0.281 [1)]	10 [4)]	300 [6)]	450 [6)]	10 [8)]
Nitrogen oxides as NO_2	21 [2)]	80 [4)]	150 [7)]	64 [6)]	120 [8)]
Ammonia					37 [9)]
Carbon monoxide	6 [2)]	20 [4)]	150 [7)]	10 [6)]	160 [8)]
PM_{10}	0.297 [3)]	2 [4)]	60 [7)]	42.5 [6)]	12 [8)]

1. EMEP/EEA Guidebook (2019), 1A1, table 4.6, average value.
2. Specific emission factors derived from reported emissions in e-AERs.
3. EMEP/EEA Guidebook (2019), 1A1, table 4.6, minimum value.
4. Emission factor from biogas incineration by sewage treatment plants.
5. EF should have been 10 g/GJ (EMEP/EEA Guidebook 2019, 1A2, table 3.2 6. minimum value). Will be corrected in the 2021 data (impact is very small).
6. Methodology report of Guis (2006).
7. EMEP/EEA Guidebook (2019), 1A2, table 3.2, minimum value.
8. Koppejan and De Bree, 2018.
9. EMEP/EEA Guidebook (2019), 1A4, table 3.48, average value.

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 plants:

- 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.

Emissions of PCB are not reported by individual companies and are therefore calculated for the entire sector. The PCB emission factor for biomass is from the EMEP/EEA Guidebook (2019), chapter 1A2, table 3.5. The PCB emission factor of solid fuels in 1A1 and 1A2 is based on the correlation between the dioxin and PCB emission factors in the Guidebook and in the Dutch emission inventory. This results in an emission factor of 52.4 μg/GJ in 1990 and 0.67 μg/GJ from 1995 onwards. See Honig et al. (2020) for more details regarding the PCB emission factor.

HCB emissions are not reported by individual companies and are therefore calculated for the entire sector, with an emission factor of 0.2 mg/ton waste.

The PM2.5 emissions are either reported by individual companies, or they are calculated using default $PM_{2.5}/PM_{10}$ ratios. See Honig et al. (2020) for the complete list of $PM_{2.5}/PM_{10}$ ratios.

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).

3.2.6 *Uncertainties and time series consistency*

Uncertainties are explained in Section 1.7.

3.2.7 *Source-specific QA/QC and verification*

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

3.2.8 *Source-specific recalculations*

The following recalculations have been performed:

- Following the review recommendation NL-1A5a-2017-0001, the emissions from electricity production from landfill gas combustion have been reallocated to 1A1a;
- The default emission factors of NMVOC, SO_x, NO_x, CO, PM_{10}, used for emissions that were not reported by individual companies,

have been updated (following review recommendation NL-1A1-2017-0001). The emission factors are based on the EMEP/EEA Guidebook (EMEP/EEA, 2019), company specific data or country specific studies. See Table 3.3 for detailed references to the emission factors;
- Default $PM_{2.5}$/PM_{10} ratios are used to calculate the $PM_{2.5}$ emissions (see Visschedijk & Dröge, 2019). The ratios have not changed, but some of the PM_{10} emission factors have changed, resulting in updated $PM_{2.5}$ emissions;
- The energy statistics for 2016 and 2017 have been improved, resulting in small changes in biogas combustion and emissions from biogas combustion;
- Minor corrections in reported emissions from individual companies;
- Emissions of PCB have been calculated for coal and biomass combustion (following recommendations NL-1A1a-2018-0001, NL-1A1a-2019-0001). The methodology is described in Section 3.2.4.

3.2.9 Source-specific planned improvements
The following two source-specific improvements are planned:
- The error in NMVOC emission factor of coal combustion (only for companies that did not report their emissions) needs to be corrected;
- 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. These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.

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.
Combustion emissions from the iron and steel plant in the Netherlands were erroneously labelled as process emissions, and are therefore allocated in 2C1. Therefore, NO_x and SO_x emissions in 1A2a are not a

key category in 2018. The total emissions from the iron and steel plant (1A2a and 2C1 together) are correct. The allocation will be corrected in the next submission.

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 2018 (%)
1A1b	Petroleum refining	SO_x	40
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	SO_x CO	0.6 0.8
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	NO_x SO_x	3.7 7.0
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	SO_x	10

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

Year	Main pollutants				Particulate matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**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	2.02	45.9	0.05	2.89	4.21	4.94	0.30	161
2005	49.3	2.01	46.3	0.11	1.41	1.83	2.03	0.12	156
2010	40.3	3.83	24.5	0.48	0.40	0.58	0.82	0.03	127
2015	35.1	2.88	19.8	0.45	0.35	0.47	0.62	0.02	98.2
2017	32.3	2.21	19.7	0.45	0.35	0.49	0.62	0.02	87.8
2018	**32.3**	**2.21**	**19.7**	**0.45**	**0.35**	**0.49**	**0.62**	**0.02**	**87.8**
1990–2018 period[1]	-68.4	-4.06	-90.3	-0.12	-5.49	-7.30	-7.59	-0.40	-178
1990–2018 period[2]	-68%	-65%	-82%	-21%	-94%	-94%	-92%	-96%	-67%

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	0.005	0.00	0.54	0.16	18.1	0.00	0.89
2005	0.01	0.00	0.00	0.84	0.01	0.78	0.08	0.09	6.50	0.08	0.51
2010	3.08	1.28	0.02	5.70	0.05	0.01	0.15	1.13	0.19	0.12	9.82
2015	0.09	0.00	0.05	0.11	0.02	0.00	0.01	0.00	0.11	0.00	1.16
2017	0.01	0.00	0.03	0.02	0.02	0.00	0.28	0.11	0.26	0.00	0.43
2018	**0.01**	**0.00**	**0.03**	**0.02**	**0.02**	**0.00**	**0.28**	**0.11**	**0.26**	**0.00**	**0.43**
1990–2018 period[1]	-1.89	-0.14	-0.15	0.01	-0.97	-0.16	-2.29	-1.31	-66.8	-0.05	-2.53
1990–2018 period[2]	-99%	-100%	-83%	131%	-98%	-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, 19% of the SO_x emissions were collectively estimated (in 2018), thus 81% were based on the AERs.

Non-ferrous metals (1A2b)
Emission data are based on AERs and collectively estimated industrial sources. For this source category, 32% of the NMVOC emissions, 16% of

the NO_x emissions and 15% of the SO_x emissions were collectively estimated (in 2018).

Chemicals (1A2c)
Emission data are based on AERs and collectively estimated industrial sources. For this source category, 3% of the NO_x emissions, 3% of the SO_x emissions, 2% of the NMVOC emissions and 1.5% of the PM_{10} emissions were collectively estimated (in 2018).

Pulp, paper and print (1A2d)
Emission data are based on AERs and collectively estimated industrial sources. For this source category, 66% of the NMVOC emissions and 8% of the NO_x emissions were collectively estimated (in 2018).

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 e1A2e. 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).

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

Substance name	Natural gas	Biogas	Coal	Fuel oil	Wood (wood industries)	Wood (other industry)
NMVOC	1)	8.45 6)	5 7)	4 8)	5.6 10)	1.07 10
Sulphur dioxide	0.281 2)	10 6)	300 8)	450 8)	10 10)	10 10)
Nitrogen oxides as NO_2	3)	80 6)	150 9)	64 8)	150 10)	120 10)
Ammonia					37 11)	37 11)
Carbon monoxide	4)	20 6)	150 9)	10 8)	750 10)	160 10)
PM_{10}	0.297 5)	2 6)	60 9)	25 8)	27 10)	12 10)

1. For 1A2b, 1A2c and 1A2d, an EF from the Guidebook is used of 2.6 g/GJ (EMEP/EEA Guidebook (2019), 1A1, table 4.6, average value). For 1A2e, 1A2f and 1A2g, a specific emission factor is used of 3.8, 2.0, 5.2 g/GJ respectively (derived from emissions reported in e-AERs).
2. EMEP/EEA Guidebook (2019), 1A1, table 4.6, average value.
3. For 1A2b, 1A2c, 1A2d, 1A2e, 1A2f and 1A2g, a specific emission factor is used of 21, 55, 37, 43, 30, 40 and 37 g/GJ respectively (derived from emissions reported in eAERs);

4. For 1A2b, an EF from the Guidebook is used of 23.6 g/GJ (EMEP/EEA Guidebook (2019), 1A1, table 4.6, minimum value). For 1A2c, 1A2d, 1A2e, 1A2f and 1A2g, a specific emission factor is used of 21, 39.3, 40, 30 and 50 g/GJ respectively (derived from emissions reported in eAERs);
5. EMEP/EEA Guidebook (2019), 1A1, table 4.6, minimum value;
6. Emission factor from biogas incineration by sewage treatment plants;
7. EF should have been 10 g/GJ (EMEP/EEA Guidebook 2019, 1A2, table 3.2 minimum value). Will be corrected in the 2021 data (impact is very small).
8. Methodology report of Guis (2006);
9. EMEP/EEA Guidebook (2019), 1A2, table 3.2, minimum value;
10. Koppejan and De Bree, 2018;
11. EMEP/EEA Guidebook (2019), 1A4, table 3.48, average value;

Emissions of PCB are not reported by individual companies and are therefore calculated for the entire sector. The PCB emission factor for biomass is from the EMEP/EEA Guidebook (2019), chapter 1A2, table 3.5. The PCB emission factor of solid fuels in 1A1 and 1A2 is based on the correlation between the dioxin and PCB emission factors in the Guidebook and in the Dutch emission inventory. This results in an emission factor of 52.4 µg/GJ in 1990 and 0.67 µg/GJ from 1995 onwards. See Honig *et al.* (2020) for more details regarding the PCB emission factor.
The $PM_{2.5}$ emissions are either reported by individual companies, or they are calculated using default $PM_{2.5}/PM_{10}$ ratios. See Honig *et al.* (2020) for the complete list of $PM_{2.5}/PM_{10}$ ratios.

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.

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

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

Next, combustion emissions from 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).

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

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

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 default emission factors of NMVOC, SO_x, NO_x, CO, PM_{10}, used for emissions that were not reported by individual companies, have been updated (following review recommendation NL-1A1-2017-0002). The emission factors are based on the EMEP/EEA Guidebook (EMEP/EEA, 2019), company specific data or country specific studies. See Table 3.3 for detailed references to the emission factors;
- Default $PM_{2.5}$/PM_{10} ratios are used to calculate the $PM_{2.5}$ emissions (see Visschedijk & Dröge, 2019). The ratios have not changed, but some of the PM_{10} emission factors have changed, resulting in updated $PM_{2.5}$ emissions;
- Minor corrections in reported emissions from individual companies;
- Emissions of PCB have been calculated for coal and biomass combustion (following recommendation NL-1A2a-2019-0001).

3.3.9 *Source-specific planned improvements*
The following two sector-specific improvements are planned:

- The error in NMVOC emission factor of coal combustion (only for companies that did not report their emissions) needs to be corrected;
- 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 (following recommendations NL-1A1b-2018-0001, NL-1A1b-2019-0002, NL-1A2a-2019-0001, NL-1A2b-2017-0001, NL-1A2b-2018-0001, NL-1A2b-2019-0001, NL-1A2c-2019-0001, NL-1A2gviii-2018-0001, NL-1A2gviii-2019-0001). These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.

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 flaring 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 2018 (%)
1A4bi Residential: Stationary	NO_x	2.7
	NMVOC	3.7
	CO	12
	PM_{10}	6.5
	$PM_{2.5}$	13
	BC	22
	Dioxins	17
	PAH	68
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 all pollutants have decreased since 1990, while fuel use has increased slightly.

The decrease of Hg and Pb emissions between 1990-1991 in NFR 1A4ai is caused by the use of hard coal in the Services sector in 1990. From 1991 onward no hard coal is used in this sector. The steady slow increase of HCB from 2007 onward is caused by the use of wood in the services sector.

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	**42.2**	**14.2**	**2.15**	**0.35**	**2.66**	**2.73**	**5.26**	**0.95**	**82.8**
1995	45.3	14.5	1.38	0.35	2.53	2.63	4.98	0.95	87.4
2000	39.8	13.5	0.87	0.30	2.32	2.43	4.68	0.86	83.4
2005	35.9	13.3	0.67	0.29	2.30	2.42	4.69	0.82	85.0
2010	36.7	12.3	0.75	0.30	2.26	2.36	4.60	0.75	87.6
2015	24.7	10.6	0.58	0.29	1.92	2.01	4.07	0.62	76.3
2017	20.1	10.0	0.65	0.32	1.83	1.91	3.89	0.57	72.8
2018	**20.1**	**10.0**	**0.65**	**0.32**	**1.83**	**1.91**	**3.89**	**0.57**	**72.8**
1990–2018 period[1]	-22.2	-4.18	-1.51	-0.03	-0.83	-0.82	-1.37	-0.38	-9.98
1990–2018 period[2]	-53%	-29%	-70%	-8%	-31%	-30%	-26%	-40%	-12%

	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	**0.78**	**0.07**	**0.11**	**108**	**3.70**	**0.05**	**3.52**	**0.71**	**1.98**	**0.00**	**2.00**
1995	0.13	0.04	0.04	7.54	3.88	0.02	0.05	0.33	0.53	0.00	0.77
2000	0.08	0.05	0.03	7.03	3.79	0.01	0.01	0.31	0.23	0.00	0.69
2005	0.08	0.05	0.03	7.04	3.97	0.00	0.01	0.35	0.23	0.00	0.74
2010	0.09	0.05	0.03	6.93	4.05	0.01	0.00	0.38	0.01	0.00	0.83
2015	0.08	0.05	0.03	6.32	3.70	0.00	0.00	0.36	0.00	0.00	0.78
2017	0.08	0.05	0.03	6.07	3.51	0.00	0.00	0.36	0.00	0.00	0.77
2018	**0.08**	**0.05**	**0.03**	**6.07**	**3.51**	**0.00**	**0.00**	**0.36**	**0.00**	**0.00**	**0.77**
990–2018 period[1]	-0.70	-0.01	-0.08	-102	-0.20	-0.05	-3.5	-0.35	-1.98	0.00	-1.23
990–2018 period[2]	-89%	-21%	-73%	-94%	-5%	-94%	-100%	-50%	-100%	-99%	-61%

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**	**Wood**
NMVOC	2.0 [1)]	8.45 [7)]	10 [12)]	0.1 [9)]	16 [10)]
Sulphur dioxide	0.2 [2)]	10 [7)]	94 [4)]	450 [3)]	10 [10)]
Nitrogen oxides as NO_2	35.9 [8)]	80 [7)]	60 [5)]	150 [3)]	122 [10)]
Ammonia					37 [6)]
Carbon monoxide	15 [2)]	20 [7)]	30 [12)]	150 [3)]	150 [10)]
PM_{10}	0.28 [11)]	2 [7)]	4.5 [12)]	60 [3)]	38 [6)]

1. EMEP/EEA Guidebook (2019), 1A4, table 3.27, average value.
2. EMEP/EEA Guidebook (2019), 1A4, table 3.27, minimum value.
3. EMEP/EEA Guidebook (2019), 1A4, table 3.7, minimum value.
4. EMEP/EEA Guidebook (2019), 1A4, table 3.9, average value.
5. EMEP/EEA Guidebook (2019), 1A4, table 3.9, close to the minimum value.
6. EMEP/EEA Guidebook (2019), 1A4, table 3.48, average value.
7. Emission factor from biogas incineration by sewage treatment plants.
8. For the years prior to 2005, see NO_x-emission factor table in Visschedijk (2007). From 2005 onwards the NO_x-emission factor decreases due to the further implementation of low NO_x technologies (EF2005: 55.8 to EF2018: 35.9).
9. EF should have been 10 g/GJ (EMEP/EEA Guidebook 2019, 1A4, table 3.7, minimum value). Will be corrected in the 2021 data (impact is very small).
10. Methodology report of Guis (2006).
11. EF should have been 0.27 g/GJ (EMEP/EEA Guidebook 2019, 1A4, table 3.27, minimum value). Will be corrected in the 2021 data (impact is very small).
12. EFs should have been 20 g NMVOC/GJ, 93 g CO/GJ and 21 g PM_{10}/GJ (EMEP/EEA Guidebook 2019, 1A4, table 3.9, average value). Will be corrected in the 2021 data (impact is very small).

3.4.5 *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). See Table 3.11. Also emission factors for charcoal combustion in barbecues is included in this table.

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	1.6 [1)]	2.0 [2)]	8.5 [5)]	1.3 [7)]	5 [5)]	30 [6)]
Sulphur dioxide	0.3 [1)]	0.3 [2)]	70 [3)]	0 [7)]	70 [3)]	450 [4)]
Nitrogen oxides as NO_2	15 [8)]	57 [8)]	51 [3)]	40 [7)]	51 [3)]	150 [4)]
Carbon monoxide	22 [1)]	30 [2)]	57 [3)]	10 [7)]	57 [3)]	2000 [4)]
PM_{10}	0.28 [1)]	2.2 [2)]	1.9 [3)]	2 [7)]	1.9 [3)]	240 [4)]

1. EMEP/EEA Guidebook (2019), 1A4, table 3.16, average value.
2. EMEP/EEA Guidebook (2019), 1A4, table 3.13, average value.
3. EMEP/EEA Guidebook (2019), 1A4, table 3.5, average value.
4. EMEP/EEA Guidebook (2019), 1A4, table 3.19, average value.
5 .EF should have been 0.69 g/GJ (EMEP/EEA Guidebook 2019, 1A4, table 3.5 average value). Will be corrected in the 2021 data (impact is very small).
6. EF should have been 300 g/GJ (EMEP/EEA Guidebook 2019, 1A4, table 3.19 average value). Will be corrected in the 2021 data (impact is very small).
7. Methodology report of Guis (2006).
8. See Kok, 2014.

Table 3.11 Emission factors for wood combustion in households from Jansen (2016) and from charcoal use in barbecues from Visschedijk et al. (2020).

Substance	Unit	Fireplace	Conventional stove	Improved stove	Ecolabelled stove	Pellet	Barbecues (charcoal)
NMVOC	g/GJ	1290	774	387	252	10	250
SO_x	g/GJ	12.9	12.9	12.9	12.9	12.9	10
NO_x	g/GJ	77.4	129.0	129.0	129.0	80.0	50
NH_3	g/GJ	29.4	29.4	1.47	1.47	0.29	
CO	g/GJ	3226	6452	3871	2903	300	6000
PM_{10}	g/GJ	161.0	194.0	97.0	52.0	30.0	150
$PM_{2.5}$	g/GJ	153.0	184.3	92.2	49.4	30.0	75
$EC_{2.5}$	g/GJ	76.4	73.3	27.5	10.3	9.0	
Pb	mg/GJ	4.71	4.71	4.71	4.71	4.71	
Cd	mg/GJ	3.23	3.23	3.23	3.23	3.23	
Hg	mg/GJ	1.94	1.94	1.94	1.94	1.94	
Dioxin	ng/GJ	1613	174	174	174	100	150
PAH4	mg/GJ	193.5	343.9	221.3	172.3	35.0	143.4

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 3.12).

Table 3.12 Agriculture/Forestry/Fishing sectors (g/GJ)

Substance name	Natural gas	Biogas	LPG	Wood
NMVOC	2.0 [1)]	8.45 [4)]	1.3 [5)]	16 [3)]
Sulphur dioxide	0.2 [2)]	10 [4)]	0 [5)]	11 [3)]
Nitrogen oxides as NO_2	61 / 41.6 [8)]	80 [4)]	40 [5)]	80 [3)]
Ammonia				37 [7)]
Carbon monoxide	15 [2)]	20 [4)]	10 [5)]	170 [3)]
PM_{10}	0.2 [6)]	2 [4)]	0.3 [5)]	17 [3)]

1. EMEP/EEA Guidebook (2019), 1A4, table 3.27, average value.
2. EMEP/EEA Guidebook (2019), 1A4, table 3.27, minimum value.
3. From 'Kennisdocument Houtstook in Nederland' (Koppejan and De Bree, 2018).
4. Emission factor from biogas incineration by sewage treatment plants.
5. Methodology report Zonneveld (Guis, 2006).
6. EF should have been 0.27 g/GJ (EMEP/EEA Guidebook 2019, 1A4, table 3.27 minimum value). Will be corrected in the 2021 data (impact is very small).
7. EMEP/EEA Guidebook (2019), 1A4, table 3.48, average value.
8. The emission factor of 61 g/GJ is used for gas engines (source: Hulskotte, 2017), while the emission factor of 41.6 is used for boilers (source: Guis, 2006).

Emissions of PCB are not reported by individual companies and are therefore calculated for the entire sector. The PCB emission factor of solid fuels in 1A4 is from the EMEP/EEA Guidebook (2019), chapter 1A4, table 3.7. The PCB emission factor of biomass is from the EMEP/EEA Guidebook (2019), tables 3.39 – 3.43.
The $PM_{2.5}$ emissions are either reported by individual companies, or they are calculated using default $PM_{2.5}/PM_{10}$ ratios. See Honig *et al.* (2020) for the complete list of $PM_{2.5}/PM_{10}$ ratios.

3.4.6 *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.

3.4.7 *Uncertainties and time series consistency*

Uncertainties are explained in Section 1.7.

3.4.8 *Source-specific QA/QC and verification*

General QA/QC is explained in Section 1.3.

3.4.9 *Source-specific recalculations*

The following recalculations have been performed:

- Wood combustion statistics from residential combustion have been updated for the complete time series. New statistics from Statistics Netherlands became available for 2018, and these data have been used to improve the model that is used to calculate the activity data. The previous survey was from 2012. Based on this new survey, the activity data for fireplaces have been updated for the complete time series, and the activity data for other types of wood stoves has been updated for the period 2012-2017. In the old model, it was expected that wood combustion would increase further, but the new survey showed

that wood combustion remained rather stable. Therefore, the emissions have been reduced in the period 2012-2017. Changes in 1990-2011 are caused by changes in model parameters for fireplaces, in such a way that the resulting wood combustion statistics of fireplaces match the trend in observed wood combustion in 2006/2007, 2012 and 2018. In 2017, this update resulted in an emission reduction of NO_x (-0.4 Gg), SO_x (-0.04 Gg), NMVOC (-1.8 Gg), CO (-14 Gg) and PM_{10} (-0.4 Gg).
- The NH_3 emission factor for residential wood combustion has been improved, based on a relationship between smouldering conditions and NH_3 emission factors. See Visschedijk (2019) for more details. As a result of the improved emission factor and the new wood combustion statistics, the NH_3 emission reduced with 0.75 Gg in 2017.
- The default emission factors of NMVOC, SO_x, NO_x, CO, PM_{10}, used for emissions that were not reported by individual companies, have been updated (following review recommendation NL-1A1-2017-0002). The emission factors are based on the EMEP/EEA Guidebook (EMEP/EEA, 2019), company specific data or country specific studies. See tables 3.9 – 3.11 for detailed references to the emission factors.
- Default $PM_{2.5}$/PM_{10} ratios are used to calculate the $PM_{2.5}$ emissions (see Visschedijk & Dröge, 2019). The ratios have not changed, but some of the PM_{10} emission factors have changed, resulting in updated $PM_{2.5}$ emissions.
- The energy statistics for 2017 have been improved.
- Emissions of PCB have been calculated for coal and biomass combustion (following recommendation NL-1A4ai-2019-0001, NL-1A4bi-2019-0001).
- Following the review recommendation NL-1A5a-2017-0001, the emissions from electricity production from landfill gas combustion have been reallocated to 1A1a. Emissions of flaring of landfill gas are reported in 1A5a.

3.4.10 Source-specific planned improvements
The following sector-specific improvements are planned:
- Error correction for some of the emission factors (see the references at tables 3.9 – 3.11).
- Mercury emissions from natural gas combustion will be calculated in the next submission (following review recommendation NL-1A4ci-2018-0001).

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*

None of the sectors in 1B is a key category. Table 3.13 shows the main sources and pollutants of this sector.

Table 3.13 Main sources and pollutants in the Fugitive emissions sector category (NFR 1B). None of these sources is a key source.

Category / Subcategory	**Pollutant**	**Contribution to total of 2018 (%)**
1B2aiv Refining	NMVOC	1.3
1B2av Distribution of oil products	NMVOC	1.6
1B2b Fugitive emissions from natural gas	NMVOC	1.0

3.5.3 *Overview of shares and trends in emissions*

An overview of the trends in emissions is shown in Table 3.14. The emissions from NMVOC decreased between 1990 and 2018.

Table 3.14 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	0.00	47.4	0.00	0.01	0.11	0.19	0.57	0.00	0.00
1995	0.00	33.5	0.02	0.01	0.14	0.21	0.38	0.00	0.00
2000	0.00	29.2	0.00	0.00	0.07	0.10	0.10	0.00	0.00
2005	0.00	20.8	0.00	0.00	0.07	0.10	0.11	0.00	0.00
2010	0.00	15.4	0.00	0.00	0.00	0.00	0.01	0.00	0.00
2015	0.00	14.3	0.00	0.00	0.05	0.05	0.05	0.00	0.00
2017	0.00	12.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2018	**0.00**	**9.9**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
1990-2018 period1)	0.00	-37.5	0.00	-0.01	-0.11	-0.18	-0.56	0.00	0.00
1990-2018 period2)		-79%		-89%	-97%	-98%	-99%		

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 1B2aiv 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 1B2av 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).

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

Detailed information on activity data and emissions can be found in Honig *et al.* (2020).

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*

The activity data for leakage losses during vehicle and aircraft refuelling have been recalculated in 2016 and 2017, resulting in a decrease of NMVOC emissions.

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), Waterborne navigation (1A3d) and Pipeline transport (1A3ei). Table 4.1 provides an overview of the source categories within the transport sector and the methodologies used for calculating emissions within the sector. For the first four source categories, national activity data and (mostly) country-specific 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 are reported under 1A5b Other, mobile and are calculated using a Tier 3 and Tier 2 methodology, respectively. Emissions from fisheries are 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 Geilenkirchen *et al*. (2020a), supplemented by tables with detailed emission and activity data, and the emission factors used in the emission calculations (Geilenkirchen *et al*., 2020b).

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 2018 level assessment and the 1990–2018 trend assessment (in italics). Some source categories are key sources for both the trend and the 2018 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. Percentages in underlined italics are from the trend contribution calculation

NFR code	Source category description	SO_2	NO_x	NMVOC	CO	PM_{10}	$PM_{2.5}$	BC	Pb [3)]
1A3ai(i)	International aviation LTO (civil)		2.5%						13.8%
1A3aii(i)	Domestic aviation LTO (civil)								
1A3bi	Passenger cars	*4.7%*	18.0%	*13.1%*	40.7%	*7.8%*	*9.6%*	*15.3%*	*43.9%*
1A3bii	Light-duty vehicles		8.4%		*5.4%*	*4.8%*	*5.5%*	15.3%	
1A3biii	Heavy-duty vehicles and buses	8.0%	13.2%	*2.5%* [2)]		*9.6%*	*12.7%*	*26.5%*	
1A3biv	Mopeds and motorcycles			4.2%	9.5%				
1A3bv	Gasoline evaporation			*6.0%*					
1A3bvi	Automobile tyre and brake wear					5.9%	2.1%		5.5% [2)]
1A3bvii	Automobile road abrasion					4.8%			
1A3c	Railways								
1A3di(ii)	International inland waterways		6.8%			2.0%	3.8%	11.2%	
1A3dii	National navigation (shipping)		5.1%				2.7%	*7.9%*	
1A2gvii	Mobile combustion in manufacturing industries and construction		3.8%			[1)]	2.9%	7.6%	
1A4aii	Commercial/institutional: mobile								
1A4bii	Residential: household and gardening (mobile)				*6.1%*				
1A4cii	Agriculture/forestry/fishing: off-road vehicles and other machinery		3.1%				2.0%	5.1% [2)]	
1A4ciii	Agriculture/forestry/fishing: National fishing	4.8%	2.8%						
1A5b	Other, Mobile (including military, land based and recreational boats)				3.8%				

Percentages in italics and underlined are from the trend contribution calculation.
1. No longer a key source (cf. IIR 2019).
2. New key source (cf. IIR 2019).
3. Road Traffic based on fuel used.

4.2 Civil aviation

4.2.1 Source category description

The source category Civil aviation (1A3a) includes emissions from all landing and take-off 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 the small size of the country, there is hardly any domestic aviation in the Netherlands. The split of LTO-related fuel consumption and resulting emissions between domestic and international aviation was not made. 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 (2018 level) and for NO_x (1990–2018 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 Geilenkirchen et al. (2020a, 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. Since 2012, fuel consumption of LTO in civil aviation continued to increase by on average 0.3 PJ per year.

The trends in emissions from civil aviation in the Netherlands are shown in Table 4.3. 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 2018, following the trend in fuel consumption. PM_{10} emissions from civil aviation increased significantly throughout the time period. 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

Year	Main Pollutants			Particulate Matter				Other	Priority Heavy Metals
	NO_x	NMVOC	SO_x	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg
1990	**1.24**	**0.38**	**0.10**	**0.02**	**0.03**	**0.03**	**0.02**	**3.57**	**1.87**
1995	1.78	0.34	0.14	0.03	0.03	0.03	0.02	4.04	1.99
2000	2.41	0.29	0.19	0.03	0.04	0.04	0.02	3.78	1.52
2005	2.74	0.27	0.22	0.03	0.04	0.04	0.02	3.57	1.14
2010	2.77	0.27	0.21	0.03	0.03	0.03	0.02	3.70	1.28
2015	3.28	0.30	0.24	0.03	0.04	0.04	0.02	3.52	0.86
2017	3.62	0.32	0.26	0.03	0.04	0.04	0.02	3.59	0.75
2018	**3.72**	**0.34**	**0.26**	**0.03**	**0.04**	**0.04**	**0.02**	**3.80**	**0.82**
1990-2018 period[1)]	2.48	-0.04	0.16	0.00	0.01	0.01	0.00	0.24	-1.05
1990-2018 period[2)]	201%	-11%	156%	17%	42%	42%	10%	7%	-56%

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.

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 Geilenkirchen et al. (2020a).

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*

Due to the small size of the country, there is hardly any domestic aviation in the Netherlands, with the exception of general aviation. Therefore, 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. 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 2018. 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, 2017a). The resulting uncertainty estimates for civil aviation are provided in Table 4.4. Uncertainty estimates for PM emissions of LTO (jet kerosene) were adjusted from 100% to 200%, resulting from a comparison with methodologies used in recent environmental studies regarding Schiphol. Activity data for fuelling and fuel handling also has a higher uncertainty (from 10% to 20%) as the data are extrapolated. Uncertainty in activity data for LTO (avgas) is adjusted from 20% to 35% due to differences found in CBS statistics for fuel sales.

Table 4.4 Uncertainty estimates for civil aviation (%)

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

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

4.2.7 *Source-specific QA/QC and verification*

This year no source-specific QA/QC and verification check was performed for civil aviation.

4.2.8 *Source-specific recalculations*

The modelling of energy use and emissions from aviation has been subject to several changes and improvements, mostly regarding input data. There has been an error correction in the maximum take-off weight (MTOW) of some aircraft types, leading to up to 6% lower fuel use and emissions for the Ground Service Equipment (GSE), which are reported under 1A5b, and a reduction up to 20% for PM emissions from tyre and brake wear, both of which are calculated using the MTOW of aircraft. For tyre and brake wear, the MTOW of helicopters is no longer included in the activity data. Changes in PM_{10} emissions are shown in Figure 4.1. For several aircraft types, the corresponding engine types have been updated, which has also led to changes in emissions and fuel use. For Schiphol Airport, the largest airport in the Netherlands, the previously used linear interpolation of emissions between 1990 and 1995 has been changed, leading to an increase of emissions, especially for 1993 and 1994.

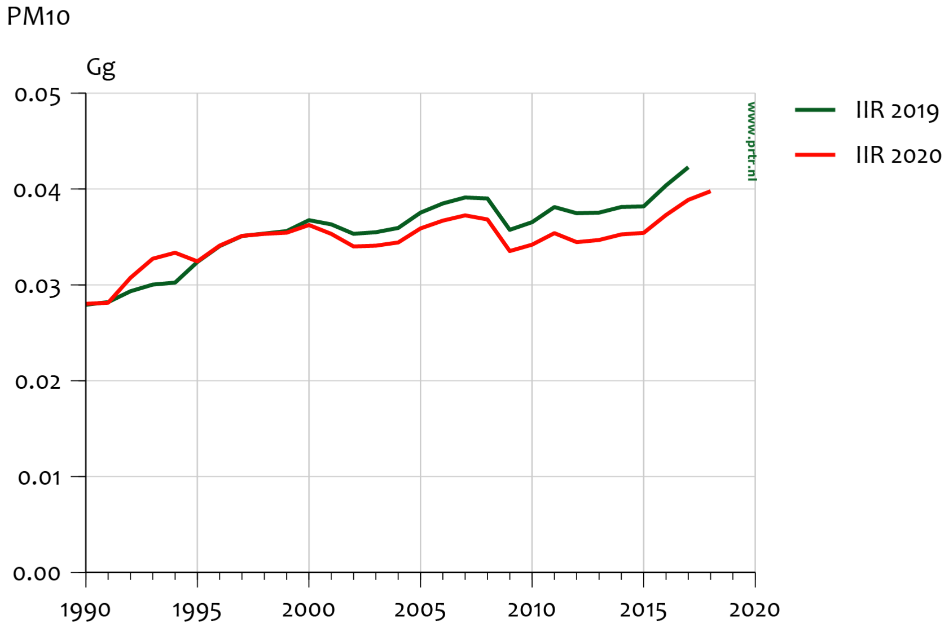

Figure 4.1 PM_{10} emissions from civil aviation in the Netherlands

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. Fuel used emissions are still reported as a memo item in the NFR, per source category.

Methodically it has not been possible to calculate emissions of metals based on fuel sold. All metals are therefore reported under fuel used as a memo item and reported as not estimated (NE) in the current NFR. In the key source analysis, metals are included based on the fuel used emissions. It should be noted that in previous years, emissions of metals were reported in the NFR, but these were on a fuel used basis. Since emissions of other components and corresponding activity data in the NFR are on a fuel sold basis, the reporting has been changed in this year's inventory as described above. In next year's submission, fuel sold emissions for metals from road transport will be included.

4.3.2 *Key sources*

The different source categories within Road transport are key sources of many substances in both the 1990–2018 trend assessment and in the 1990 and 2018 level assessments, as shown in Table 4.5.

Table 4.5 Key source analysis for Road transport subcategories

Source category	Name	1990 level	2018 level	1990-2018 trend
1A3bi	Passenger cars	NO_x, NMVOC, CO, PM_{10}, PM2.5, BC, Pb[1)]	NOx, NMVOC, CO, PM_{10}, PM2.5, BC, Pb[1)], Hg[1)]	SO_2, NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, BC, Pb[1)], Hg[1)]
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,	SO_2, 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}, $PM_{2.5}$, Pb[1)]	PM_{10}
1A3bvii	Road abrasion		PM_{10}	PM_{10}

1. Based on fuel used

4.3.3 *Overview of shares and trends in emissions*

Road transport is a major contributor to air pollutant emissions in the Netherlands. Taken together, the different source categories within road transport accounted for 35% of NO_x emissions (national totals), 16% of PM_{10}, 13% of $PM_{2.5}$, 32% of BC, 11% of NMVOC and 53% of CO emissions in 2018. 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 2018 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**	**18.4**	**18.4**	**18.4**	**9.03**	**710**
1995	223	121	14.4	2.40	13.3	13.3	13.3	7.00	489
2000	179	67.6	3.58	4.34	9.9	9.9	9.9	6.14	398
2005	158	41.1	0.24	5.12	7.31	7.31	7.31	4.92	392
2010	134	34.5	0.21	4.57	4.59	4.59	4.59	3.08	360
2015	94.5	26.7	0.18	3.87	1.99	1.99	1.99	1.24	318
2017	86.2	26.6	0.19	4.04	1.58	1.58	1.58	0.92	311
2018	**83.5**	**25.8**	**0.20**	**4.13**	**1.39**	**1.39**	**1.39**	**0.77**	**307**
1990-2018 period[1)]	-199	-162	-15.2	3.18	-17.0	-17.0	-17.0	-8.26	-403
1990-2018 period[2)]	-70%	-86%	-99%	334%	-92%	-92%	-92%	-91%	-57%

	Priority Heavy Metals [3)]			POPs [3)]		Other Heavy Metals [3)]					
	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	**248**	**0.09**	**0.06**	**2.37**	**1.66**	**0.00**	**2.13**	**20**	**0.60**	**0.01**	**32.8**
1995	80.1	0.10	0.07	1.36	1.12	0.00	2.11	20	0.60	0.01	34.4
2000	0.78	0.11	0.08	0.69	0.69	0.00	2.13	19	0.62	0.01	37.7
2005	0.83	0.12	0.08	0.50	0.43	0.00	2.27	21	0.66	0.01	40.2
2010	0.85	0.12	0.08	0.34	0.32	0.00	2.33	21	0.67	0.01	41.3
2015	0.86	0.12	0.08	0.25	0.23	0.00	2.34	21	0.68	0.01	41.5
2017	0.89	0.13	0.08	0.25	0.22	0.00	2.44	22	0.71	0.01	43.1
2018	**0.91**	**0.13**	**0.09**	**0.24**	**0.21**	**0.00**	**2.49**	**23**	**0.72**	**0.01**	**44.2**
1990-2018 period[1)]	-247	0.04	0.02	-2.13	-1.45	0.00	0.36	2.79	0.12	0.00	11.4
1990-2018 period[2)]	-100%	42%	39%	-90%	-87%	37%	17%	14%	20%	38%	35%

1. Absolute difference.
2. Relative difference from 1990 in %.
3. Road Traffic based on fuel used.

Emissions of SO_x decreased by 99% between 1990 and 2018 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 2018.
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 110 billion in 2018 (see Figure 4.2).

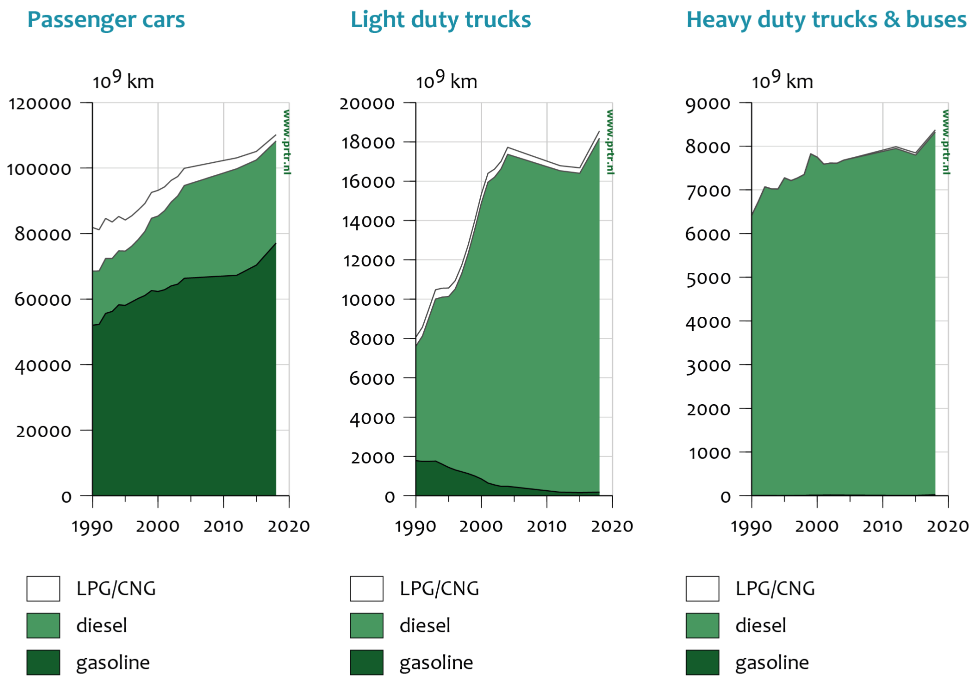

Figure 4.2 Kilometres driven per vehicle and fuel type in the Netherlands (source: Statistics Netherlands)

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 89% between 1990 and 2018. Yet since 2008, the total diesel mileage has remained constant. Petrol mileage increased by 48% between 1990 and 2018. The share of LPG in the passenger car fleet decreased significantly, from 16% in 1990 to 2% in 2018. 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. 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 2018, 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 4% of $PM_{2.5}$ emissions and 2% of PM_{10} emissions in the Netherlands in 2018. PM_{10} exhaust emissions from passenger cars decreased by more than 90% throughout the time series. Emissions from both petrol- and diesel-powered cars decreased significantly throughout the time series due to increasingly stringent EU emission standards for new passenger cars. The continuing decrease of PM_{10} and $PM_{2.5}$ exhaust emissions in recent years is primarily due to the increasing market penetration of diesel-powered passenger cars equipped with diesel particulate filters (DPF). DPFs are required to comply with the Euro-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 significantly from 1990 to 2006, as a result of the introduction of the three-way catalyst. From 2007, emissions decreased until to 4 Gg in 2018. 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% throughout the time series 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 2018 were 16% 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 2018. 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 2018. 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 81% between 2005 and 2018.

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 4.1). 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 2018 (see Figure 4.3). Emissions have decreased significantly in recent years due to the decrease in vehicle mileages between 2008 and 2014 (Figure 4.2) and a decrease in the fleet averaged NO_x emission factor (Figure 4.3). 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).

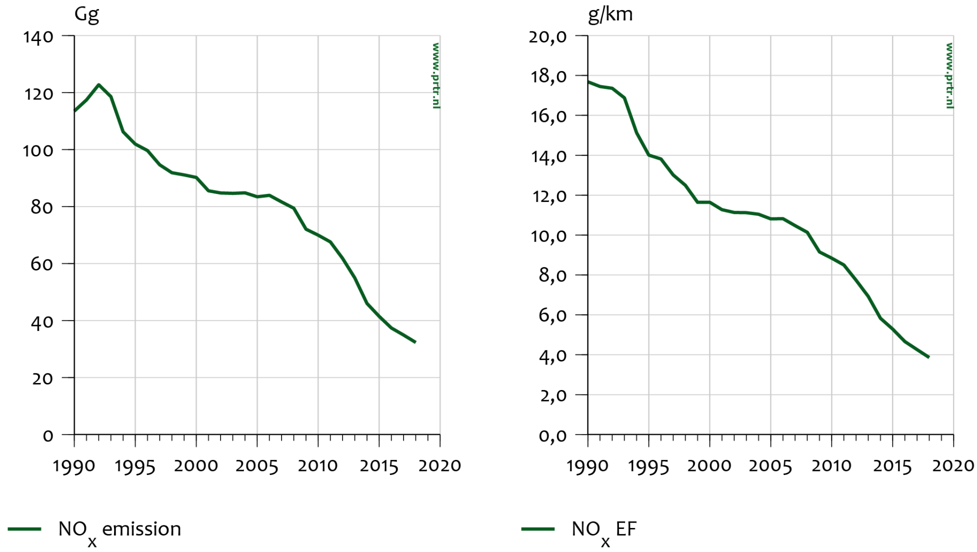

Figure 4.3 NO_x emissions and NO_x implied emission factors of heavy-duty vehicles in the Netherlands

NMVOC exhaust emissions decreased by 93% throughout the time series and PM_{10} and $PM_{2.5}$ exhaust emissions decreased by 96%. 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.

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 2018. 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 2018, emissions amounted to 477 Mg, which corresponded to an increase of 208% 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. Motorcycles and mopeds were responsible for 4% of NMVOC emissions and 9% of CO emissions in the Netherlands in 2018. Even though the number of vehicle kilometres driven almost doubled between 1990 and 2018, 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 2018. The share in $PM_{2.5}$ emissions was approximately 1% in 2018.

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 2018 (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 2018 (motorcycles and mopeds were mainly responsible for the rest of evaporative NMVOC emissions, other road vehicles contributed below 1%).

PM emissions from tyre and brake wear and road abrasion (1A3bvi and 1A3bvii)
Vehicle tyre and brake wear (1A3bvi) and road abrasion (1A3bvii) were responsible for 6% and 5% of PM_{10} emissions in the Netherlands, respectively. PM_{10} emissions from brake wear, tyre wear and road abrasion increased throughout most of the time series, as 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}.

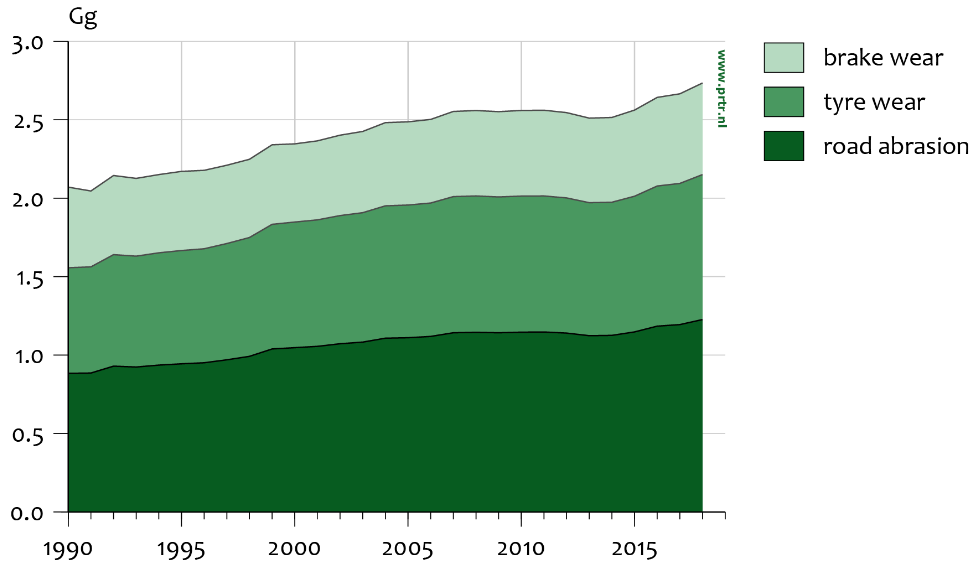

Figure 4.4 Emissions of PM_{10} resulting from brake and tyre wear and road abrasion

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:

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

Starting from 2012 onwards, a bottom-up methodology has been implemented based on vehicle kilometres driven per individual vehicle. Data per license plate number was available from RDW (Driver and Vehicle Licensing Agency). Subsequently, each license plate number was matched to a vehicle class, as defined by vehicle type, weight class, fuel type, emission legislation and specific exhaust gas technologies. More than 350 vehicle classes are distinguished. For each vehicle class, the road type distribution is estimated based on annual vehicle kilometres driven and built year. More elaborate information on activity data is presented in Geilenkirchen *et al.* (2020).

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. For newer vehicles (Euro-III – Euro-VI), measurement data are available which 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.

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 Geilenkirchen et al. (2020a). 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.

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 Geilenkirchen *et al.* (2020b). 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. Figure 4.5 shows both the bottom-up estimates for fuel used by road transport and reported fuel sold to road transport per fuel type for the 1990–2018 time series.

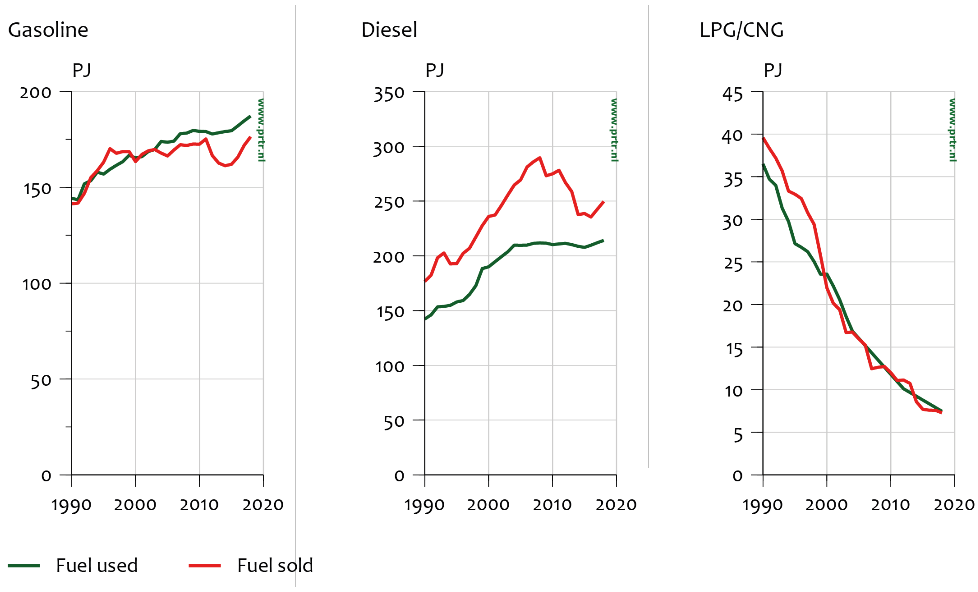

Figure 4.5 Fuel used vs. fuel sold trends, for gasoline- (petrol), diesel- and LPG-fuelled road transport in the Netherlands

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 4.6. 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 4.6. 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.

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.

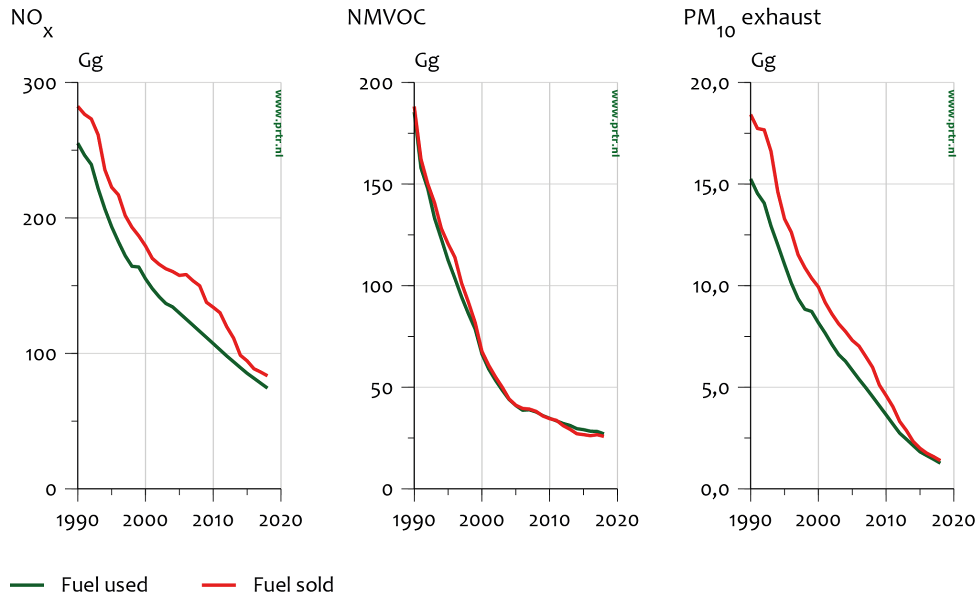

Figure 4.6 NO_x, NMVOC and PM_{10} exhaust emissions from road transport in the Netherlands based on fuel used and fuel sold

4.3.5 *Methodological issues*

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

- The PM_{10} and $PM_{2.5}$ emission factors for brake and tyre wear and for road abrasion are rather uncertain due to a lack of 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, 2017a). 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	Petrol	5	20	20	200	200	200	500	100
Passenger	Diesel	5	20	20	100	50	50	50	100
cars	LPG	5	20		200	200	200	500	50
1A3bii	Petrol	5	20	20		200	200	500	50
Light-duty	Diesel	5	20	20		50	50	50	100
vehicles	LPG	5				200	200	500	
1A3biii	Petrol	10	20	20		200	200	500	
Heavy-duty	Diesel	10	20	20	100	50	50	50	100
vehicles	LPG	10				200	200	500	
1A3biii	Natural gas	5							
Buses	Petrol	5	20	20		200	200	500	
	Diesel	5	20	20		50	50	50	
	LPG	5				200	200	500	
1A3biv	Petrol	20	200	20		500	500	500	500
Mopeds/ motorcycles	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 (2017a).

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 Geilenkirchen et al. (2020)).

The most important recalculation is a change in methodology for the calculation of emissions from passenger cars and light and heavy duty trucks and buses. As of 2020, emissions for these categories are calculated for every individual vehicle in the Dutch car fleet using a bottom-up method which takes annual mileages per vehicle (based on odometer readings) as a starting point. Road type distributions are calculated per vehicle based on the annual mileage using formulas derived by TNO from licence plate registrations. In general, the higher the annual mileage, the higher the share on motorways, whereas low annual mileages correspond to a higher share of urban driving. In order to calculate emissions, each vehicle is assigned to one of the 300+ VERSIT vehicle classes.

Using this methodology, we can now calculate emissions per vehicle class much more precisely. Previously, annual mileages were derived only at an aggregated level, e.g. for all petrol cars older than 10 years. Within this group there are large differences though in the emissions per vehicle kilometre. For some substances, e.g. PM_{10}, older vehicles have a large share in emissions totals because of the very low emissions of modern vehicles equipped with DPFs. The new methodology was applied for reference years 2012, 2015 and 2018 and will be available for every year onwards. For years between 2012-2018, an interpolation was made of vehicle class distributions using national vehicle kilometre totals per vehicle category. The same applies for 2005-2012. Emission data for 2004 were unchanged. A more detailed description of the bottom-up methodology is presented in Geilenkirchen *et al.* (2020). In next year’s submission a more detailed approach will be used to estimate emissions in the 2005-2011, 2013-2014 and 2016-2017 periods. The new methodology was also used to recalculate CO_2 emissions for road transport and thus the amount of fuel used per vehicle category and as such also influences the activity data for the (fuel sold) emissions.

The impact of the new methodology differs per substance and is especially large for PM, TSP and BC because of the reasons outlined above. Exhaust emissions of light duty trucks (1A3bii) for these substances for example are between 11 and 26 percent lower in the 2012-2017 period than previously reported, as shown in Figure 4.7. For other substances the impact of the new methodology is much smaller. NO_x emissions of 1A3b have increased slightly (1-3 percent) for the 2012-2017 period compared to last year’s inventory.

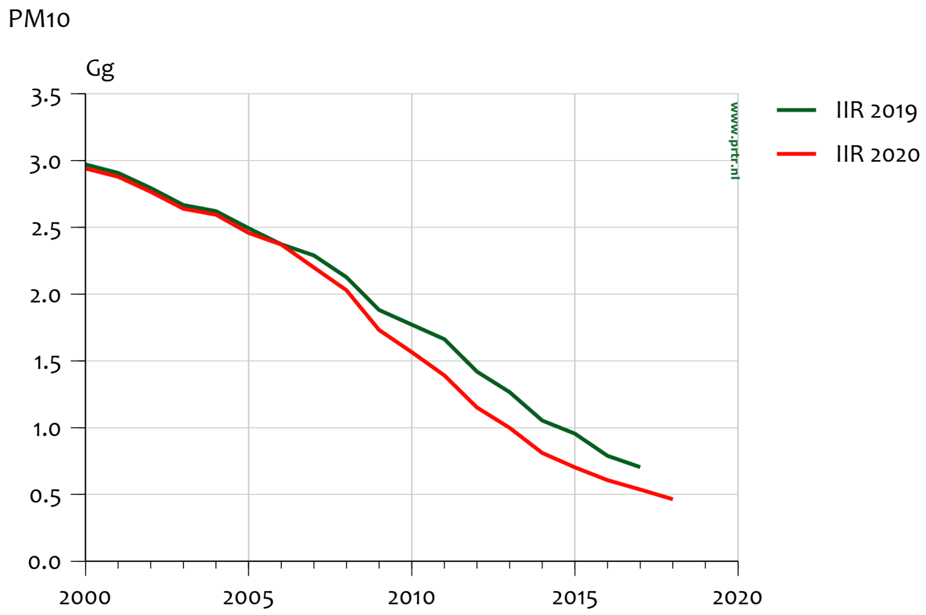

Figure 4.7 PM_{10} exhaust emissions from light duty vehicles in the Netherlands

This year's inventory also includes other recalculations for road transport:

- NH_3 from passenger cars: On road measurements have shown that NH_3-emissions of RDE approved Euro-6 diesel passenger cars (Euro-6d) are significantly higher than were assumed before. This leads to a minor adjustment in NH_3-emissions for recent years of the time series as Euro-6 diesel passenger cars are not yet on the road on a large scale.
- NO_x from heavy duty vehicles: NO_x emissions from lorries and trucks with SCR-catalysts (Euro-V and Euro-VI) were adjusted upwards because an estimated 5 to 10 percent of SCR-catalysts does not function properly (or at all) due to malfunction or tampering, resulting in substantial increases in NO_x emissions per vehicle kilometer. This 5 to 10 percent estimate was derived from on-road measurements in Flanders and Denmark. NO_x emissions from 1A3biii have increased by 6 to 8 percent for the 2012-2017 period compared to last year's submission, although it should be noted that these changes are also influenced by the new methodology described before. Figure 4.8 shows the old and new time series for NO_x from 1A3biii.
- Emission totals for the 1990-2004 period have changed slightly (+/- 1-2 percent) for road transport due to minor adjustments in the activity data.

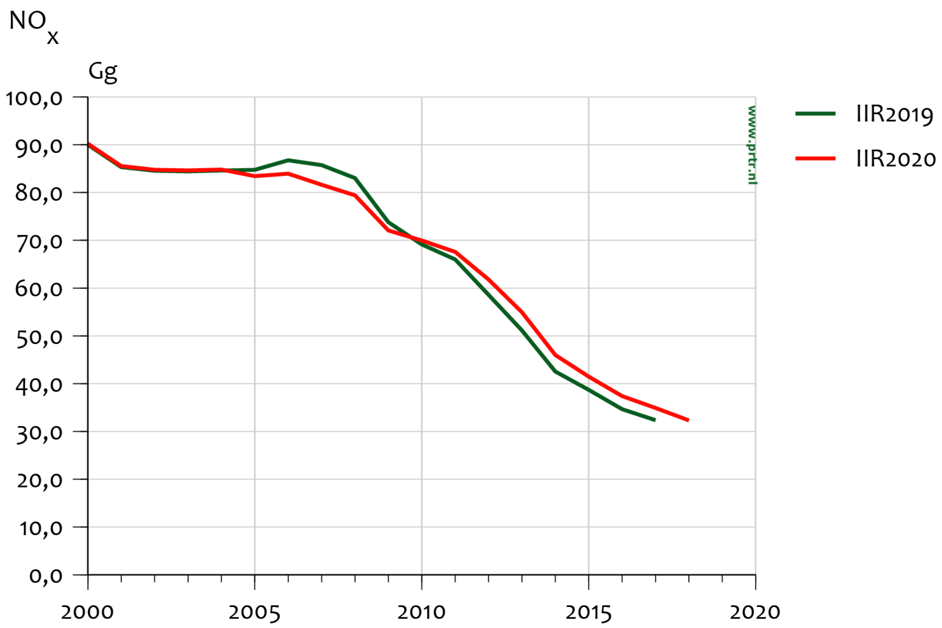

Figure 4.8 NO_x exhaust emissions from heavy duty vehicles in the Netherlands

Finally, in this year's submission, metals are not included in the NFR for road transport. In previous years, the metal emissions that were reported were in fact fuel used emissions. Fuel sold emissions are not calculated in the current methodology. Therefore, the metal emissions are reported as a memo item under fuel used. In the NFR under fuel sold, metal emissions are reported this year as NE, as they were actually indeed not estimated. However, we plan to include fuel sold metal emissions as of next year.

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. Both these planned improvements were mentioned in the IIR 2019 as well, but scheduling constraints prohibited implementation in the IIR 2020.
Methodically it has not been possible to calculate emissions of metals based on fuel sold. These are therefore not estimated (NE) in the current NFR. They are however reported under fuel used as a memo item. Next year's submission will include fuel sold emissions for all relevant substances in the NFR.

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 2020 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 2018. 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. In 2018 fuel consumption dropped to 1 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 2018. Pb emissions from railways result from the wear on carbon brushes, which are 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 almost 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

	Main Pollutants				Particulate Matter				Other	Priority Heavy Metals 3)
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb
Year	Gg	Gg	Gg	Mg	Gg	Gg	Gg	Gg	Gg	Mg
1990	**2.18**	**0.07**	**0.10**	**0.28**	**0.05**	**0.05**	**0.05**	**0.02**	**0.26**	0.22
1995	2.36	0.08	0.10	0.30	0.06	0.06	0.06	0.02	0.28	0.26
2000	2.90	0.09	0.12	0.37	0.07	0.07	0.07	0.03	0.33	0.28
2005	2.54	0.08	0.11	0.33	0.06	0.06	0.06	0.02	0.28	0.27
2010	2.54	0.08	0.02	0.33	0.06	0.06	0.06	0.02	0.28	0.29
2015	2.12	0.07	0.00	0.27	0.05	0.05	0.05	0.02	0.25	0.25
2017	2.11	0.07	0.00	0.27	0.05	0.05	0.05	0.02	0.25	0.26
2018	**1.72**	**0.06**	**0.00**	**0.22**	**0.04**	**0.05**	**0.05**	**0.02**	**0.20**	**0.26**
1990-2018 period1)	-0.45	-0.01	-0.10	-0.06	-0.01	-0.01	-0.01	0.00	-0.05	0.05
1990-2018 period2)	-21%	-20%	-100%	-21%	-14%	-14%	-14%	-18%	-20%	22%

1. Absolute difference.
2. Relative difference from 1990 in %.
3. Based on fuel used

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 based on 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 Geilenkirchen et al. (2020a).

4.4.5 *Methodological issues*

Emission factors for railways have not been updated recently (except NO_x) 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, 2017a). 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[1]	Electricity	-	-	-	-		200	200	-

Dellaert & Dröge (2017a).

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 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.

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

4.4.8 *Source-specific recalculations*

Resulting from a system update, activity data has been rounded towards 100 TJs in the NFR. This results in a change in emissions between +0.5% and -0.5%.

4.4.9 *Source-specific planned improvements*

In next year's submission, activity data will be corrected and not be rounded towards 100 TJs. Besides this, a methodology review for railways has been performed by CE Delft (CE Delft, 2020), which may lead to an adjustment in the distribution of diesel consumption between passenger and freight trains.

Besides these, there are no other 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). Emissions resulting from degassing of inland ships are included under 2D3i. 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 2018. 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 2018.

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 2018 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 2018. 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 2018.

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 2018.

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	0.43	5.77
2015	25.5	1.44	0.01	0.01	0.85	0.91	0.91	0.46	6.05
2017	25.5	1.38	0.01	0.01	0.83	0.88	0.88	0.45	5.90
2018	**25.6**	**1.41**	**0.01**	**0.01**	**0.82**	**0.87**	**0.87**	**0.45**	**6.02**
1990-2018 period[1)]	-3.16	-0.59	-1.82	0.00	-0.43	-0.44	-0.44	-0.11	-1.98
1990-2018 period[2)]	-11%	-29%	-99%	13%	-34%	-34%	-34%	-20%	-25%

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

SO_x emissions from inland navigation decreased by 99% between 2009 and 2018 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 2018.

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 3.8% of total national CO emissions. The share of emissions of all other pollutants from recreational shipping in total emissions in the Netherlands in 2018 was small.

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 and 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 Geilenkirchen et al. (2020a). 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 Geilenkirchen et al. (2020a, 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 Geilenkirchen et al. (2020a).

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, 2017a). 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.In the IIR 2020 the uncertainty estimate for NMVOC emissions of degassing cargo is adjusted upwards from 100% to 250%.

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

NFR	Type	Fuel	Uncertainty activity data	Uncertainty emission factor						
				NO_x	SO_x	NH_3	PM_{10}	$PM_{2.5}$	EC	NMVOC
1A3di(i)	Anchored NCP[2]	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	200	20	100	100	100	100	100
1A5b	Recreational shipping, petrol evaporation		100	-	-		-	-	-	200
2D3i	Inland shipping, degassing cargo		100	-	-	-	-	-	-	250

Dellaert & Dröge (2017a).

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*

There were no source-specific recalculations for waterborne navigation.

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

[2] Netherlands continental shelf (NCP)

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 2018 level assessment. Source category 1A4bii Residential: Household and gardening (mobile) is a key source of emissions of CO in both the 2018 level and trend assessments, whereas source category 1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery is a key source of NO_x, $PM_{2.5}$ and BC emissions in the 2018 level assessment. Source category 1A4aii Commercial/institutional: Mobile 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 emissions, 6% of $PM_{2.5}$ emissions and 3% of PM_{10} emissions in the Netherlands in 2018. 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 2018 increased by 6.5% compared to 2017. Since the start of the economic crisis, energy use by construction machinery has decreased from 25 PJ in 2008 to 21 PJ in 2017, but increased again to 24 PJ in 2018. Figure 4.8 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 2018.

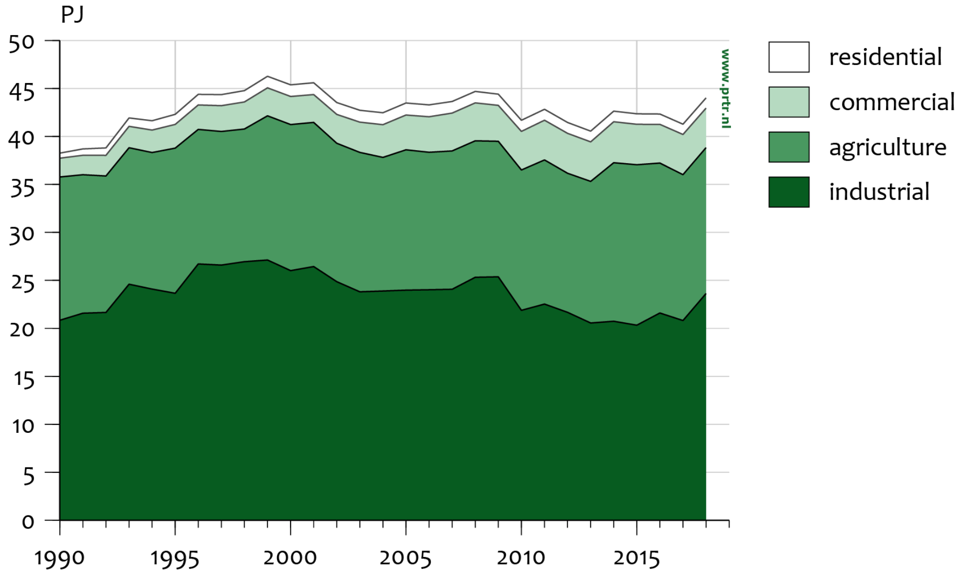

Figure 4.9 Fuel consumption in non-road mobile machinery in different sectors in the Netherlands

The trends in emissions from NRMM in the Netherlands are shown in Table 4.12. 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 Figure 4.10. Since 1990, NO_x emissions have decreased by 48%, whereas fuel consumption has increased by 15%.

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	**38.0**	**8.08**	**3.00**	**0.01**	**3.56**	**3.75**	**3.75**	**1.82**	**37.3**
1995	41.4	8.30	3.02	0.01	3.06	3.21	3.21	1.55	54.6
2000	43.2	7.93	3.22	0.01	2.74	2.88	2.88	1.38	57.7
2005	35.5	6.06	3.09	0.01	2.21	2.32	2.32	1.11	54.5
2010	28.1	4.46	0.30	0.01	1.26	1.32	1.32	0.62	52.2
2015	24.4	3.44	0.02	0.01	0.94	0.99	0.99	0.46	50.4
2017	19.7	2.88	0.02	0.01	0.75	0.79	0.79	0.37	49.3
2018	**18.9**	**2.72**	**0.02**	**0.01**	**0.72**	**0.75**	**0.75**	**0.35**	**49.1**
1990-2018 period1)	-19.1	-5.37	-2.99	0.00	-2.85	-3.00	-3.00	-1.47	11.7
1990-2018 period2)	-50%	-66%	-99%	14%	-80%	-80%	-80%	-81%	31%

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 diesel 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 2018 was less than 1% for all pollutants.

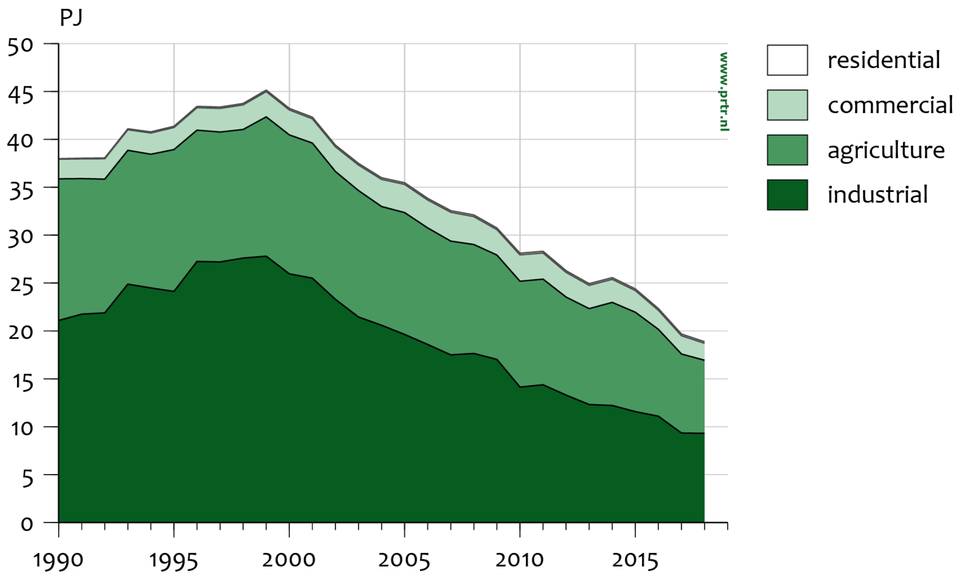

Figure 4.10 NO_x emissions by non-road mobile machinery in different sectors in the Netherlands

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 Geilenkirchen et al. (2020a). 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 Geilenkirchen et al. (2020a).

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 Geilenkirchen et al. (2020a).

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, 2017a). The resulting uncertainty estimates for NRMM are provided in Table 4.13.

The uncertainty in activity data for construction (diesel) and industry (diesel) was adjusted upwards from 35% to 50%. The reason is that we are missing reliable sales numbers of machines for 2015-2018.

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	50	50	20	200	100	100	100	100
1A2gvii	Industry	Diesel	50	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

Dellaert & Dröge (2017a).

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*

There have been several changes and improvements made to the modelling of NRMM energy use and emissions. A more accurate, year-specific value for the calorific value of petrol has been introduced as determined by Statistics Netherlands. A gradual (0.3% per year) improvement of diesel engine efficiency has been introduced, leading to a reduction of several percent in the diesel consumption and emissions (up to 5% in 2017). From 2018 onwards, a gradual efficiency improvement of the machine hydraulic systems is introduced, also leading to small reductions in fuel consumption and emissions. Both efficiency effects reflect the reduced fuel consumption (per hour) of NRMM that is seen in practice. Furthermore, the calculation model now calculates emissions both from average engine load and from idling (during which there may be significant NO_x emissions). This causes an increase in NO_x emissions for the complete time period.

For several pollutants, the emission factors for some STAGE classes were updated, informed by measurements performed in 2018 by TNO on several machines (Ligterink et al., 2018). In short, the emission factors for CO (~10 – 100% higher emissions) and hydrocarbons (HC) (~15% higher emissions) were increased for several STAGE classes, while the STAGE II HC emission factor has been lowered (~7% lower emissions), as well as the PM emission factor for multiple STAGE classes (~15% lower emissions). Figure 4.11 shows NO_x and $PM_{2.5}$ emissions in this year's and last year's IIR.

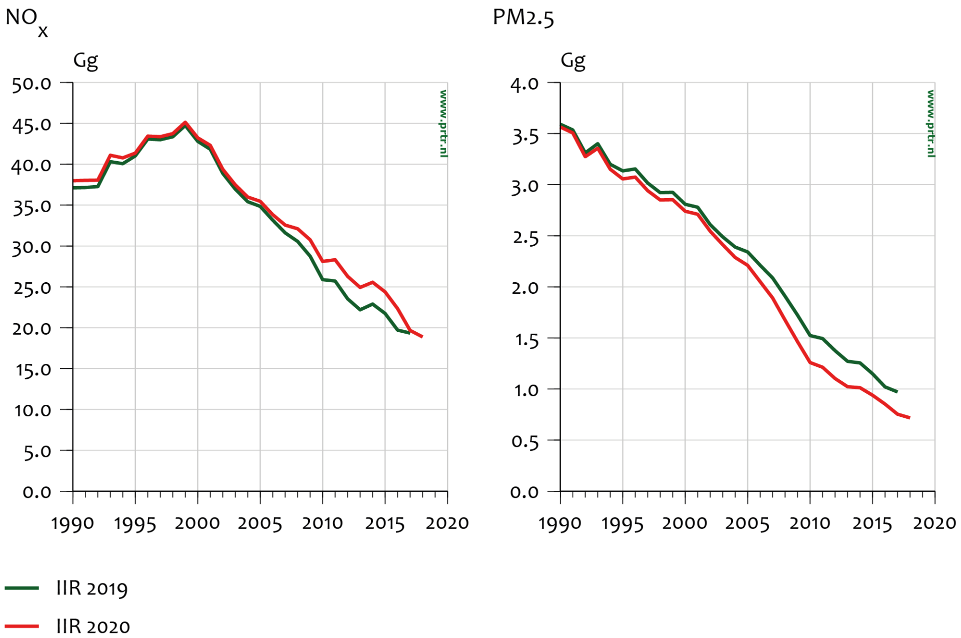

Figure 4.11 NO_x and $PM_{2.5}$ emissions from non-road mobile machinery in the Netherlands

4.6.9 *Source-specific planned improvements*

Emissions from cooling units on trucks are currently not estimated in the EMMA model. In 2020, 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 for SO_x and NO_x in the 2020 inventory.

4.7.3 *Overview of emission shares and trends*

National fishing is a small emission source in the Netherlands. In 2018, national fishing was responsible for 0.3% 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 4.14. For the most part, emissions from national fishing show similar trends to fuel consumption. NO_x emissions decreased significantly between 1990 and 2018, 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

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**20.4**	**1.34**	**5.13**	**0.00**	**1.09**	**1.15**	**1.15**	**0.33**	**1.44**
1995	22.9	1.37	6.11	0.00	1.21	1.27	1.27	0.36	1.50
2000	22.4	1.26	5.42	0.00	1.12	1.18	1.18	0.34	1.40
2005	15.4	0.80	3.57	0.00	0.69	0.73	0.73	0.21	0.90
2010	10.9	0.49	1.42	0.00	0.47	0.49	0.49	0.14	0.59
2015	8.82	0.36	0.21	0.00	0.31	0.33	0.33	0.10	0.45
2017	7.15	0.28	0.08	0.00	0.25	0.26	0.26	0.08	0.34
2018	**6.88**	**0.27**	**0.08**	**0.00**	**0.24**	**0.25**	**0.25**	**0.07**	**0.32**
1990-2018 period[1)]	-13.5	-1.07	-5.05	0.00	-0.85	-0.90	-0.90	-0.25	-1.12
1990-2018 period[2)]	-66%	-80%	-98%	-61%	-78%	-78%	-78%	-77%	-78%

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 & 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 Geilenkirchen et al. (2020a).

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 as of 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, 2017a). The resulting uncertainty estimates for national fishing are provided in Table 4.15.

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

Dellaert & Dröge (2017a).

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 downwards 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. This has caused a decrease in SO_x emissions from 310 Mg to 80 Mg in 2017 compared with the IIR 2019.

For 2016 and 2017 CO emission factors were also adjusted downwards, resulting in a decrease of 7% in CO emissions from national fishing.

4.7.9 *Source-specific planned improvements*

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

4.8 Pipeline transport

The NMVOC emissions of the pipeline transport of natural gas are available for the whole time series. Since no separate combustion and process emissions are available for historic years and the combustion emissions of natural gas transmission are only a small part of the total NMVOC emissions all NMVOC emissions of the transmission of natural gas are allocated to category 1B2b. See Section 3.5 Fugitive emissions and background information in paragraph 3.5.2 of Honig *et al.* (2020).

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.

38% 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

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**5.17**	**235**	**10.0**	**5.43**	**16.4**	**29.8**	**49.6**	**0.13**	**10.1**
1995	3.29	175	2.75	5.18	11.0	19.0	34.3	0.07	4.71
2000	1.92	133	1.53	4.00	7.12	12.4	18.5	0.03	3.89
2005	0.58	110	1.02	3.64	6.67	11.7	16.9	0.02	2.65
2010	0.54	110	0.91	2.56	6.36	11.0	15.1	0.02	2.94
2015	0.75	97.8	0.87	2.17	5.64	10.1	14.8	0.02	3.17
2017	0.76	95.3	0.88	2.33	5.81	10.4	14.4	0.02	3.19
2018	**6.39**	**91.4**	**4.01**	**2.53**	**5.66**	**10.3**	**14.2**	**0.02**	**56.02**
1990-2018 period[1)]	1.22	-143	-6.01	-2.90	-10.8	-19.6	-35.4	-0.12	45.96
1990-2018 period[2)]	24%	-61%	-60%	-53%	-66%	-66%	-71%	-88%	457%

	Priority Heavy Metals			POPs		Other Heavy Metals					
	Pb	Cd	Hg	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	**67.2**	**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
2017	6.50	0.52	0.25	11.8	0.14	0.47	0.63	12.0	1.09	0.06	39.0
2018	**3.76**	**2.21**	**0.25**	**11.3**	**0.14**	**0.28**	**0.80**	**10.7**	**0.84**	**0.07**	**302**
1990-2018 period[1)]	-63.4	1.31	-0.99	-36.9	-13.0	-0.27	-2.15	3.27	-1.92	-0.25	156
1990-2018 period[2)]	-94%	145%	-80%	-77%	-99%	-49%	-73%	44%	-70%	-79%	107%

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

Important note to the table: NO_x, SO_x and CO combustion emissions from the iron and steel plant in the Netherlands were erroneously registered as process emissions, and are therefore allocated in 2C1 instead of 1A2a. As a result of that, these emissions are erroneously presented in this table, and 2C1 was considered a key source for these. The total emissions from the iron and steel plant (1A2a and 2C1 together) are correct. The allocation will be corrected in the next submission.

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.

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).

5.1.2 *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:

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

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).

5.1.3 *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 Approach2 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 Approach2 uncertainties at NFR source category level.

Table 5.2 Overview of Approach2 uncertainties for IPPU NFR source categories

NFR source category	Pollutants uncertainty					
	NH_3	NO_x	SO_x	NMVOC	PM_{10}	$PM_{2.5}$
2A	64%	65%	91%	98%	182%	176%
2B	97%	NA	NA	58%	66%	69%
2C	91%	50%	50%	99%	91%	93%
2D	64%	102%	113%	38%	73%	74%
2G	NA	NA	NA	NA	NA	NA
2H	182%	50%	NA	114%	46%	45%
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	**51%**	**44%**	**43%**	**35%**	**35%**	**43%**

The Approach2 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 (14% contribution to total);
- 2D3d: NMVOC (6% contribution to total);
- 2D3i: NMVOC and $PM_{10/2.5}$ (both 6% contribution to total);
- 2H2: NMVOC and $PM_{10/2.5}$ (3 and 8% contribution to total, respectively);
- 2H3: NMVOC and $PM_{10/2.5}$ (4 and 11% 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.

5.1.4 *Source-specific QA/QC and verification*

The source categories of this sector are covered by the general QA/QC procedures, as discussed in Section 1.6.2 of Chapter 1.

5.1.5 *Source-specific recalculations*

Emission series of PCBs from Tata Steel have been corrected due to review recommendations.

5.1.6 *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 2018 (%)
2A3	Glass production	Pb	10.6
2A6	Other Mineral Products	$PM_{10}/PM_{2.5}$	4.2/7.5
		Hg	20

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}	$PM_{2.5}$	Hg
Unit:	Mg	Gg	Gg	Mg
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	0.10
2015	1.0	1.1	1.0	0.11
2017	1.6	1.1	1.0	0.10
2018	0.6	1.1	1.0	0.12

From 1990 to 2018, Pb emissions from 2A3 decreased from 7.3 to 0.6 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 2018 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 confidentiality 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 2018 (%)**
2B10a	Chemical industry: Other	NMVOC	2.1
		$PM_{10}/PM_{2.5}$	4.6/6.0

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: **Unit:**	**NMVOC** **Gg**	**PM_{10}** **Gg**	**$PM_{2.5}$** **Gg**
Year				
1990		33.0	4.1	2.6
1995		18.0	3.0	1.9
2000		12.6	1.2	0.8
2005		7.9	1.2	0.7
2010		5.7	1.3	0.9
2015		4.7	1.1	0.7
2017		4.8	1.4	0.9
2018		5.1	1.2	0.8

From 1990 to 2018, NMVOC emissions decreased from 33 Gg to 5.1 Gg and PM_{10} emissions decreased from 4.1 Gg to 1.2 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 (2015 = 100)

Year	**Index**
2005	94.1
2006	99.7
2007	103.3
2008	97
2009	93.4
2010	104.3
2011	102.5
2012	108
2013	103.3
2014	102.8
2015	100
2016	106.3
2017	106.8
2018	107.4

5.3.5 *Source-specific recalculations*

Emissions of $PM_{2.5}$ were recalculated because information on particle size distribution ($PM_{2.5}$-fractions) had changed, which had impacted the emission estimates. This is explained in Appendix 4 of the ENINA methodology report (Honig *et al.*, 2020).

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 confidentiality 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 2018 (%)
2C1	Iron and steel production	$PM_{10}/PM_{2.5}$	4.7/6.0
		Pb	39.0
		Hg	17.0
2C6	Zinc production	Pb	7.0
		Cd	81.0

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: NFR Name:	2C1 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	0.4	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
2018	1.2	0.8	2.3	0.1	0.26	0.07

The emissions of the key source pollutants PM_{10}, $PM_{2.5}$, Pb and Hg from 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.

5.4.4 *Source-specific recalculations*

Due to review, PCB-emissions from Tata Steel were recalculated.

The BREF Iron and Steel states that PCB emissions are possible from the sinter processes and the electric arc furnace (EAF). There are no EAFs in the Iron and Steel industry in the Netherlands. The sinter installation at Tata differs from most sinter installations in the EU. Since 1995 the sinter installation is equipped with a flue gas recirculation system. With this system most of the PM, PCB and PCDD/F are decomposed. Additionally, in 1998 a high pressure flue gas washer was installed to further improve the removal of PM, PCB, PCDD/F and PAK from the flue gas. To even further reduce the emissions, the flue gas washer was replaced in 2013 with a system of injecting activated carbon in the flue gas followed by bag filtration.
At the moment there is no information on PCB emissions available for the period 1990-1999. However in the period that the flue gas recirculation system and the washer were in place, Tata in 2008 performed a measurement (triple measurement) on PCB and found an average concentration of <0.1 ng TEQ PCB/M^3 or <9.73636E-11 kg TEQ PCB/Mg Sinter (pay attention to the < sign). With a production in 2008 of 4,165,308 Mg Sinter this leads to an emission of PCB that's lower that 0.43 g. This measurement is assumed to be valid for the period 2000-2013. From the PCDD/F reporting (based on measurements) it can be seen that the emissions after installing the activated carbon injector and bag filtration unit, declined with a factor 10. Under the assumption (also used for the PTC by the TERT) that there is a fixed ratio between PCDD/F and PCB, it reasonably that the emissions of PCB will also have declined with a factor 10.
With this information a recalculation was performed using the Tier 1 ratio between EF's of PCDD/F and PCB from the 2016 Guidebook and calculated with the reported PCCD/F the PCB emissions for the period 1990-1999. For the period 2000-2013 the PCB measurement from 2008 was used (thus an emission factor of 9.73636E-11 kg TEQ PCB/Mg Sinter) with the annual production of Sinter (confidential). And for the period 2014-2018 an emission factor of 9.73636E-12 kg TEQ PCB/Mg Sinter was used (factor 10 lower than the measurement from 2008). Table 5.10 shows the new PCB series:

Table 5.10 Overview of PCB emissions from Iron and steel production (2C6)

NFR Code:	2C1
NFR Name:	Iron and steel production
Pollutant:	PCBs
Unit:	g
Year	
1990	19,167
1995	21,250
1996	16,090
1997	10,932
1998	5,773
1999	3,470
2000	0.369
2005	0.428
2010	0.384
2014	0.033
2015	0.035
2017	0.037
2018	0.037

Aluminium production (2C3)
Aluminium production is responsible for 0.27% 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.

During the 1990–2018 period, PAH emissions decreased from 6.9 Mg in 1990 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, 2C6 is now a key source of Pb. Also 2C6 is a key source for Cd. 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.

Table 5.11 provides an overview of the process emissions from the key source of zinc production (category 2C6).

Table 5.11 Overview of emissions from Zinc production (2C6)

NFR Code: NFR Name:	**2C6 Zinc production**	
Pollutant:	**Cd**	**Pb**
Unit:	**Mg**	**Mg**
Year		
1990	0.11	0.32
1995	0.06	0.37
2000	0.07	0.52
2005	0.02	0.44
2010	0.03	0.43
2015	0.15	1.12
2017	0.21	1.04
2018	2.00	0.42

Emissions of Cd in 2018 increased by a factor 10 compared to 2017. However, this appears to be the result of an improved measurement methodology at the concerned zinc producing company. For the next submission we investigate whether this might be reason for a recalculation of the whole series.

5.4.5 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).

28% 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 5.12.

Table 5.12 Key sources of Solvents and product use (2D)

	Category / Subcategory	Pollutant	Contribution to total of 2018 (%)
2D3a	Domestic solvent use including fungicides	NMVOC	14
2D3d	Coating applications	NMVOC	6
2D3i	Other solvent use	NMVOC	6
		$PM_{10}/PM_{2.5}$	6.2/12.4
		DIOX	31

5.5.3 *Overview of emission shares and trends*

Table 5.13 provides an overview of the emissions from the key sources of this category.

Table 5.13 Overview of emissions from key sources of Solvents and product use (2D)

NFR Code: NFR Name:	2D3a Domestic solvent use including fungicides	2D3d Coating applications	2D3i Other solvent use			
Pollutant: Unit: Year	NMVOC Gg	NMVOC Gg	NMVOC Gg	PM_{10} Gg	$PM_{2.5}$ Gg	Dioxin g I-Teq
1990	24	93	19	2.0	2.0	25.0
1995	27	67	18	2.0	2.0	23.0
2000	29	41	17	2.2	2.2	20.0
2005	31	26	15	2.0	2.0	18.0
2010	32	28	16	2.0	2.0	15.0
2015	33	19	14	1.7	1.7	13.0
2017	34	15	15	1.6	1.6	11.5
2018	34	15	15	1.6	1.6	11.0

Due to an error in the calculations, after completing the NFR it appeared that 3.5 Gg of NMVOC is missing at 2D3h in 2018: Printin. This will be corrected in the next submission!

The emission sources in this key source are:

- Cosmetics (and toiletries);
- Cleaning agents;
- Car products;
- Others.

The increase in NMVOC emissions during the period 1990–2018 was mainly due to Cosmetics (and toiletries).

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

Mainly due to the lower average NMVOC content of the paints used, 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 and 2018.

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 (Ruyssenaars *et al.*, 2020).

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 15 Gg in 2018. 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 11 g I-TEQ in 2018.

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 2.0 Gg in 1990 to 1.6 Gg in 2018.

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 164 Gg in 2011 to 108 Gg in 2018 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 that 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 the ENINA methodology report (Honig *et al*., 2020).

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 5.14.

Table 5.14 Key sources of Other production industry (2H)

	Category / Subcategory	Pollutant	Contribution to total of 2018 (%)
2H2	Food and beverages industry	NMVOC	3.3
		$PM_{10}/PM_{2.5}$	7.8/4.2
2H3	Other industrial processes	NMVOC	3.7
		$PM_{10}/PM_{2.5}$	10.7/6.4

5.6.3 *Overview of emission shares and trends*

Table 5.15 provides an overview of the emissions from the key sources of this category.

Table 5.15 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:	NMVOC	PM_{10}	$PM_{2.5}$	NMVOC	PM_{10}	$PM_{2.5}$
Unit:	Gg	Gg	Gg	Gg	Gg	Gg
Year						
1990	11	4.3	1.1	25	5.4	1.7
1995	11	2.3	0.6	13	3.1	0.8
2000	10	1.9	0.5	6	3.2	0.9
2005	10	1.8	0.5	10	2.7	0.8
2010	10	1.6	0.4	10	2.6	0.7
2015	8	1.8	0.5	10	2.6	0.7
2017	8	1.9	0.5	10	2.6	0.8
2018	8	2.0	0.5	9	2.7	0.8

Food and beverages industry (2H2)

From 1990 to 2018, PM_{10} emissions decreased from 4.3 to 2.0 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 2018, NMVOC emissions decreased from 25 Gg to 10 Gg.

Due to an error in the calculations, after completing the NFR it appeared that 1 Gg of NMVOC is missing at 2H3 (plastic products). The table should show 10 instead of 9 Gg NMVOC in 2018. This will be corrected in the next submission!

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 2.7 Gg during the 1990–2018 period. The emission contribution of the storage and handling of dry bulk products was 1.4 Gg in 1990 and 0.7 Gg in 2018. 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.

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 of '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 Informative Inventory Report (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 is prohibited in the Netherlands during the whole time series (article 10.2 of the Environmental Management Act, or 'Wet Milieubeheer' in Dutch). Emissions from the source category 3I do not meet the threshold to be reported.

Emissions of the greenhouse gases methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) from the agricultural sector are reported in the annual National Inventory Report (NIR). All emissions were calculated according to the methods described in Lagerwerf *et al.* (2019). All activity data is summarised in Van Bruggen *et al.* (2020), except the activity data on the N-excretion which is reported in CBS (2019).

In 2018, 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 2018. Although Zn 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 2018 multiple key sources were identified as presented in Table 6.1 (see Appendix 2 for details):

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

NFR Category	NH_3	NO_x	PM_{10}	$PM_{2.5}$	NMVOC
3B Manure management					
Cattle					
Dairy cattle	L, T				L, T
Non-dairy cattle	L, T				L, T
Swine	L, T		L		
Poultry					
Laying hens	T		L, T		
Broilers			L, T		
3D Crop production and agricultural soils					
Inorganic N-fertilizers	L, T	L, T			
Animal manure applied to soils	L, T	L, T			L, T
Farm-level agricultural operations including storage, handling and transport of agricultural products					L, T

6.1.2 *Trends*

Ammonia

NH_3 emissions decreased between 1990 and 2018, with the largest reduction in the first few years of the time series. This was mainly caused by a ban on the surface spreading of manure, enforced in the period 1991-1995, making it mandatory to incorporate manure into the soil either directly or shortly after application. In addition, it became mandatory to cover outside slurry manure storages. More recently, the introduction of low-emission housing for animals further decreased ammonia emissions.

Maximum application standards for manure and fertilizer (because of implementation of the Nitrates Directive) and systems of livestock production rights promoted efficiency of animal production. An example of the improved efficiency 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 the alternative maize, resulting in an overall higher N excretion.

The milk quotas led to an increase the milk production per dairy cow. Increased production per animal led to a decrease in animal numbers and consequently lower emissions. With the abolishment of the milk quota in 2015 more dairy cattle were kept from 2014 onwards, leading to a further increase of production, of both milk and manure. The increased manure production caused an exceeding of the national phosphate production ceiling as set in European agreements, which in turn led to an introduction of phosphate quotas for dairy cattle as of the first of January 2018. This quota limits the amount of dairy cattle a farmer can keep and resulted in a decreasing trend in the animal numbers from 2017 onwards.

The amount of manure exported increased six fold in the period 1990 to 2016 and did not further increase in 2017 and 2018. Part of the NH_3 emissions from animal housing are comprised in the washing liquid of air scrubbers, which was used as an inorganic N-fertilizer shifting some N to category 3D Crop production and agricultural soils.

Since most of the NH_3 emissions originated from the agricultural sector, the trend in NH_3 emission seen from 1990 to 2018 from agriculture was also reflected in the decreasing trend of the national total.

Nitrogen oxides
NO_x emissions decreased over the 1990-2018 period due to a lower inorganic N-fertilizer use, a decrease in N excretion during grazing, less manure N applied to soil and, in recent years, a decrease of cattle numbers.

Particulate matter
PM emissions for most animal categories decreased slightly over the 1990–2018 period due to decreased animal numbers; however, the PM emissions from laying hen houses almost quadrupled for PM_{10} and more than doubled for $PM_{2.5}$. This was caused by a shift from battery cage systems with liquid manure to floor housing or aviary systems, with solid manure and higher associated emission for PM_{10} and $PM_{2.5}$. This graduate transition between 1990 and 2012 was initiated by a ban on battery cage systems in 2012 and led to an overall increase in PM emissions from manure management.

NMVOC
Overall, the NMVOC emissions from agriculture remained stable from 1990 to 2018. 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 the increase in manure management emissions. This decrease was caused by low-ammonia-emission application techniques.

6.2 Manure management (3B)

6.2.1 Source category description
In the category Manure management (3B), emissions from the treatment and storage of animal manure were presented. 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 the category 3B4giv Other poultry, include the emissions from ducks. Emissions resulting from the application of animal manure or during grazing were 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 2018 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 for PM_{10} emissions within sector 3B were laying hens (3B4gi), amounting to 11% of the national total. Broilers (3B4gii; 4%) and swine (3B3; 4%) were also key categories for PM_{10}. For NMVOC emissions dairy cattle (3B1a) is the largest contribution to the national total with 18%. The category 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 6.2 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 6.2 Emissions of main pollutants and particulate matter from sector 3B Manure management

	Main Pollutants			Particulate Matter		
	NO_x	NMVOC	NH_3	$PM_{2.5}$	PM_{10}	TSP
Year	Gg	Gg	Gg	Gg	Gg	Gg
1990	**3.7**	**42**	**98**	**0.424**	**4.1**	**4.1**
1995	3.9	41	96	0.4	4.2	4.2
2000	3.2	45	75	0.5	4.7	4.7
2005	2.9	43	65	0.4	4.6	4.6
2010	3.1	59	65	0.5	5.2	5.2
2015	3.5	67	57	0.5	5.7	5.7
2017	3.7	70	58	0.5	5.5	5.5
2018	**3.7**	**66**	**56**	**0.4**	**5.1**	**5.1**
1990-2018 period [1)]	0.0	24	-43	0.0	1.0	1.0
1990-2018 period [2)]	-1%	59%	-43%	1%	25%	25%

[1)] Absolute difference in Gg
[2)] Relative difference to 1990 in percentage

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.

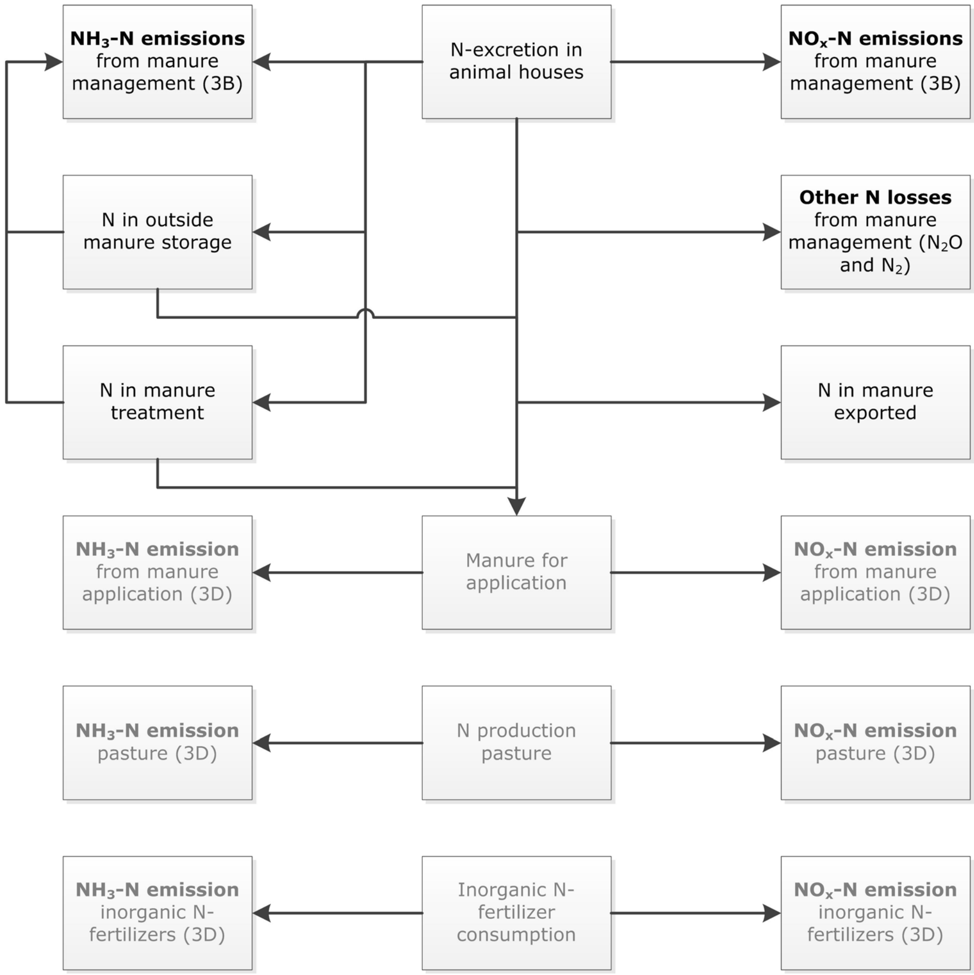

Figure 6.1 Nitrogen flows in relation to NH_3 and NO_x emissions where the boxes with black letters highlight the emissions included in 3B Manure management and the boxes with grey letters are included in 3D Crop production and agricultural soils.

Between 1990 and 2018, NH_3 emissions from manure management reduced by 43%. Higher production rates per animal and restrictions via quotas resulted in a decreasing trend in the animal numbers of cattle, sheep and swine. N excretions per animal decreased in the time series due to lower dietary crude protein for all animal categories. In 2017 the N excretion increased again for cattle, which can be explained by an increase of nutrient requirements through a higher average milk production and body weight. Furthermore, NH_3 emissions decreased due to the increased proportion of low-emission housing, in which a sharp increase can be seen in swine housing in 2018.

As NO_x emissions were also influenced by the above-mentioned developments, NO_x emissions decreased by 1% from 1990 to 2018.

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

NMVOC
The emissions from NMVOC showed an increasing trend of 59% from 1990 to 2018, mostly caused by an increase of silage feeding to dairy cattle in the animal house, leading to more NMVOC emissions in the animal house. The increase in poultry numbers also added to this increasing trend.

6.2.4 *Activity data and (implied) emission factors*

Activity data include animal numbers as determined by the annual agricultural census (see the summary in Table 6.3 and Van Bruggen *et al.* (2020) 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).

Table 6.3 Animal numbers over the 1990-2018 period (in 1,000 heads)

Animal type	1990	1995	2000	2005	2010	2015	2017	2018
Cattle	4,926	4,654	4,069	3,797	3,975	4,134	4,023	3,844
dairy cattle	1,878	1,708	1,504	1,433	1,479	1,622	1,672	1,591
non-dairy cattle	3,048	2,946	2,565	2,364	2,497	2,512	2,351	2,252
Sheep[1]	1,702	1,674	1,305	1,361	1,130	946	799	866
Swine	13,915	14,397	13,118	11,312	12,255	12,603	12,401	12,407
Goats	61	76	179	292	353	470	533	588
Horses[1]	70	100	117	133	141	117	85	87
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	105,771	98,568
laying hens	51,592	45,734	53,078	48,418	56,500	57,656	55,858	55,197
broilers	41,172	43,827	50,937	44,496	44,748	49,107	48,233	41,789
turkeys	1,052	1,207	1,544	1,245	1,036	863	670	657
other poultry	1,086	869	958	1,031	1,087	932	1,009	924
Other animals	1,340	951	981	1,058	1,261	1,404	1,262	1,245
Fur-bearing animals	554	463	589	697	962	1,023	919	913
Rabbits	786	488	392	360	299	381	343	332

[1] Excluding privately owned animals.
Source: Van Bruggen *et al.* (2020).

Phosphate rights for dairy cattle sets a limit as of January 1st, 2018. This quota limited the number of dairy cattle a farmer could keep from that date on. The Agricultural census is based on the number on April 1st, because of a strong decrease in the number of cattle following the quota in January 2018, the number of cattle present at April 1st on the farms was not representative for the average number of cattle from April 2017 to April 2018. Therefore, for the emission calculations of 2017 and 2018, the average number of dairy cattle was adjusted, using the Identification and Registration system (CBS, 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.*, 2020).

N-emissions

Emissions of NH_3 and NO_x from manure in animal houses, manure treatment and outside manure storages were calculated using the NEMA model at a Tier 3 level. The 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 historic data were recalculated in 2009 (CBS, 2012a) and supplemented yearly, thereby ensuring consistency (CBS, 2011 through 2019).

The Total Ammoniacal Nitrogen (TAN) in manure was calculated based on the faecal digestibility of the N in various feed components within the rations. From the N excretion data, the TAN-excretion per animal type and NH_3 emission factor per housing type were calculated, taking into account mineralization and immobilization. The Tier 1 default N_2O emission factors from the IPCC 2006 Guidelines were applied for both N_2O and NO_x emissions, following research from Oenema *et al.* (2000) that set the NO_x emissions equal to N_2O emission. According to this same study, N_2 losses were set to a factor 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 (Melse and Groenestein, 2016). The sum of emissions of animal housing, manure treatment and outside manure storage per livestock category were reported under their respective subcategories in sector 3B Manure management, except for the emissions associated with the digesting of manure which are allocated to 5B2 Biological treatment of waste – Anaerobic digestion at biogas facilities. The amount of N available for application was calculated by subtracting all N emissions during manure management, the N removed from agriculture by manure treatment and the net export of manure. The N in applied manure is used for calculating emissions from manure application, allocated to sector 3D. As a result of new insights into the feed intake of horses and ponies the N excretion has increased in 2018 (Bikker *et al.*, 2019).

Implied emission factors for NH_3 emissions in sector 3B Manure management were calculated for the main NFR categories (Table 6.4). The NH_3 emission per animal decreased for all animal species due to improved efficiency, low NH_3 emission housing systems and covering outside 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 cattle IEF. 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 of cattle.

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

Animal type	1990	1995	2000	2005	2010	2015	2017	2018
Cattle	6.8	6.8	5.8	6.5	6.8	7.3	8.3	8.4
Dairy cattle	11.8	11.9	9.5	11.5	11.8	12.0	13.6	13.6
Non-dairy cattle	3.7	3.9	3.6	3.4	3.9	4.3	4.5	4.8
Sheep	0.36	0.37	0.41	0.23	0.12	0.11	0.12	0.15
Swine	3.5	3.4	2.7	2.2	1.9	1.2	1.1	1.0
Goats	1.6	1.6	1.4	1.2	1.2	1.3	1.3	1.4
Horses	4.5	4.5	4.5	4.3	4.0	4.0	4.1	5.1
Mules and asses	IE	IE	IE	IE	2.8	2.8	2.8	3.2
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	0.02	0.02
Turkeys	0.80	0.79	0.80	0.85	0.95	0.94	0.94	0.82
Other poultry	0.31	0.30	0.28	0.24	0.21	0.18	0.18	0.17
Other animals	0.40	0.38	0.32	0.28	0.22	0.24	0.24	0.23
Fur-bearing animals	0.37	0.36	0.29	0.22	0.17	0.19	0.18	0.17
Rabbits	0.42	0.39	0.37	0.40	0.36	0.38	0.38	0.36

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

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

Animal type	1990	1995	2000	2005	2010	2015	2017	2018
Cattle	0.49	0.54	0.50	0.48	0.50	0.58	0.64	0.66
Dairy cattle	0.71	0.75	0.67	0.70	0.71	0.78	0.86	0.86
Non-dairy cattle	0.35	0.42	0.41	0.34	0.38	0.45	0.48	0.51
Sheep	0.03	0.03	0.03	0.02	0.01	0.01	0.01	0.01
Swine	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05
Goats	0.40	0.40	0.35	0.34	0.36	0.38	0.37	0.43
Horses	0.46	0.45	0.44	0.44	0.40	0.41	0.41	0.55
Mules and asses	IE	IE	IE	IE	0.22	0.22	0.22	0.22
Poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Laying hens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Broilers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Turkeys	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Other poultry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other animals	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02
Fur-bearing animals	0.03	0.03	0.02	0.02	0.01	0.02	0.02	0.01
Rabbits	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

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 permits. Implied emission factors for PM_{10} and $PM_{2.5}$ are shown in Table 6.6 and Table 6.7.

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

Animal type	1990	1995	2000	2005	2010	2015	2017	2018
Cattle	85.4	82.8	78.3	78.7	77.8	80.3	82.9	82.3
Dairy cattle	115	115	115	120	124	127	127	126
Non-dairy cattle	67.3	64.3	56.9	53.7	50.6	50.0	51.7	51.5
Sheep	4.2	4.2	4.2	3.9	1.8	1.8	1.8	1.8
Swine	113	112	112	110	104	77.3	72.0	72.4
Goats	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
Horses	220	220	220	220	220	220	220	220
Mules and asses	IE	IE	IE	IE	160	160	160	160
Poultry	22.0	23.1	26.5	31.9	35.0	40.1	39.8	39.4
Laying hens	14.9	16.1	22.8	33.6	39.3	50.2	49.9	48.8
Broilers	26.8	26.8	26.8	26.7	26.6	26.1	26.0	24.8
Turkeys	100	98.1	95.1	95.1	95.1	95.1	94.0	93.7
Other poultry	105	105	105	105	105	102	101	102
Other animals	4.2	4.7	5.4	5.8	6.5	6.3	6.3	6.3
Fur-bearing animals	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Rabbits	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3

Table 6.7 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	2017	2018
Cattle	23.5	22.8	21.6	21.7	21.4	22.1	22.8	22.7
Dairy cattle	31.7	31.7	31.7	33.1	34.1	35.1	34.9	34.7
Non-dairy cattle	18.5	17.7	15.7	14.8	13.9	13.8	14.2	14.2
Sheep	1.2	1.2	1.2	1.2	0.5	0.5	0.5	0.5
Swine	5.8	5.7	5.7	5.4	5.1	3.7	3.4	3.4
Goats	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Horses	140	140	140	140	140	140	140	140
Mules and asses	IE	IE	IE	IE	100	100	100	100
Poultry	2.2	2.3	2.5	2.7	2.7	2.9	2.8	2.8
Laying hens	1.4	1.5	1.7	2.1	2.5	3.1	3.1	3.0
Broilers	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8
Turkeys	47.0	46.0	44.6	44.6	44.6	44.6	44.1	44.0
Other poultry	5.0	5.0	5.0	5.0	5.0	4.9	4.8	4.9
Other animals	1.9	2.2	2.6	2.9	3.3	3.1	3.1	3.1
Fur-bearing animals	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Rabbits	0.28	0.28	0.28	0.28	0.27	0.27	0.27	0.26

NMVOC

The NMVOC emissions reported under manure management include the emissions from manure in the animal house, manure in outside storage and the silage feeding in the animal house. Most NMVOC emissions occur during the feeding of silage. The increase in IEF that can be seen with cattle is caused by an increased feeding of silage (Table 6.8). NMVOC is also released from the storage of manure in the animal house and outside 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 (CBS, 2019).

Table 6.8 Implied emission factors for NMVOC from 3B Manure management (in kg NMVOC/animal)

Animal type	1990	1995	2000	2005	2010	2015	2017	2018
Cattle	6.0	6.2	8.0	8.4	12.1	13.3	14.3	14.3
Dairy cattle	8.2	8.0	15.1	16.9	24.1	25.7	27.0	27.5
Non-dairy cattle	4.6	5.1	3.8	3.2	5.0	5.3	5.2	5.0
Sheep	0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.02
Swine	0.42	0.39	0.35	0.32	0.29	0.27	0.29	0.28
Goats	0.86	0.79	0.42	0.82	0.87	0.86	0.84	0.91
Horses	0.64	0.63	0.62	0.59	0.59	0.61	0.61	0.62
Mules and asses	IE	IE	IE	IE	0.25	0.25	0.25	0.25
Poultry	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Laying hens	0.05	0.06	0.05	0.05	0.06	0.06	0.07	0.06
Broilers	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Turkeys	0.08	0.08	0.08	0.07	0.07	0.07	0.13	0.13
Other poultry	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.07
Other animals	0.14	0.17	0.21	0.23	0.26	0.25	0.25	0.25
Fur-bearing animals	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
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 on NH_3 emissions was performed in 2015, in 2017 updated to include manure treatment and NMVOC emissions. Using reassessed uncertainty estimates of activity data (CBS, 2012b) and the judgement of experts (Lagerwerf *et al.*, 2019), an uncertainty of 20% in the total NH_3 emission from sector 3B Manure management was calculated. Including the emissions in sector 3D Crop production and agricultural soils, the combined uncertainty in NH_3 emissions from the agriculture sector was 25%. A Monte Carlo-analysis on uncertainties of the total inventory (including sectors outside agriculture) was performed in 2018 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 was conducted 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*

No source-specific recalculations were made.

6.2.8 *Source-specific planned improvements*

Emissions from privately kept horses, mules and asses and sheep are currently reported under 6A. These emissions are calculated with the same model as the emissions reported under 3B. As recommended in the review of 2019, these emissions will be included into 3B for the entire time series. However due to the complexity of the model and the database, not enough time was available to make these changes. All efforts will be made to make these changes for the IIR of 2021.

We were not able to improve the inventory this year with the emissions from HCB coming from the use of pesticides. This improvement will be implemented in the 2021 submission.

6.3 Crop production and agricultural soils (3D)

6.3.1 *Source category description*

In the category Crop production and agricultural soils (3D), emissions related to the agricultural use of land are presented. 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 fertilizers 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-fertilizers and pesticides, the supply of concentrate feed to farms, haymaking and crop harvesting. NMVOC emissions are allocated to category 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 for NH_3 emissions, amounting to 31% of the national total. Inorganic N-fertilizers (3Da1) were also a key source of NH_3, making up 7% of the national total. In NO_x animal manure applied to soils (3Da2a, 5%) and inorganic N-fertilizers (3Da1, 4%) were key sources. 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 that originated 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	**46**	**57**	**232**	**0.1**	**0.8**	**0.8**	0
1995	44	26	109	0.1	0.8	0.8	0
2000	37	27	82	0.1	0.8	0.8	0
2005	31	24	69	0.1	0.8	0.8	6.8
2010	28	23	50	0.1	0.8	0.8	4.5
2015	29	26	53	0.1	0.7	0.7	4.5
2017	30	28	56	0.1	0.7	0.7	4.5
2018	**29**	**27**	**55**	**0.1**	**0.7**	**0.7**	4.5
1990-2018 period [1]	-17	-31	-177	-0.01	-0.07	-0.07	4.5
1990-2018 period [2]	-37%	-54%	-76%	-8%	-9%	-9%	

[1] Absolute difference in Gg.
[2] Relative difference to 1990 in percentage.

N-emissions
Emissions of NH_3 of crop production and agricultural soils have decreased by 76% between 1990 and 2018, 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-fertilizer also decreased during the time series, following policies aimed at reducing the nutrient supply to soils (i.e. implementation of the EU Nitrates Directive).

NO_x emissions reduced by 37% between 1990 and 2018, mainly as the result of lower N-input through inorganic N-fertilizer, less time spent grazing and a reduction in manure application.

Particulate matter
The particulate matter emissions reported in this source category originated from the use of inorganic N-fertilizer, 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
Similar as to NH_3, NMVOC emissions of crop production and agricultural soils show a decrease between 1990 and 2018 by 54%, also the result of changing manure application methods to reduce 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 therewith silage storage.

Zinc
Zinc emissions have reduced 35% from 2005 to 2018, due to a reduction in pesticide use. Before 2005, there were no zinc emissions related to the pesticides then used.

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 outside storages (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-fertilizer and sewage sludge application, compost use and the grazing of animals were calculated using the EMEP default emission factor.

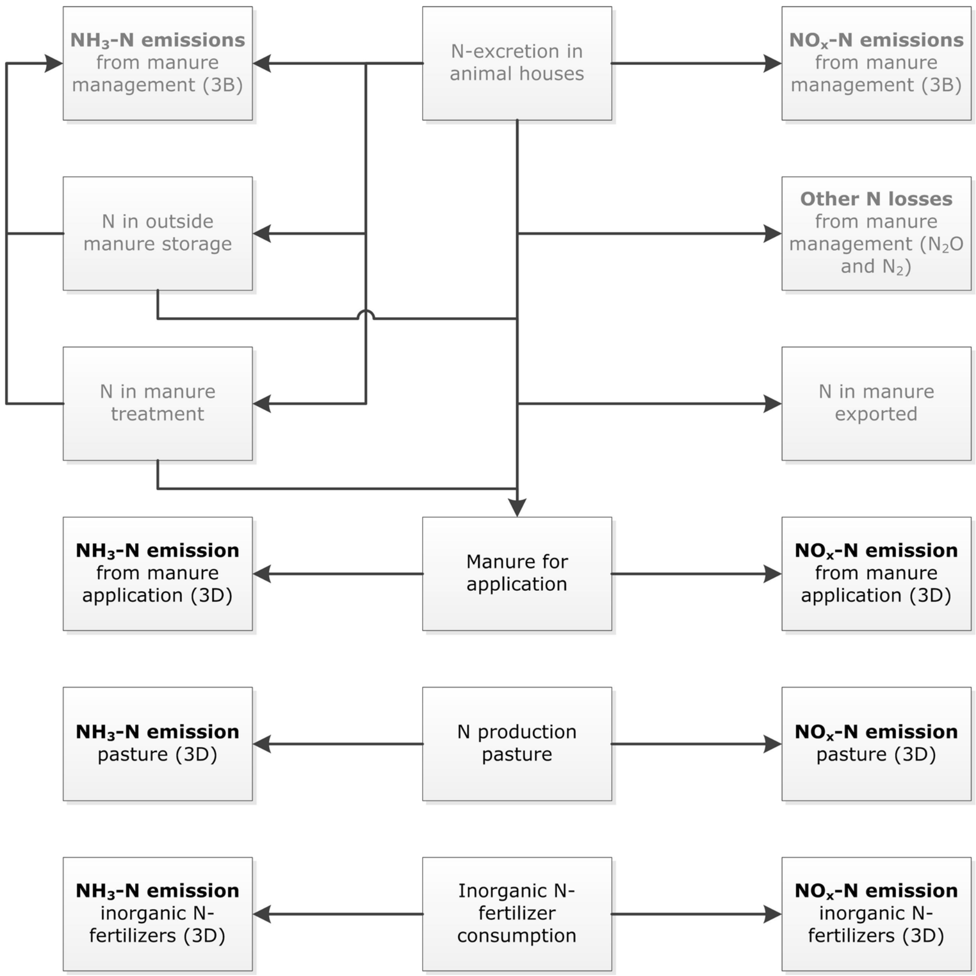

Figure 6.2 Nitrogen flows in relation to NH_3 and NO_x emissions where the boxes with black letters highlight the emissions included in 3D Crop production and agricultural soils and the boxes with grey letters are included in 3B Manure management.

NH_3 emissions from the use of inorganic N-fertilizers were calculated using data on the amount of inorganic N-fertilizer used in agriculture. Several types of inorganic N-fertilizer were distinguished – each with a specific NH_3 emission factor. In recent years, the amount of applied urea fertilizer has increased and a growing share is used as liquid urea or coated with urease inhibitors to reduce NH_3 emission and/or is applied with NH_3 low-emission techniques. To account for this development, additional subcategories of urea fertilizer were specified for the 1990-2018 time series, as described in the methodology report of Lagerwerf *et al.* (2019). The used subgroups and the emission factors for each subgroup have originally been published in Van Bruggen *et al.* (2017).

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 through 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 depicted 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 reduction in emissions from urine and dung deposited by grazing animals was mainly explained by less grazing of cattle.

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

Emission source	1990	1995	2000	2005	2010	2015	2017	2018
Application of inorganic N-fertilizers	0.03	0.03	0.04	0.05	0.04	0.04	0.04	0.04
Application of animal manure	0.50	0.20	0.19	0.18	0.13	0.12	0.13	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 fertilizers (compost)	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.06
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	0.02	0.02	0.02	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-fertilizers 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 emissions from other agricultural processes (e.g. the supply of concentrate feed to farms, the use of pesticides and haymaking) was estimated using fixed factors (Lagerwerf *et al.*, 2019). Crop harvesting was calculated based on acreage data from the agricultural census and EMEP default emission factors (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 the 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).

6.3.5 *Uncertainties and time series consistency*

A propagation of error analysis of NH_3 emissions was performed in 2015, with an update in 2017 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-fertilizer use and 56% for grazing emissions. The total uncertainty in the 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 total NH_3 emissions from agriculture comes to 25%. A Monte Carlo-analysis on the uncertainties of the total inventory was performed in 2018 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.

In the IIR of 2018 crop residues and the cultivation of organic soils were added to the inventory for NO_x. The emissions were allocated to 3Da4 Crop residues applied to soils and 3I Agriculture other respectively. In the IIR of 2019 NO_x emissions from crop residues were allocated to 3I Agriculture other instead of 3Da4 Crop residues applied to soils. This error has been corrected in the current IIR.

6.3.6 *Source-specific QA/QC and verification*

This source category is covered in Chapter 1 under general QA/QC procedures.

6.3.7 *Source-specific recalculations*

The definitive amount of inorganic fertilizer used in 2017 is included into the activity data. The total amount of inorganic fertilizer used in 2017 was 237.8 Gg N, which was adjusted to 230.2 Gg N in 2017. This resulted in a decrease of both NH_3 and NO_x emissions.

The EF of inorganic fertilizer used in greenhouses is set to zero resulting into a decrease of 0.7 Gg NH_3 emissions in 1990 and 0.4 NH_3 emissions in 2016. The EF of inorganic fertilizer used in greenhouses was set to zero due to the wind still conditions in the greenhouses and the manner of applying the inorganic fertilizer (in solution), more details can be found in (Van Bruggen *et al.*, 2020).

New research was carried out on the emissions from crop residues resulting in a new EF, based on De Ruijter and Huijsmans (2019). This resulted in a decrease of 15.6 Mg NH_3 emissions in 1990, 30.5 Mg NH_3 emissions in 2017, 17.4 Mg NO_x emissions in 1990 and 12.9 Mg NO_x emissions in 2017.

A change in methodology in LULUCF resulted into a change in area of peat and other organic soils as is described in chapter 6 of this IIR from 2014 onwards. The emissions decrease with 11.3 Mg NO_x emission in 2015 and 33.8 Mg NO_x emission in 2017.

6.3.8 Source-specific planned improvements

Emissions from organic N and inorganic fertilizers applied on private properties or nature areas are currently reported under 6A. These emissions are calculated with the same model as the emissions reported under 3D. As recommended in the review of 2019, these emissions will be included into 3D. However due to the complexity of the model and the database, not enough time was available to make these changes. All efforts will be made to make these changes for the IIR of 2021.

HCB emissions from impurities in pesticides will be added to 3Df in the IIR of 2021. Due to time constraints it was not feasible to add them to the IIR of 2020. All efforts will be made to make these changes for the IIR of 2021.

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.

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.

7.2 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 NH_3, emissions have increased since 1990. 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	**0.10**	**2.4**	**0.02**	**0.15**	**0.48**	**0.52**	**1.0**	**0.11**
1995	0.13	2.3	0.03	0.43	0.51	0.55	1.1	0.12
2000	0.12	2.0	0.02	0.44	0.52	0.56	1.1	0.12
2005	0.11	1.7	0.02	0.45	0.49	0.53	1.1	0.11
2010	0.15	1.6	0.02	0.53	0.56	0.60	1.2	0.13
2015	0.22	1.4	0.03	0.56	0.55	0.59	1.2	0.13
2017	0.22	1.4	0.03	0.61	0.56	0.61	1.2	0.13
2018	**0.22**	**1.4**	**0.03**	**0.58**	**0.56**	**0.60**	**1.2**	**0.13**
1990-2018 period[1)]	0.12	-1.0	0.01	0.42	0.08	0.09	0.19	0.02
1990-2018 period[2)]	118%	-41%	57%	280%	17%	17%	19%	21%

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

7.2.1 *Methodological issues*

The methodology used to calculate most of the emissions from the source categories under the Waste sector are described in Honig *et al.* (2020). 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.

7.2.2 *Uncertainties and time series consistency*

As explained in Section 1.6.3, the Netherlands implemented an Approach2 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 Approach2 uncertainties at NFR source category level.

Table 7.2 Overview of the Approach2 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	100%	100%	100%
5B	59%	101%	101%	NA	NA	NA
5C	381%	321%	320%	359%	339%	380%
5D	NA	NA	NA	199%	NA	NA
5E	191%	199%	198%	199%	195%	190%
Total Waste sector	**61%**	**104%**	**147%**	**187%**	**169%**	**169%**

The Approach2 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.

7.2.3 Source-specific QA/QC and verification
There are no source-specific QA/QC procedures. The categories in this sector are covered by the general QA/QC procedures, as discussed in Chapter 1.

7.2.4 Source-specific recalculations
In the 2019 NECD review a recommendation is made regarding the PM-emissions that take place during the process of landfilling. These emissions are now added to the inventory based on the amounts of waste landfilled each year and the Tier 1 emission factor from the Guidebook (2019).

7.2.5 Source-specific planned improvements
There are no source-specific planned improvements.

7.3 Solid waste disposal on land (5A)

7.3.1 Source-category description
The source category of Solid waste disposal on land (5A) comprises the direct emissions from landfills, from captured landfill gas and PM-emissions coming from the landfilling process.

Extracted (captured) landfill gas is mainly used as an energy source (combined heat and power production or transferred to the natural gas network), emissions coming from this are reported under 1A1a. A relatively small amount of landfill gas is flared and the emissions coming from this are reported under 1A5a.

The remaining fraction of the landfill gas emits to the atmosphere. With regard to these 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.

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

In the 2019 NECD review a recommendation is made regarding the PM-emissions that take place during the process of landfilling. These emissions are now added to the inventory.

7.3.2 Overview of shares and trends in emissions

NMVOC emission levels related to this source category are relatively low, at 1.47 Gg and 0.30 Gg in 1990 and 2018, respectively.

$PM_{2.5}$ emissions are also relatively low, at 0.0005 Gg and 0.0001 Gg in 1990 and 2018, 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 Tg in 1990 to only 3.2 Tg in 2018 (-77%). 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 Mg waste in 1990, to 51.3 kg C per Mg in 2018 (-61%). 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.

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 CH_4 in landfill gas	0.574 from 1945 to 2004; thereafter constant at 0.5	Oonk (2016)
$MCF_{(x)}$ = Methane correction factor for management	1	
Delay time	6 months	

7.3.3 *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/m³	
Dioxins	$0.9E^{-9}$ g/m³	$0.3E^{-9}$ g/m³	
SO_x (based on all sulphur)			104 mg/m³
NO_x (as NO_2)	0.3 g/m³	3 g/m³	
CO	2.7% C	3.4 g/m³	
Soot	0.05% hydrocarbons		
CO_2 (biogenic)	total C minus CO minus soot		
Other aliphatic non-halogenated hydrocarbons			700 mg/m³
Dichloromethane			20 mg/m³
Trichloromethane			1 mg/m³
Chlorodifluormethane (HCFC-22)			10 mg/m³
Dichlorodifluormethane (CFC-12)			20 mg/m³
Trichlorofluormethane (CFC-11)			5 mg/m³
Chloroethene			10 mg/m³
Cis-1,2-Dichloroethene			1 mg/m³
1,1,1-Trichloroethene			2 mg/m³
Trichloroethene (Tri)			10 mg/m³
Tetrachloroethene (Per)			10 mg/m³
Chloropentafluorethane			1 mg/m³
1,2-dichloro-1,1,2,2-tetrafluoroethane (CFC-114)			2 mg/m³
1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)			1 mg/m³
Mercaptan, non-specified			10 mg/m³
Benzene			7 mg/m³
Toluene			120 mg/m³
H_2S			100 mg/m³

Table 7.4 Emission factors used for the emission of PM during landfilling

Compound	Emission factor g/Mg
PM_{10}	0.219
$PM_{2.5}$	0.033

7.4 Composting and anaerobic digestion (5B)

7.4.1 Source category description

The source category Composting and anaerobic digestion (5B) comprises emissions from the following 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
2017	2,442	1,492
2018	2,480	1,503

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)).

7.4.2 *Overview of shares and trends in emissions*

Composting

Emissions of NH_3 related to composting are relatively small (0.05 Gg and 0.24 Gg for 1990 and 2018, 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 0.21 Gg, 0.10 Gg and 0.006 Gg, respectively, in 2018). Therefore, shares and trends in these emissions are not elaborated here.

7.4.3 *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
2017	2,335	1,027
2018	2,375	1,065

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
2017	106.5	465.0
2018	104.1	437.8

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 Lagerwerf *et al.* (2019). The calculations are done with the NEMA model for calculating agricultural emissions (Van Bruggen *et al.*, 2020).

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 Netherlands Enterprise Agency (RVO).

7.5 Waste incineration (5C)

7.5.1 Source category description

The source category Waste incineration (5C) comprises emissions from the following categories:

- 5C1a Municipal waste incineration;
- 5C1bi Industrial waste incineration;
- 5C1bii Hazardous waste incineration;
- 5C1biii Clinical waste incineration;
- 5C1biv Sewage sludge incineration;
- 5C1bv Cremations;
- 5C1bvi Other waste incineration;
- 5C2 Open burning of waste.

In the Netherlands, municipal waste, industrial waste, hazardous waste, clinical waste and sewage sludge are incinerated. The heat generated by waste incineration is used to produce electricity and 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

7.5.2 *Overview of shares and trends in emissions*

Emission levels in this source category are relatively low. Therefore, the shares and trends in these emissions are not elaborated here.

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

Cremations (5C1bv)

The number of cremations in the Netherlands is published online by the Dutch National Association of Crematoria (LVC), at www.lvc-online.nl (LVC, 2020).

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
2017	150,027	96,688	64	100
2018	153,249	100,089	65	100

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

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 BlmSchV)) 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.

Open burning of waste (5C2)
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 250 m^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^3 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.

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 Mg/m^3.
The density of pallets is based on a standard pallet size of 0.8 x 1.2 x 0.144 m and a standard pallet weight of 25 kg, resulting in a density of 0.18 Mg/m^3.

Heating value of pallets
The heating value of pallets has been derived from the kachelmodel of 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).

Up till now Netherlands uses a Tier 3 method: Annual Environmental Reports of companies provide emission data per company. For NMVOC emissions are mostly under the reporting threshold, therefore NMVOC process emission data covering the whole wastewater sector are not available yet. In 2019, we intend to start reporting these emissions for the whole sector domestic wastewater treatment 5D1, using standardized Emissions Factors, developed by the waste water sector itself. A first quick estimate revealed that the total emissions of NMVOC for domestic wastewater treatment will be approximately 7,200 kg, which is 0.003% of total national NMVOC emissions. For industrial wastewater we have to consider which method can be used, which will be complicated since activity data on industrial wastewater treatment are no longer available as from 2016 on, due to strong budget cuts.

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 fertilizer 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.

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.
Accidental building and car fires produce, among others, emissions of particulate matter and dioxins. Emissions are calculated by multiplying the number of car fires and house fires with emission factors. For car fires, the default emission factors from the EMEP/EEA Guidebook (2019) are used. For house fires, country-specific emission factors have been derived, based on the amount of combustible materials in an average Dutch household combined with a percentage burned in each fire. The emissions of all pollutants (except dioxin) from the combustible materials of the construction and the combustible materials of the interior materials are calculated with the emission factors in table 3.39 on small combustion in chapter 1A4 of the Guidebook. The emissions of dioxin are calculated using the EF from Aasestad (2017) of 170 µg I-TEQ per Mg burned material. The dioxin emission factor has been improved as a result of a review recommendation from the 2019 NECD review. More details regarding the methodology is described in Visschedijk *et al.* (2020).

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 (2019; 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 2018.

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 Other sources (6A), both being 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 2018 (%)
6A	Other sources	NH_3	7.3

8.2.3 *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**	**12.0**	0.07	**0.04**	**0.07**
1995	1.93	9.56	0.07	0.04	0.07
2000	1.69	8.27	0.07	0.04	0.07
2005	1.99	9.77	0.07	0.04	0.07
2010	1.76	8.73	0.07	0.04	0.07
2015	1.90	9.55	0.07	0.04	0.07
2017	1.81	9.60	0.07	0.05	0.07
2018	**1.90**	**10.1**	0.07	**0.05**	**0.07**
1990–2017 period[1]	0.21	-1.94	0.01	0.00	0.01
1990–2017 period[2]	12%	-16%	8%	8%	8%

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

8.2.4 *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 animal houses 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 2018.

Population numbers in the Netherlands are derived from CBS Statline (http://statline.cbs.nl/) and increased from 14,892,574 in 1990 to 17,181,084 in 2018.

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 2.8 Gg in 2018, while NO_x emissions from this source increased from 1.6 Gg in 1990 to 1.7 Gg in 2018.

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 2018.

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 Mg 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.

8.2.5 *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.

8.2.6 *Uncertainties and time series consistency*
No accurate information was available for assessing uncertainties about emissions from sources in this sector.

8.2.7 *Source-specific QA/QC and verification*
Verification for the source Domestic animals (pets) is 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.

8.2.8 *Source-specific recalculations*
There are no source-specific recalculations.

8.2.9 *Source-specific planned improvements*

Emissions related to agriculture (privately owned livestock and manure sold and applied to private properties or nature areas) are to be allocated to Sector 3 Agriculture, see Sections 6.2.8 and 6.3.8.

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 2019

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 2019 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 2020. 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 IIR 2019

Compared with the IIR 2019 (Wever *et al.*, 2019), only a few methodological changes were implemented in the Pollutant Release and Transfer (PRTR) system:

- Improved bottom up estimates for road traffic;
- Revision of residential wood combustion model;
- Calculations of PCB emissions from manufacturing industry;
- Inclusion of PCDDD/F emissions from accidental fires;
- New NMVOC emission estimates for some consumer products (adhesives and leather care) and industrial bakeries.

10.2 Improvements

10.3 Improvements made

During the compilation of the IIR 2019 minor errors were detected, and these have been repaired in the IIR 2020. The following significant improvements were carried out during the improvement process of the Dutch PRTR:

- Update of the NRMM estimates;
- NH_3 emissions from agriculture changed in line with the update of parameters in the N flow model (especially NH_3 emissions from greenhouses and agricultural soils);
- Improvement of the allocation of the Dutch emission sources to the NFR (sub)categories;
- Use of improved activity data for 2017, resulting in several changes to the figures for that year.

Please see the paragraphs: Source-specific recalculations in the sectoral sections for further details on the recalculations and improvements.

10.4 Planned improvements

The remaining actions with respect to content will be prioritised and are planned for implementation in the inventories of 2020 and 2021. Appendix 3 gives an overview of the relevant plans.

10.5 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 2019.
In general the national emissions of the different pollutants only show limited changes compared to the previous submission (0- 5%).

Table 10.1 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010, 2015 and 2017 (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 2019	**656.6**	**603.9**	**196.3**	**351.3**	**52.7**	**75.1**	**99.1**	**13.5**	**1150.9**
	IIR 2020	**657.0**	**608.6**	**196.4**	**350.0**	**52.4**	**73.0**	**96.8**	**13.4**	**1149.9**
Difference	absolute	**0.5**	**4.7**	**0.1**	**-1.3**	**-0.3**	**-2.1**	**-2.3**	**-0.1**	**-1.0**
	%	*0.1%*	*0.8%*	*0.0%*	*-0.4%*	*-0.7%*	*-2.9%*	*-2.3%*	*-0.5%*	*-0.1%*
2000	IIR 2019	**464.9**	**332.7**	**78.0**	**176.3**	**29.9**	**44.1**	**53.2**	**9.9**	**761.9**
	IIR 2020	**465.1**	**337.3**	**78.0**	**175.0**	**29.4**	**41.7**	**50.7**	**9.8**	**760.3**
Difference:	absolute	**0.2**	**4.5**	**0.0**	**-1.3**	**-0.5**	**-2.4**	**-2.5**	**-0.1**	**-1.6**
	%	*0.1%*	*1.4%*	*0.1%*	*-0.7%*	*-1.5%*	*-5.5%*	*-4.7%*	*-0.8%*	*-0.2%*
2010	IIR 2019	**332.6**	**267.9**	**35.3**	**134.2**	**18.6**	**31.5**	**38.9**	**5.5**	**685.2**
	IIR 2020	**339.7**	**270.4**	**35.5**	**132.6**	**17.7**	**28.4**	**35.8**	**5.3**	**669.6**
Difference:	absolute	**7.1**	**2.4**	**0.2**	**-1.5**	**-0.9**	**-3.1**	**-3.0**	**-0.3**	**-15.6**
	%	*2.1%*	*0.9%*	*0.6%*	*-1.2%*	*-4.9%*	*-9.7%*	*-7.8%*	*-4.8%*	*-2.3%*
2015	IIR 2019	**272.5**	**253.0**	**30.8**	**128.9**	**15.0**	**27.9**	**36.0**	**3.6**	**575.6**
	IIR 2020	**277.0**	**254.6**	**30.6**	**127.7**	**13.7**	**24.5**	**32.3**	**3.1**	**562.1**
Difference:	absolute	**4.4**	**1.6**	**-0.3**	**-1.3**	**-1.3**	**-3.4**	**-3.6**	**-0.5**	**-13.5**
	%	*1.6%*	*0.6%*	*-0.8%*	*-1.0%*	*-8.6%*	*-12.3%*	*-10.1%*	*-12.9%*	*-2.3%*
2017	IIR 2019	**258.0**	**250.8**	**28.5**	**128.1**	**14.1**	**27.2**	**34.7**	**3.2**	**563.8**
	IIR 2020	**252.0**	**253.1**	**26.2**	**131.1**	**12.9**	**23.5**	**30.4**	**2.6**	**548.6**
Difference:	absolute	**-6.0**	**2.3**	**-2.4**	**3.0**	**-1.3**	**-3.7**	**-4.2**	**-0.6**	**-15.2**
	%	*-2.3%*	*0.9%*	*-8.3%*	*2.4%*	*-8.9%*	*-13.4%*	*-12.2%*	*-17.6%*	*-2.7%*

Changes in NMVOC emissions originate for the biggest part from new estimates in the food industry (bakeries). Almost all changes in NO_x and SO_2 emissions stem from recalculations of the emissions from transport and NRMM. NH_3 emissions decreased due the recalculation of the emissions from fertiliser use in greenhouses and from crop residues.

Emissions from particle related species and CO changed mainly due to the recalculations of the emissions from transport and NRMM.

Table 10.2 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010, 2015 and 2017 (metals)

National total		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
		Mg	**Mg**	**Mg**	**Mg**	**Mg**	**Mg**	**Mg**	**Mg**	**Mg**
1990	IIR 2019	**332.8**	**2.2**	**3.6**	**1.3**	**11.9**	**36.3**	**74.9**	**0.4**	**225.1**
	IIR 2020	**89.7**	**2.1**	**3.5**	**1.3**	**9.8**	**16.5**	**74.3**	**0.4**	**192.4**
Difference:	absolute	**-243.1**	**-0.1**	**-0.1**	**0.0**	**-2.1**	**-19.8**	**-0.6**	**0.0**	**-32.7**
	%	*-73.1%*	*-4.3%*	*-1.7%*	*0.4%*	*-17.8%*	*-54.6%*	*-0.8%*	*-2.0%*	*-14.5%*
2000	IIR 2019	**27.4**	**1.0**	**1.1**	**0.9**	**5.1**	**37.8**	**19.5**	**0.5**	**96.5**
	IIR 2020	**26.6**	**0.9**	**1.0**	**0.9**	**3.0**	**18.5**	**18.9**	**0.5**	**58.8**
Difference:	absolute	**-0.7**	**-0.1**	**-0.1**	**0.0**	**-2.1**	**-19.3**	**-0.6**	**0.0**	**-37.7**
	%	*-2.7%*	*-10.8%*	*-6.9%*	*-0.2%*	*-41.7%*	*-51.1%*	*-3.1%*	*-2.1%*	*-39.0%*
2010	IIR 2019	**37.6**	**2.6**	**0.7**	**0.6**	**3.9**	**43.5**	**2.1**	**1.5**	**103.5**
	IIR 2020	**36.8**	**2.5**	**0.6**	**0.6**	**1.5**	**22.3**	**1.6**	**1.5**	**62.3**
Difference:	absolute	**-0.8**	**-0.1**	**-0.1**	**0.0**	**-2.3**	**-21.2**	**-0.5**	**0.0**	**-41.2**
	%	*-2.2%*	*-4.6%*	*-11.3%*	*-0.3%*	*-60.5%*	*-48.7%*	*-24.3%*	*-0.7%*	*-39.8%*
2015	IIR 2019	**8.7**	**0.7**	**0.7**	**0.7**	**3.5**	**38.9**	**2.0**	**1.0**	**103.1**
	IIR 2020	**7.9**	**0.5**	**0.6**	**0.7**	**1.1**	**17.4**	**1.3**	**1.0**	**61.6**
Difference:	absolute	**-0.8**	**-0.1**	**-0.1**	**0.0**	**-2.3**	**-21.5**	**-0.7**	**0.0**	**-41.5**
	%	*-9.6%*	*-19.4%*	*-12.8%*	*-0.4%*	*-67.5%*	*-55.2%*	*-34.0%*	*-1.1%*	*-40.2%*
2017	IIR 2019	**9.0**	**0.7**	**0.7**	**0.7**	**3.7**	**39.8**	**2.2**	**0.6**	**100.9**
	IIR 2020	**7.7**	**0.6**	**0.5**	**0.5**	**1.1**	**18.7**	**1.4**	**0.2**	**50.0**
Difference:	absolute	**-1.2**	**0.0**	**-0.2**	**-0.2**	**-2.6**	**-21.0**	**-0.8**	**-0.4**	**-50.9**
	%	*-13.8%*	*-7.1%*	*-28.6%*	*-25.7%*	*-69.5%*	*-52.8%*	*-35.6%*	*-69.3%*	*-50.5%*

The big decrease in Pb emissions is caused by an error in the 2019 submission for 1990. The emissions from “Road transport: Passenger cars” were estimated too high last year and this error is now corrected. Almost all changes in the metal emissions originate from the recalculations in the Transport sector.

Table 10.3 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010, 2015 and 2017 (PCDD/F, PAHs , HCB and PCB)

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	HCB	PCB
		g I-Teq	Mg	Mg	Mg	Mg	Mg		
1990	IIR 2019	**744.0**	**5.5**	**8.1**	**4.1**	**2.9**	**20.6**	**45.3**	**0.0**
	IIR 2020	**752.4**	**4.9**	**7.6**	**3.8**	**2.6**	**19.0**	**45.3**	**39.1**
Difference	absolute	**8.4**	**-0.5**	**-0.5**	**-0.3**	**-0.2**	**-1.6**	**0.0**	**39.1**
	%	*1.1%*	*-9.8%*	*-6.7%*	*-7.7%*	*-7.8%*	*-7.9%*	*0.0%*	
2000	IIR 2019	**32.7**	**2.0**	**2.0**	**1.0**	**0.9**	**6.0**	**1.5**	**0.0**
	IIR 2020	**44.4**	**1.8**	**1.7**	**0.9**	**0.8**	**5.2**	**1.5**	**0.2**
Difference	absolute	**11.6**	**-0.2**	**-0.3**	**-0.1**	**-0.1**	**-0.7**	**0.0**	**0.2**
	%	*35.5%*	*-12.2%*	*-12.7%*	*-13.3%*	*-9.4%*	*-12.1%*	*-0.1%*	
2010	IIR 2019	**33.2**	**1.9**	**1.9**	**1.0**	**0.9**	**5.8**	**2.4**	**0.0**
	IIR 2020	**47.0**	**1.8**	**1.8**	**0.9**	**0.9**	**5.4**	**2.4**	**0.2**
Difference	absolute	**13.8**	**-0.1**	**-0.1**	**-0.1**	**-0.1**	**-0.4**	**0.0**	**0.2**
	%	*41.5%*	*-6.4%*	*-7.1%*	*-7.5%*	*-7.2%*	*-7.0%*	*0.0%*	
2017	IIR 2019	**23.2**	**1.9**	**1.9**	**1.0**	**0.9**	**5.7**	**3.4**	**0.0**
	IIR 2020	**35.6**	**1.6**	**1.5**	**0.8**	**0.8**	**4.7**	**3.3**	**0.3**
Difference	absolute	**12.4**	**-0.3**	**-0.3**	**-0.2**	**-0.2**	**-1.0**	**-0.1**	**0.3**
	%	*53.6%*	*-17.1%*	*-16.7%*	*-17.1%*	*-19.0%*	*-17.3%*	*-2.4%*	

Again the revision of the transport emission model is responsible for the changes of the Dutch PAH emissions. PCDD/PCDF emission increased compared to the last submission due to a new estimate for the source accidental fires.
Also PCB emissions are increased as from now, estimates for the PCB emissions in 1A1a, 1A1c and 1A2a are included in the inventory.

11 Projections

The emission projections are unchanged to those reported in the IIR 2019 (Wever *et al.*, 2019).

In 2020 an update of the projections is being made. This will be the basis for the projections to be reported in the 2021 submission.

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 of the emission ceilings

12.1.1 Historical and actual exceedances

In the 2020 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 12.1 Summary of reported emissions, exceedances of ceilings and approved adjustments for NMVOC and NH_3.

	NMVOC								
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Reported emission	270.4	267.2	264.2	261.1	249.6	257.0	254.7	254.7	241.6
Exceedances of emission ceilings:									
- NECD	85.4	82.2	79.2	76.1	64.6	73.0	69.7	69.7	56.6
- Gothenburg	79.4	76.2	73.2	70.1	58.6	66.0	63.7	63.7	50.6
Approved adjustments	82.5	81.3	81.2	75.4	67.7	79.1	72.7	71.9	55.0
	NH_3								
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Reported emission	132.7	129.5	123.7	123.0	126.8	128.0	127.9	131.3	129.5
Exceedances of emission ceilings:									
- NECD and Gothenburg	4.7	1.5	-	-	-	0	-	3.3	1.5
Approved adjustments	-	-	-	-	2.1	1.8	2.0	4.6	2.3

12.1.2 Meeting the reduction commitments without adjustments

In 2020 the Netherlands emissions projections will be fully updated and recalculated. These will be the basis for the IIR 2021 report.

As explained in Chapter 11, in 2019 there was an update of the 2020 projection for NH_3-emissions from agriculture. This update includes a new emission source: Manure treatment.

The NMVOC sources under 3B Manure management and 3D Agricultural soils are not included in the current projections outlined in Chapter 11. Emissions from these NMVOC sources are reported in the NFR subsectors 3B and 3D, and are thus excluded in the NECD compliance check 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 in the compliance check.

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 3B (use of silage) and 3D (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 below 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 in the NECD and Gothenburg protocol 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 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.

In 2019 the Netherlands applied for adjustments for several (new) sources for NH3 and NMVOC. After reviewing the requested adjustments the adjustments were approved. As for 2018 the emission ceilings for NH3 and NMVOC are exceeded due to the same sources, the approved adjustments will be applied also for 2018 compliance.

12.2.1 *NH_3 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 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.

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 approved adjustments (Table 12.1), the Netherlands will be in compliance again.

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 oxides (SO_x), nitrogen oxides (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 animal houses (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.

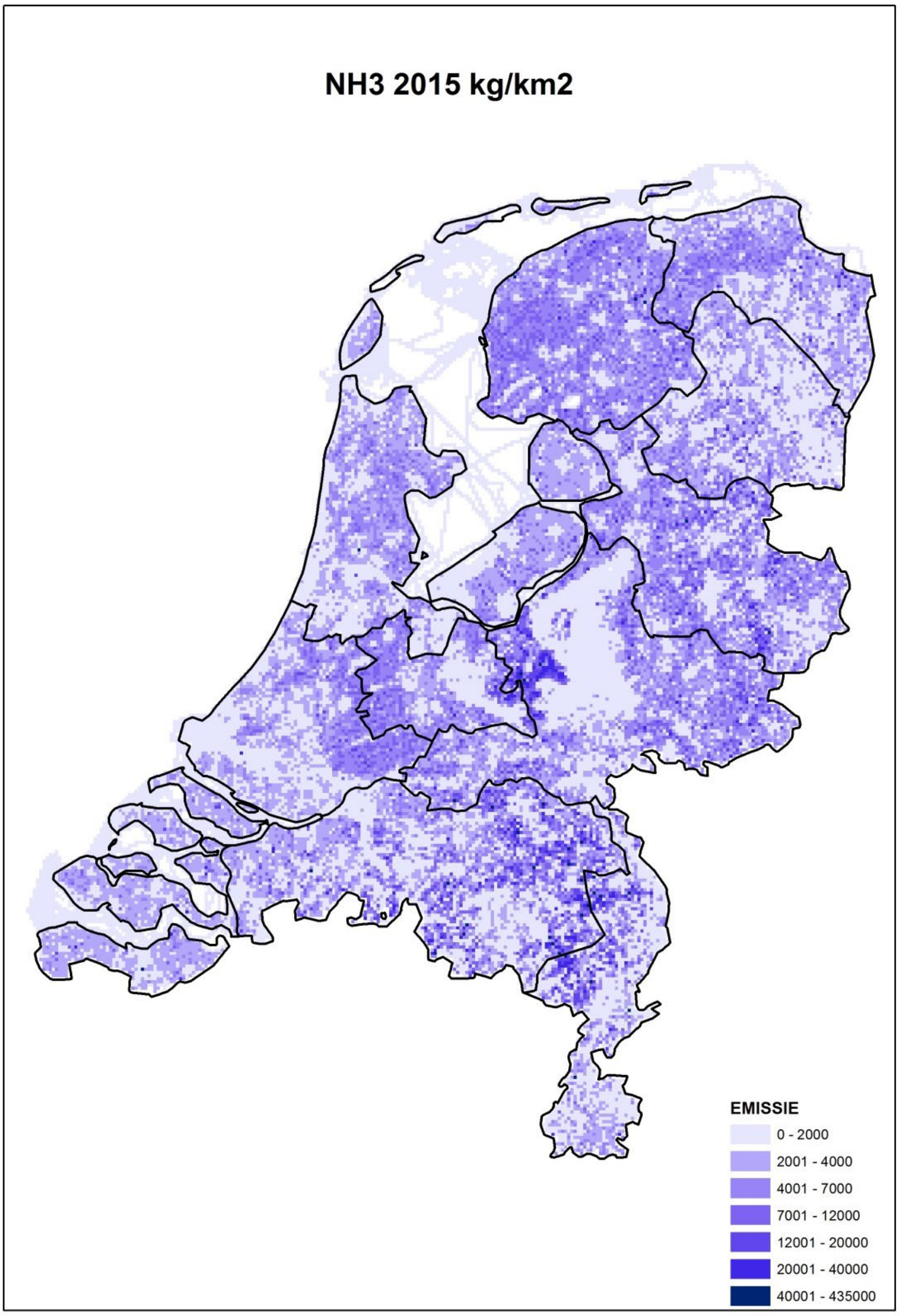

Figure 13.1 Geographical distribution of NH_3 emissions in the Netherlands in 2015

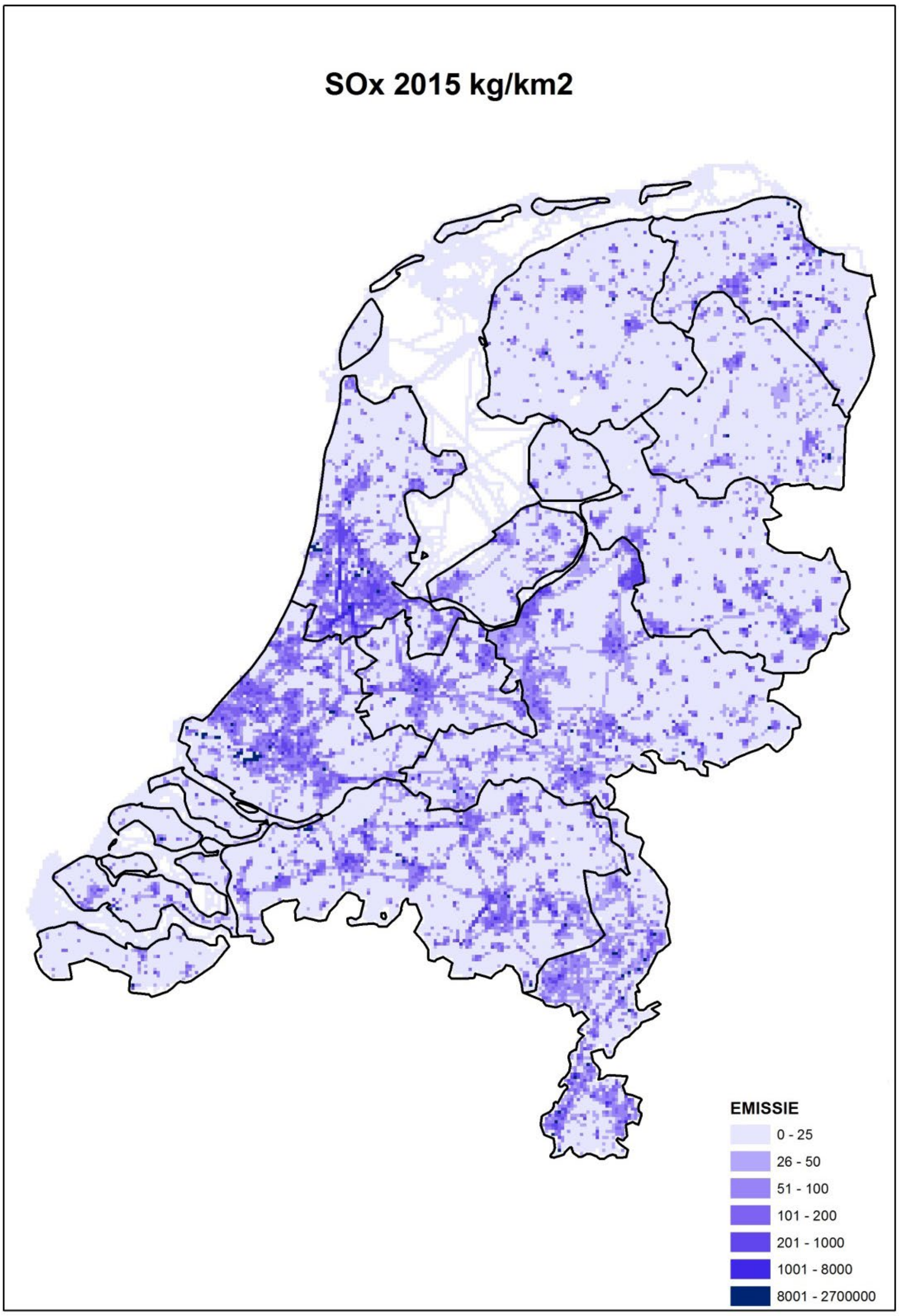

Figure 13.2 Geographical distribution of SO_x emissions in the Netherlands in 2015

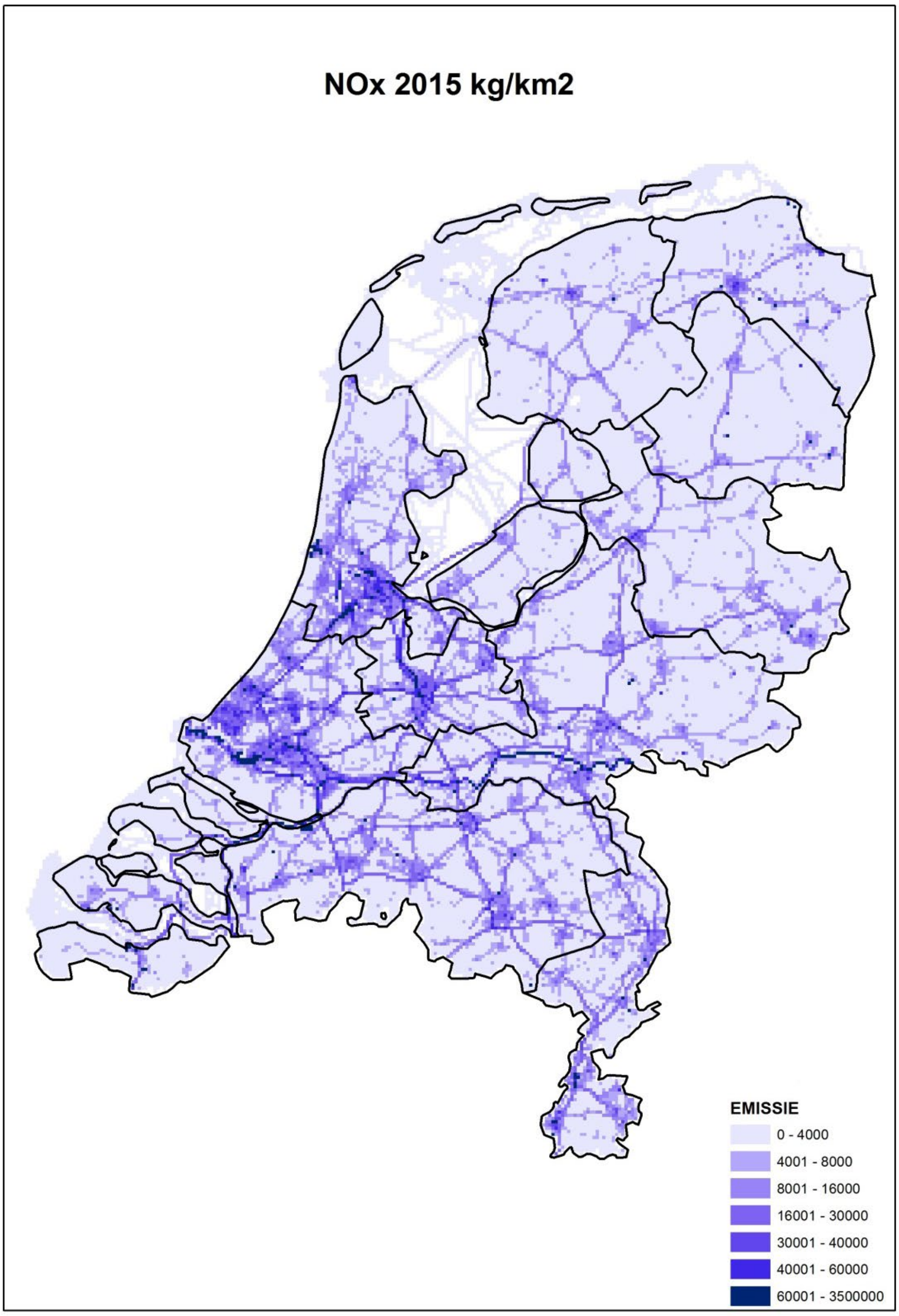

Figure 13.3 Geographical distribution of NO_x emissions in the Netherlands in 2015

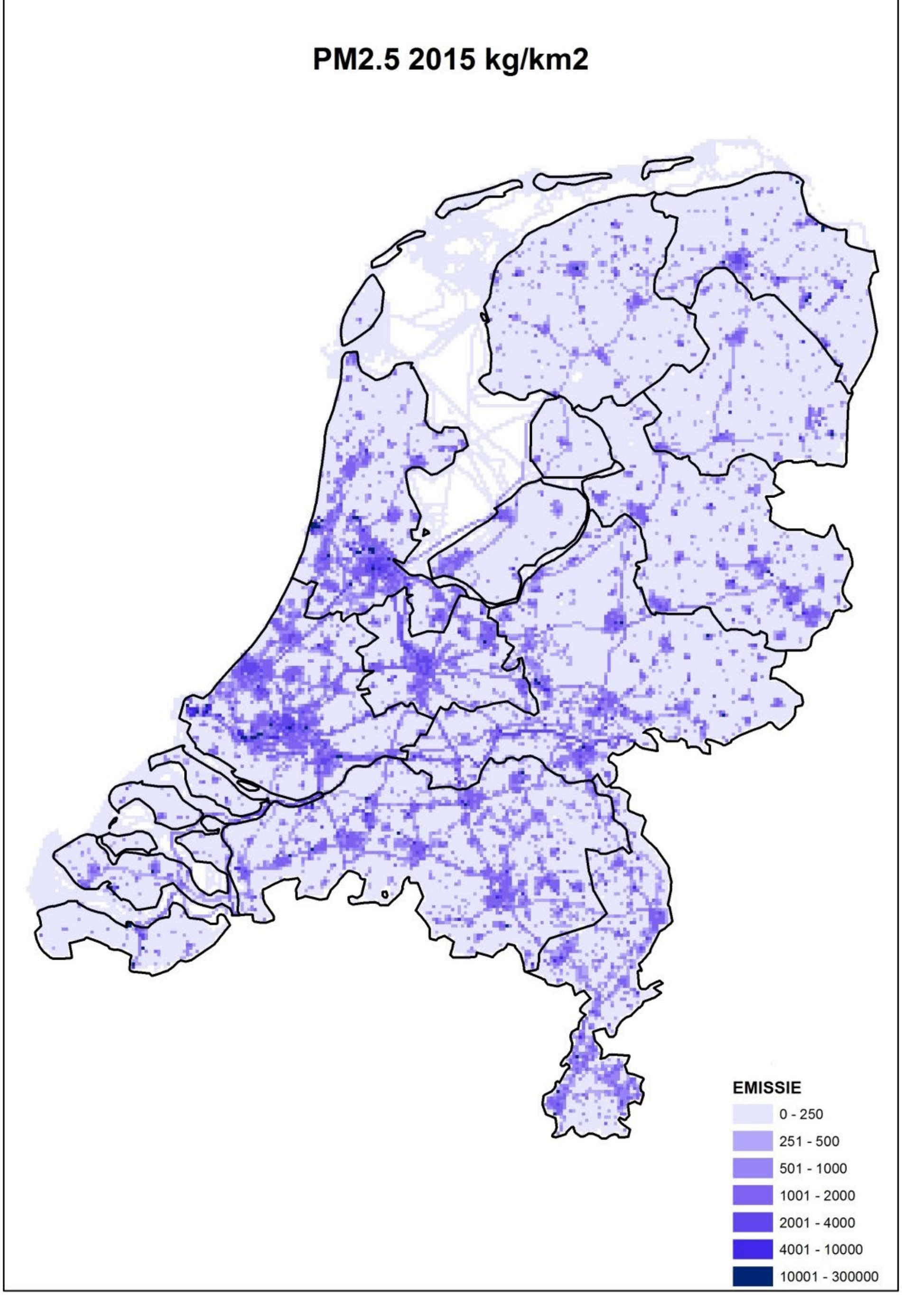

Figure 13.4 Geographical distribution of $PM_{2.5}$ emissions in the Netherlands in 2015

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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, NMVOC, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	1A2a	The emissions from coke production are reported by the combined coke production and iron/steel production plant in the Netherlands. It is not possible to split the emissions between coke production and iron/steel production, and therefore the emissions of this source are reported in 1A2a.
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}, $PM_{2.5}$	1A2a	Emissions from coke production are reported by the combined coke production and iron/steel production plant in the Netherlands. It is not possible to split the emissions between coke production and iron/steel production, and therefore all emissions are reported in 1A2a.
1B2aiv	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 included 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 confidentiality 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 confidentiality 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 confidentiality 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 confidentiality 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 confidentiality 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 SO_x and NO_x from Aluminium production, all SO_x and NO_x 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 confidentiality 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 IIR 2019, Section 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, BC and CO	1A1a and 1A5a	Emissions from heat and power production and flaring are included in the sector Energy. See Chapter 7
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.

NFR code	Substance(s)	Included in NFR code	Explanation
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	NO_x, SO_x, NH_3, BC and CO	1A1ai	The natural gas used for cremation cannot be split from the natural gas used for heating the crematoria buildings. Therefore, all emissions from natural gas combustion in this sector are allocated to 1A4ai.
5D1	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC and CO	1A4ai	Emissions from heat and power production are included in the sector Energy.
5D2	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC and CO	1A4ai	Emissions from heat and power production are included in the sector Energy.

Table A1.2 The Not Estimated (NE) notation key explained

NFR code	Substance(s)	Reason for non-estimation
All except 1A1a, 1A1c, 1A2a, 1A2gviii, 1A4bi, 2C1, 5C2 and 5E	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, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible
1A2b	BC, Se and HCBs	assumed negligible
1A2c	BC, Pb, Cd, As, Cr, Cu, Ni, Se, PAHs and HCBs	assumed negligible
1A2d	BC, Pb, Cd, As, Cr, Cu, Ni, Se, Zn, 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
1a2gviii	Cd, As, Cr, Se and Zn	assumed negligible
1A3ai(i)	NH_3 and Hg	assumed negligible
1A3b till 1A3biv	Pb, Cd, Hg, As, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible; for fuel sold no method available
1A3bv	Dioxins, PAHs and HCBs	assumed negligible; for fuel sold no method available
1A3bvi	Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible; for fuel sold no method available
1A3bvii	Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible
1A3di(ii) and 1A3dii	HCBs	assumed negligible
1A4ai	Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn	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	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
2C3	Dioxins	assumed negligible
2D3b and 2D3c	NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs and HCBs	assumed negligible
3Da2a, 3Da2b, 3Da2c, 3Da3 and 3Da4	TSP, PM_{10} and $PM_{2.5}$	assumed negligible
3Db	NH_3, TSP, PM_{10} and $PM_{2.5}$	assumed negligible
3Dd	NMVOC	assumed negligible
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, Pb, Cd, Hg, As, Cr, Cu, Ni and Se	assumed negligible
3I	NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni and Se	assumed negligible
6A	SO_x, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Dioxins, PAHs 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 2018 and 1990 level assessment, a trend assessment was performed. In both approaches, key source categories are identified using a cumulative threshold of 80%.

For the key source analyses the emission for metals and POP's were taken from the fuel used calculations of road traffic.

SO_x key sources

Table A2.1.a SO_x key source categories identified by 2018 level assessment (emissions in Gg)

NFR14 Code	Long name	2018 Gg	Contribution	Cumulative contribution
1A1b	Petroleum refining	9.8	40%	40%
1A1a	Public electricity and heat production	4.0	16%	56%
2C1	Iron and steel production	3.0	12%	68%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	2.5	10%	78%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	1.7	7.0%	85%

Table A2.1.b SO_x key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A1b	Petroleum refining	67.1	34%	34%
1A1a	Public electricity and heat production	48.5	25%	59%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	20.0	10%	69%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	9.1	5%	74%
1A3biii	Road transport: Heavy duty vehicles and buses	7.8	4%	78.%
2A6	Other mineral products (please specify in the IIR)	5.5	3%	80%

Table A2.1.c SO_x key source categories identified by 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	1.1%	18%	18%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.9%	16%	34%
1A1b	Petroleum refining	0.7%	12%	46%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.5%	8%	54%
1A3biii	Road transport: Heavy duty vehicles and buses	0.5%	8%	62%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.4%	7%	69%
1A4ciii	Agriculture/Forestry/Fishi ng: National fishing	0.3%	5%	74%
1A3bi	Road transport: Passenger cars	0.3%	5%	78%
2A6	Other mineral products (please specify in the IIR)	0.1%	2%	81%

NO_x key sources

Table A2.2.a NO_x key source categories identified by 2018 level assessment (emissions in Gg)

NFR14 Code	Long name	2018 Gg	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy duty vehicles and buses	32.3	13%	13%
1A3bi	Road transport: Passenger cars	30.6	13%	26%
1A3bii	Road transport: Light duty vehicles	19.5	8%	34%
1A3di(ii)	International inland waterways	16.6	7%	41%
1A1a	Public electricity and heat production	15.6	6%	47%
3Da2a	Animal manure applied to soils	12.3	5%	52%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	9.3	4%	56%
1A3dii	National navigation (shipping)	9.0	4%	59%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	9.0	4%	63%
3Da1	Inorganic N-fertilizers (includes also urea application)	8.5	3%	67%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	7.6	3%	70%
1A4ci	Agriculture/Forestry/Fishing: Stationary	7.6	3%	73%
1A4ciii	Agriculture/Forestry/Fishing: National fishing	6.9	3%	76%
1A4bi	Residential: Stationary	6.5	3%	78%
2C1	Iron and steel production	5.5	2%	81%

Table A2.2.b NO_x key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	145.1	22%	22%
1A3biii	Road transport: Heavy duty vehicles and buses	113.5	17%	39%
1A1a	Public electricity and heat production	82.9	13%	52%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	35.9	5%	57%
1A3bii	Road transport: Light duty vehicles	23.3	4%	61%
1A3di(ii)	International inland waterways	22.3	3%	64%
1A4bi	Residential: Stationary	21.6	3%	68%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	21.1	3%	71%
1A4ciii	Agriculture/Forestry/Fishing: National fishing	20.4	3%	74%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	19.7	3%	77%

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A1b	Petroleum refining	18.8	3%	80%
3Da1	Inorganic N-fertilizers (includes also urea application)	15.6	2%	82%

Table A2.2.c NO_x key source categories identified by 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	3.5%	18%	18%
1A1a	Public electricity and heat production	2.3%	12%	30%
1A3bii	Road transport: Light duty vehicles	1.6%	8%	38%
1A3biii	Road transport: Heavy duty vehicles and buses	1.5%	8%	46%
1A3di(ii)	International inland waterways	1.3%	6%	52%
1A3dii	National navigation (shipping)	1.0%	5%	57%
3Da2a	Animal manure applied to soils	1.0%	5%	63%
2C1	Iron and steel production	0.8%	4%	67%
1A4ci	Agriculture/Forestry/Fishing: Stationary	0.7%	3%	70%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.7%	3%	74%
1A3ai(i)	International aviation LTO (civil)	0.5%	3%	76%
3Da1	Inorganic N-fertilizers (includes also urea application)	0.4%	2%	78%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.4%	1.9%	80%

NH_3 key sources

Table A2.3.a NH_3 key source categories identified by 2018 level assessment (emissions in Gg)

NFR14 Code	Long name	2018 Gg	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	40.4	31%	31%
3B1a	Manure management - Dairy cattle	21.6	17%	48%
3B3	Manure management - Swine	12.4	10%	58%
3B1b	Manure management - Non-dairy cattle	10.7	8%	66%
6A	Other (included in national total for entire territory) (please specify in IIR)	10.1	8%	74%
3Da1	Inorganic N-fertilizers (includes also urea application)	9.0	7%	81%

Table A2.3.b NH_3 key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	196.6	56%	56%
3B3	Manure management – Swine	49.2	14%	70%
3B1a	Manure management – Dairy cattle	22.2	6%	77%
3Da3	Urine and dung deposited by grazing animals	15.0	4%	81%

Table A2.3.c NH_3 key source categories identified by 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
3Da2a	Animal manure applied to soils	9.2%	37%	37%
3B1a	Manure management - Dairy cattle	3.8%	15%	52%
3B1b	Manure management - Non-dairy cattle	1.9%	8%	60%
3B3	Manure management - Swine	1.6%	7%	66%
6A	Other (included in national total for entire territory) (please specify in IIR)	1.6%	6%	72%
3B4gi	Manure management - Laying hens	1.3%	5%	77%
3Da1	Inorganic N-fertilizers (includes also urea application)	1.2%	5%	82%

NMVOC key sources

Table A2.4.a NMVOC key source categories identified by 2018 level assessment (emissions in Gg)

NFR14 Code	Long name	2018 Gg	Contribution	Cumulative contribution
3B1a	Manure management - Dairy cattle	43.7	18%	18%
2D3a	Domestic solvent use including fungicides	34.3	14%	32%
2D3i	Other solvent use (please specify in the IIR)	15.0	6%	39%
2D3d	Coating applications	14.7	6%	45%
3Da2a	Animal manure applied to soils	13.2	6%	50%
1A3bi	Road transport: Passenger cars	12.3	5%	55%
3Dc	Farm-level agricultural operations including storage. handling and transport of agricultural products	11.6	5%	60%
3B1b	Manure management - Non-dairy cattle	11.3	5%	65%
1A3biv	Road transport: Mopeds & motorcycles	10.2	4%	69%
1A4bi	Residential: Stationary	9.0	4%	73%
2H3	Other industrial processes (please specify in the IIR)	9.0	4%	77%
2H2	Food and beverages industry	7.8	3%	80%
2B10a	Chemical industry: Other (please specify in the IIR)	5.1	2%	82%

Table A2.4.b NMVOC key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	100.6	17%	17%
2D3d	Coating applications	93.1	15%	32%
3Da2a	Animal manure applied to soils	49.5	8.2%	40 %
1A3bv	Road transport: Gasoline evaporation	35.8	5.9%	46%
2B10a	Chemical industry: Other	33.4	5.5%	52%
2H3	Other industrial processes	25.3	4.2%	56%
1A3biv	Road transport: Mopeds & motorcycles	24.7	4.1%	60%
2D3a	Domestic solvent use including fungicides	23.7	3.9%	64%
2D3i	Other solvent use	19.4	3.0%	67%
1B2av	Distribution of oil products	16.9	2.8%	70%

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy duty vehicles and buses	16.1	2.6%	73%
3B1a	Manure management – Dairy cattle	15.3	2.5%	75%
1B2aiv	Fugitive emissions oil: Refining/storage	14.8	2.4%	77%
2D3h	Printing	14.4	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 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
3B1a	Manure management - Dairy cattle	6.2%	18%	18%
1A3bi	Road transport: Passenger cars	4.5%	13%	31%
2D3a	Domestic solvent use including fungicides	4.1%	12%	43%
2D3d	Coating applications	3.6%	11%	54%
1A3bv	Road transport: Gasoline evaporation	2.0%	6%	60%
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	1.6%	5%	64%
2B10a	Chemical industry: Other (please specify in the IIR)	1.3%	4%	68%
2D3i	Other solvent use (please specify in the IIR)	1.2%	3%	72%
3Da2a	Animal manure applied to soils	1.0%	3%	75%
3B1b	Manure management - Non-dairy cattle	0.9%	3%	77%
2D3h	Printing	0.9%	3%	80%
1A3biii	Road transport: Heavy duty vehicles and buses	0.9%	2%	82%

CO key sources

Table A2.5.a CO key source categories identified by 2018 level assessment (emissions in Gg)

NFR14 Code	Long name	2018 Gg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	223.2	41%	41%
1A4bi	Residential: Stationary	65.0	12%	53%
2C1	Iron and steel production	52.6	10%	62%
1A3biv	Road transport: Mopeds & motorcycles	52.2	10%	72%
1A4bii	Residential: Household and gardening (mobile)	28.1	5%	77%
1A5b	Other. Mobile (including military, land based and recreational boats)	20.7	4%	80%

Table A2.5.b CO key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	587.4	51%	51%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	187.4	16%	67%
1A4bi	Residential: Stationary	77.6	7%	74%
1A3bii	Road transport: Light duty vehicles	47.8	4%	78%
1A3biv	Road transport: Mopeds & motorcycles	44.7	4%	82%

Table A2.5.c CO key source categories identified by 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	7.4%	24%	24%
1A3bi	Road transport: Passenger cars	5.0%	16%	41%
2C1	Iron and steel production	4.6%	15%	56%
1A3biv	Road transport: Mopeds & motorcycles	2.7%	9%	65%
1A4bi	Residential: Stationary	2.4%	8%	73%
1A4bii	Residential: Household and gardening (mobile)	1.8%	6%	79%
1A3bii	Road transport: Light duty vehicles	1.7%	5%	84%

PM_{10} key sources

Table A2.6.a PM_{10} key source categories identified by 2018 level assessment (emissions in Gg)

NFR14 Code	Long name	2018	Contribution	Cumulative contribution
2H3	Other industrial processes (please specify in the IIR)	2.7	11%	11%
3B4gi	Manure management - Laying hens	2.7	11%	21%
2H2	Food and beverages industry	2.0	8%	29%
1A4bi	Residential: Stationary	1.7	7%	36%
2D3i	Other solvent use (please specify in the IIR)	1.6	6%	42%
1A3bvi	Road transport: Automobile tyre and brake wear	1.5	6%	48%
1A3bvii	Road transport: Automobile road abrasion	1.2	5%	52%
2C1	Iron and steel production	1.2	5%	57%
2B10a	Chemical industry: Other (please specify in the IIR)	1.2	5%	62%
2A6	Other mineral products (please specify in the IIR)	1.1	4%	66%
3B4gii	Manure management - Broilers	1.0	4%	70%
3B3	Manure management - Swine	0.9	4%	73%
1A3di(ii)	International inland waterways	0.5	2%	75%
1A3bi	Road transport: Passenger cars	0.5	2%	77%
1A3bii	Road transport: Light duty vehicles	0.5	2%	79%
5E	Other waste (please specify in IIR)	0.5	2%	81%

Table A2.6.b PM_{10} key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
2C1	Iron and steel production	9.1	12%	12%
1A3biii	Road transport: Heavy duty vehicles and buses	7.1	9%	22%
1A3bi	Road transport: Passenger cars	6.4	9%	30%
1A1b	Petroleum refining	6.4	8%	39%
2H3	Other industrial processes (please specify in the IIR)	5.4	7%	46%
1A3bii	Road transport: Light duty vehicles	4.5	6%	52%
2H2	Food and beverages industry	4.3	6%	58%
2B10a	Chemical industry: Other (please specify in the IIR)	4.1	5%	63%

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	2.5	3%	67%
1A1a	Public electricity and heat production	2.2	3%	69%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	2.2	3%	72%
2A6	Other mineral products (please specify in the IIR)	2.0	3%	75%
2D3i	Other solvent use (please specify in the IIR)	2.0	3%	78%
3B3	Manure management - Swine	1.6	2%	80%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.3	2%	82%

Table A2.6.c PM_{10} key source categories identified by 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
3B4gi	Manure management - Laying hens	3.2%	11%	11%
1A3biii	Road transport: Heavy duty vehicles and buses	2.8%	10%	21%
1A1b	Petroleum refining	2.6%	9%	29%
2C1	Iron and steel production	2.6%	9%	38%
1A3bi	Road transport: Passenger cars	2.3%	8%	46%
1A3bvi	Road transport: Automobile tyre and brake wear	1.5%	5%	51%
1A3bii	Road transport: Light duty vehicles	1.4%	5%	56%
1A3bvii	Road transport: Automobile road abrasion	1.2%	4%	60%
2D3i	Other solvent use (please specify in the IIR)	1.2%	4%	64%
2H3	Other industrial processes (please specify in the IIR)	1.2%	4%	68%
1A4bi	Residential: Stationary	1.1%	4%	72%
3B4gii	Manure management - Broilers	0.9%	3%	75%
1A1a	Public electricity and heat production	0.8%	3%	77%
2H2	Food and beverages industry	0.7%	2%	79%
2A6	Other mineral products (please specify in the IIR)	0.5%	2%	81%

$PM_{2.5}$ key sources

Table A2.7.a $PM_{2.5}$ key source categories identified by 2018 level assessment (emissions in Gg)

NFR14 Code	Long name	2018 Gg	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	1.6	13%	13%
2D3i	Other solvent use (please specify in the IIR)	1.6	12%	25%
2A6	Other mineral products (please specify in the IIR)	1.0	8%	33%
2H3	Other industrial processes (please specify in the IIR)	0.8	6%	39%
2B10a	Chemical industry: Other (please specify in the IIR)	0.8	6%	45%
2C1	Iron and steel production	0.8	6%	51%
2H2	Food and beverages industry	0.5	4%	55%
1A3di(ii)	International inland waterways	0.5	4%	59%
1A3bi	Road transport: Passenger cars	0.5	4%	63%
1A3bii	Road transport: Light duty vehicles	0.5	4%	66%
5E	Other waste (please specify in IIR)	0.4	3%	70%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.4	3%	73%
1A3dii	National navigation (shipping)	0.3	3%	75%
1A3biii	Road transport: Heavy duty vehicles and buses	0.3	2%	77%
1A3bvi	Road transport: Automobile tyre and brake wear	0.3	2%	80%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.2	2%	82%

Table A2.7.b $PM_{2.5}$ key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy duty vehicles and buses	7.1	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	4.5	9%	55%
2B10a	Chemical industry: Other (please specify in the IIR)	2.6	5%	60%

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	2.4	5%	64%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	2.1	4%	68%
2D3i	Other solvent use (please specify in the IIR)	2.0	4%	72%
1A1a	Public electricity and heat production	1.8	3%	75%
2H3	Other industrial processes (please specify in the IIR)	1.7	3%	79%
2A6	Other mineral products (please specify in the IIR)	1.6	3%	82%

Table A2.7.c $PM_{2.5}$ key source categories identified by 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3biii	Road transport: Heavy duty vehicles and buses	2.7%	13%	13%
2D3i	Other solvent use (please specify in the IIR)	2.1%	10%	22%
1A3bi	Road transport: Passenger cars	2.0%	10%	32%
1A4bi	Residential: Stationary	1.9%	9%	41%
1A1b	Petroleum refining	1.9%	9%	50%
2C1	Iron and steel production	1.3%	6%	56%
1A3bii	Road transport: Light duty vehicles	1.2%	6%	61%
2A6	Other mineral products (please specify in the IIR)	1.1%	5%	66%
2H3	Other industrial processes (please specify in the IIR)	0.8%	4%	70%
5E	Other waste (please specify in IIR)	0.6%	3%	73%
1A1a	Public electricity and heat production	0.6%	3%	75%
2H2	Food and beverages industry	0.5%	2%	78%
1A3dii	National navigation (shipping)	0.5%	2%	80%

Black Carbon key sources

Table A2.8.a Black carbon key source categories identified by 2018 level assessment (emissions in Gg)

NFR14 Code	Long name	2017 2018 Gg	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	0.5	22%	22%
1A3bii	Road transport: Light duty vehicles	0.4	15%	37%
1A3di(ii)	International inland waterways	0.3	11%	48%
1A3bi	Road transport: Passenger cars	0.2	10%	58%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.2	8%	66%
1A3dii	National navigation (shipping)	0.2	7%	74%
1A3biii	Road transport: Heavy duty vehicles and buses	0.1	5%	79%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.1	5%	84%

Table A2.8.b Black carbon key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990 Gg	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy duty vehicles and buses	3.5	26%	26.2%
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: (please specify in the IIR)	1.1	8%	75%
1A4bi	Residential: Stationary	0.9	7%	82%

Table A2.8.c Black carbon key source categories identified by 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3biii	Road transport: Heavy duty vehicles and buses	3.8%	27%	27%
1A4bi	Residential: Stationary	2.7%	19%	45%
1A3bi	Road transport: Passenger cars	2.2%	15%	61%
1A3di(ii)	International inland waterways	1.5%	10%	71%
1A3dii	National navigation (shipping)	1.1%	8%	79%
5E	Other waste (please specify in IIR)	0.7%	5%	83%

Pb key sources

Table A2.9.a Pb key source categories identified by 2018 level assessment (emissions in Mg)

NFR14 Code	Long name	2017 2018 Mg	Contribution	Cumulative contribution
2C1	Iron and steel production	2.3	39%	39%
1A3ai(i)	International aviation LTO (civil)	0.8	14%	53%
2A3	Glass production	0.6	11%	63%
1A3bi	Road transport: Passenger cars	0.5	8%	71%
2C6	Zinc production	0.4	7%	78%
1A3bvi [1)]	Road transport: Automobile tyre and brake wear	0.3	5%	84%

1. emissions based on fuel used.

Table A2.9.b Pb key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
1A3bi [1)]	Road transport: Passenger cars	230	68%	68%
2C1	Iron and steel production	56	17%	85%

1. emissions based on fuel used.

Table A2.9.c Pb key source categories identified by 1990–20182017 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi [1)]	Road transport: Passenger cars	1.1%	44%	44%
2C1	Iron and steel production	0.4%	16%	60%
1A3ai(i)	International aviation LTO (civil)	0.2%	10%	70%
2A3	Glass production	0.1%	6%	76%
2C6	Zinc production	0.1%	5%	81%

1. emissions based on fuel used.

Hg key sources

Table A2.10.a Hg key source categories identified by 20182017 level assessment (emissions in Mg)

NFR14 Code	Long name	2018 Mg	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	0.2	31%	31%
2A6	Other mineral products (please specify in the IIR)	0.1	20%	51%
2C1	Iron and steel production	0.1	17%	67%
1A3bi [1)]	Road transport: Passenger cars	0.1	11%	79%
1A4bi	Residential: Stationary	0.0	5%	84%

1. emissions based on fuel used.

Table A2.10.b Hg key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	1.9	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 1990–20182017 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	3.8%	29%	29%
2A6	Other mineral products (please specify in the IIR)	3.4%	26%	55%
1A3bi [1)]	Road transport: Passenger cars	1.6%	12%	67%
2C1	Iron and steel production	1.0%	7%	74%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.9%	6%	81%

1. emissions based on fuel used.

Cd key sources

Table A2.11.a Cd key source categories identified by 20182017 level assessment (emissions in Mg)

NFR14 Code	Long name	2018 Mg	Contribution	Cumulative contribution
2C6	Zinc production	2.0	81%	81%

Table A2.11.b Cd key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	1.9	54%	54%
2C1	Iron and steel production	0.7	20%	73%
1A1b	Petroleum refining	0.4	11%	84%

Table A2.11.c Cd key source categories identified by 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2C6	Zinc production	86.4%	50%	50%
1A1a	Public electricity and heat production	47.5%	28%	78%
2C1	Iron and steel production	31.5%	18%	96%

Dioxin key sources

Table A2.12.a Dioxin key source categories identified by 2018 level assessment (emissions in g I-Teq)

NFR14 Code	Long name	2018 g I-Teq	Contribution	Cumulative contribution
5E	Other waste (please specify in IIR)	15.7	45%	45%
2D3i	Other solvent use	11.0	31%	76%
1A4bi	Residential: Stationary	5.8	17%	93%

Table A2.12.b Dioxin key source categories identified by 1990 level assessment (emissions in g I-Teq)

NFR14 Code	Long name	1990 g I-Teq	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	582.6	77%	77%
1A4ai	Commercial/institutional: Stationary	100.0	13%	91%

Table A2.12.c Dioxin key source categories identified by 1990–2018 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	3.4%	41%	41%
5E	Other waste (please specify in IIR)	2.0%	24%	65%
2D3i	Other solvent use	1.3%	16%	81%

PAH key sources

Table A2.13.a PAH key source categories identified by 2018 level assessment (emissions in Mg)

NFR14 Code	Long name	2018 Mg	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	3.7	68%	68%
5E	Other waste	0.5	12%	80%

Table A2.13.b PAH key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990 Mg	Contribution	Cumulative contribution
2C3	Aluminium production	6.9	33%	33%
1A4bi	Residential: Stationary	3.7	18%	51%
2D3d	Coating applications	2.4	12%	63%
2C1	Iron and steel production	1.6	8%	71%
2H3	Other industrial processes (please specify in the IIR)	1.4	7%	78%
1A3bi [1)]	Road transport: Passenger cars	0.8	4%	82%

1. emissions based on fuel used.

Table A2.13.c PAH key source categories identified by 1990–20182017 trend assessment

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A4bi [1)]	Residential: Stationary	11.8%	43%	43%
2C3	Aluminium production	7.8%	28%	71%
5E	Other waste (please specify in IIR)	2.3%	8%	80%
2C1	Iron and steel production	1.5%	6%	85%

1. emissions based on fuel used.

Appendix 3 Status of review recommendations implementation

EMEP/CLRTAP stage 3 review
As a result of the EMEP/CLRTAP stage 3 review on the IIR 2015 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 IIR 2016
6	See from issue 43 onwards	76	progressively in IIR 2016–2018
7	See from issue 43 onwards	77	In IIR 2016
8	See from issue 43 onwards	78	No action necessary
9	See from issue 43 onwards	79	In IIR 2016
10	See from issue 43 onwards	80	In IIR 2016
11	See from issue 43 onwards	81	progressively in IIR 2016–2018
12	See from issue 43 onwards	82	progressively in IIR 2016–2018
13	See from issue 43 onwards	83	No action necessary
14	See from issue 43 onwards	84	In IIR 2016
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 IIR 2016
20	See from issue 43 onwards	90	In IIR 2016
21	See from issue 43 onwards	91	In IIR 2016
22	See from issue 43 onwards	92	progressively in IIR 2016–2018
23	See from issue 43 onwards	93	In IIR 2016
24	See from issue 43 onwards	94	No action necessary
25	See from issue 43 onwards	95	In IIR 2016
26	See from issue 43 onwards	96	In IIR 2016
27	See from issue 43 onwards	97	In IIR 2016
28	See from issue 43 onwards	98	In IIR 2016
29	See from issue 43 onwards	99	In IIR 2016

Issue in review report	Implemented in	Issue in review report	Implemented in
30	See from issue 43 onwards	100	In IIR 2017
31	See from issue 43 onwards	101	In IIR 2017
32	See from issue 43 onwards	102	In IIR 2016
33	See from issue 43 onwards	103	In IIR 2017
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 IIR 2017/2018
37	See from issue 43 onwards	107	No action necessary
38	See from issue 43 onwards	108	In IIR 2017
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 IIR 2016
42	See from issue 43 onwards	112	In IIR 2016
43	Not yet implemented	113	In IIR 2016
44	Not yet implemented	114	In IIR 2017
45	No action necessary	115	In IIR 2016
46	Not yet implemented	116	In IIR 2016
47	Not yet implemented	117	In IIR 2016
48	In IIR 2016	118	In IIR 2017
49	In IIR 2016	119	In IIR 2016
50	In IIR 2016	120	In IIR 2016
51	In IIR 2016	121	See Issue 127
52	In IIR 2017	122	In IIR 2017
53	In IIR 2018	123	In IIR 2017
54	In IIR 2018	124	No action necessary
55	In IIR 2018	125	No action necessary
56	In IIR 2016	126	In IIR 2017
57	In IIR 2018	127	In IIR 2017
58	In IIR 2018	128	In IIR 2017
59	In IIR 2016	129	In IIR 2017
60	No action necessary	130	In IIR 2017
61	In IIR 2016	131	In IIR 2017
62	In IIR	132	No action necessary
63	In IIR 2018	133	In IIR 2016
64	No action necessary	134	In IIR 2016
65	In IIR 2016	135	In IIR 2016
66	In IIR 2016	136	In IIR 2016
67	In IIR 2017	137	In IIR 2017
68	In IIR 2016	138	In IIR
69	In IIR 2016	139	In IIR 2017
70	In IIR 2017		

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 2019.

Table A3.2 Overview of the implementation of actions from the 2019 NECD review

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
NL-1A1-2017-0001	The report on $PM_{2.5}$ fractions has been published on the Emission registration website (www.prtr.nl). Furthermore, the $PM_{2.5}$ fractions have been added to the appendix of the ENINA methodology report (Honig *et al.*, 2020), which is part of the IIR submission.	Appendix in the ENINA methodology report (Honig *et al.*, 2020).
NL-1A1-2017-0002	The default emission factors of NMVOC, SO_x, NO_x, CO, PM_{10}, used for emissions that were not reported by individual companies, have been updated (following review recommendation NL-1A1-2017-0002). The emission factors are based on the EMEP/EEA Guidebook (EMEP/EEA, 2019), company specific data or country specific studies. See Sections 3.2.4, 3.3.4 and 3.4.4.	3.2.4, 3.3.4 and 3.4.4
NL-1A2b-2017-0001	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. These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.	3.3.9
NL-1A2gvii-2017-0001	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).	Biomass is included in the NFR-tables.
NL-1A3aii(i)-2017-0001	Emissions from domestic flights are very small and are included	The issue is on our improvements long list. Within the available

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
	in the inventory, see Section 4.2.5. The issue is on the long list of improvements.	resources every year a selection of these improvements is prioritized for implementation.
NL-1A3b-2017-0001	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.	Biomass is included in the NFR-tables.
NL-1A3c-2017-0002	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.	Biomass is included in the NFR-tables.
NL-1A5a-2017-0001	Landfill gas combustion for energy production is now allocated in 1A1a, while landfill gas flaring stays in 1A5a.	3.2.8 and 3.4.8
NL-2D3g-2017-0001	The reason why disaggregation of the reported emissions under 2B10a is not possible is given in Section 5.3.1.	5.3.1
NL-2H2-2017-0001	The activities which belong to 2H2 are listed in Section 5.6.1. The explanation why no activity data or emission factors are available can be found in Section 5.6.1.	6.6.1
NL-1A1-2018-0001	Emissions of PCB have been calculated and reported.	Method is described in 3.2.4
NL-1A1b-2018-0001	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. These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.	3.2.9
NL-1A2b-2018-0001	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. These studies started in 2019	3.3.9

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
	with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.	
NL-1A2gviii-2018-0001	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. These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.	3.3.9
NL-1A3biii-2018-0001	That the Netherlands will address the recommendation in its 2019 submission. The 2019 TERT has however identified that this is still a potential issue as the finding still remains.	The recommendation has not been implemented. The reason is that PCDD/F are not included in the NFR-tables this year.
NL-1A3biv-2018-0001	The Netherlands explained that at this moment this improvement is not planned but noted the observation and indicated that it will assess if the implementation of this improvement is possible for the submission of 2019.	The recommendation has not been implemented. The reason is that PCDD/F are not included in the NFR-tables this year.
NL-1A3dii-2018-0001	The Netherlands explained that the improvement will be scheduled for the next submission of data.	The recommendation has not been implemented in this year’s submission. HCB and PCB emissions will not be included in the NFR, because they are negligible.
NL-1A4ai-2018-0002	An explanation of the trend is included in Section 3.4.3	3.4.3
NL-1A4ci-2018-0001	Developing a country-specific method for mercury emissions from natural gas combustion. Based on preliminary information from the gas company, it is expected that the emissions could be a factor 10 lower than the default emission factors from the EMEP/EEA Guidebook (2019). The mercury emissions from natural gas combustion will be	3.4.9

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
	calculated in the next submission.	
NL-1A4ciii-2018-0001	The Netherlands explained that the improvement will be scheduled for the next submission of data.	The recommendation has not been implemented in this year’s submission.
NL-2B10a-2018-0002	The Netherlands explained that the time series was incomplete, and resources have not yet been allocated to address this for use in estimating emissions in future submissions.	No reference
NL-2D3a-2018-0001	The Netherlands explained emissions would be estimated in the next submission.	Now NA in NFR
NL-2D3g-2018-0001	The TERT recommends that the Netherlands checks the revised methodology in the 2019 Guidebook and obtains the necessary activity data to estimate emissions and reports the emissions along with a methodological description and information on the data sources used in the 2020 submission.	5.3.1
NL-1A1a-2019-0001	Emissions of PCB have been calculated and reported.	Method is described in 3.2.4
NL-1A1a-2019-0002	The emission factor of HCB from waste combustion is added to Section 3.2.4	3.2.4
NL-1A1b-2019-0002	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. These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.	3.2.9
NL-1A1c-2019-0001	$PM_{2.5}$ ratios are included in the appendix of the ENINA methodology report (Honig *et al.*, 2020), which is part of this submission. Links to this report are included in Sections 3.2.4, 3.3.4 and 3.4.4	3.2.4, 3.3.4, 3.4.4
NL-1A2a-2019-0001	The AERs from individual companies are not complete. In the coming years, a few sectors	3.3.9

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
	will be studied and AERs will be completed as far as possible. These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.	
NL-1A2a-2019-0002	Emissions of PCB have been calculated and reported.	Method is described in 3.3.4
NL-1A2b-2019-0001	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. These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.	3.3.9
NL-1A2c-2019-0001	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. These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.	3.3.9
NL-1A2gviii-2019-0001	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. These studies started in 2019 with the chemical sector and the refineries (which is not yet finished), and it has yet to be decided which sector will be studied this year.	3.3.9
NL-1A2gviii-2019-0002	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. These studies started in 2019 with the chemical sector and the refineries (which is not yet	3.3.9

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
	finished), and it has yet to be decided which sector will be studied this year.	
NL-1A3b-2019-0001	The TERT recommends that the Netherlands include PCB emission estimates from road transport and a transparent description of the methodology in their 2020 submission.	The recommendation has not been implemented in this year's submission.
NL-1A3bi-2019-0001	In response to a question raised during the review, the Netherlands provided references for their emission factor sources and agreed that they would check their emission factors if time was available for the 2020 submission.	The recommendation has not been implemented in this year's submission.
NL-1A3c-2019-0001	The TERT recommends that the Netherlands use the notation key 'NA' for PCB and HCB emissions from railways in future submissions.	The notation key 'NA' has been used in the NFR-tables.
NL-1A4ai-2019-0001	Emissions of PCB have been calculated and reported.	Method is described in 3.4.4
NL-1A4bi-2019-0001	Emissions of PCB have been calculated and reported.	Method is described in 3.4.4
NL-1A4bi-2019-0002	A table is added to Section 3.4.4 containing emission factors for wood combustion (including emission factors for dioxin emissions from wood combustion).	3.4.4
NL-0A-2019-0002	The TERT accepts the response and recommends that the Netherlands provides justification for the low emission level in category 2C6 in the IIR of the next submission.	
NL-0B-2019-0001	The TERT recommends that starting from the 2020 submission the Netherlands reports on row 144 values equal to those on row 141 in case there are no accepted adjustments reported on row 143.	In this submission
NL-1B2d-2019-0001	Other fugitive emissions from category 1B2d are not estimated. Whilst the EMEP/EEA Guidebook provides	3.5.5

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
	Tier 1 emission factors for geothermal power emissions these are not applicable because in the Netherlands the geothermal power projects are not combined with electricity production.	
NL-2A3-2019-0001	The Netherlands explained that the time series was incomplete, and now are addressing this for use in estimating emissions in future submissions.	No reference
NL-2A3-2019-0002	The Netherlands explained that the time series was incomplete, and now are addressing this for use in estimating emissions in future submissions.	No reference
NL-2A6-2019-0001	The TERT recommends that the Netherlands in future submissions include recalculation explanations in the IIR for all NFR categories for which recalculations have been done.	No reference
NL-2B10a-2019-0002	The report on $PM_{2.5}$ fractions have been published on the Emission registration website (www.prtr.nl). Furthermore, the $PM_{2.5}$ fractions have been added to the appendix of the ENINA methodology report (Honig *et al.*, 2020), which is part of the IIR submission.	Appendix in the ENINA methodology report (Honig *et al.*, 2020).
NL-2C1-2019-0001	The Netherlands provided some initial estimates for all years and stated that it will be included in the next submission.	5.4.4
NL-2C6-2019-0001	The Netherlands explained that the time series was incomplete, and now are addressing this for use in estimating emissions in future submissions.	No reference
NL-2C7a-2019-0001	The Netherlands explained that the time series was incomplete, and now are addressing this for use in estimating emissions in future submissions.	No reference
NL-2C7a-2019-0002	The Netherlands explained that the time series was incomplete, and now are addressing this for	No reference

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
	use in estimating emissions in future submissions.	
NL-2D3a-2019-0001	Therefore, the TERT recommends that the Netherlands review their inventory against the 2019 version of the Guidebook and update it, if necessary, before their next submission. Please also see NL-2D3a-2018-0001 on the same subject.	Now NA in NFR
NL-2H2-2019-0001	The Netherlands informed the TERT that information on particle size distribution had changed, which had impacted the emission estimates. The TERT finds the explanation plausible. The TERT recommends that the Netherlands in future submissions include recalculation explanations for all NFR categories for which recalculations have been done.	
NL-2K-2019-0001	As stated in the Revised Estimate, these POPs were banned out in the eighties in the Netherlands, therefore emissions are zero.	No reference
NL-3B-2019-0003	Due to the complexity of the model and the database, not enough time was available to make these changes. All efforts will be made to make these changes for the IIR of 2021.	6.2.8
NL-3Df-2019-0001	The HCB emissions from impurities in pesticides will be reported in the IIR of 2021.	6.2.8
NL-5A-2019-0001	In order to improve the completeness and the comparability of the inventory, the TERT recommends that the Netherlands includes PM emissions from NFR 5A in its inventory paying attention to that the most appropriate activity data to apply default PM EF is not the amount of MSW disposed in landfills but	The emissions from waste are added. See also 7.2.

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
	the amount of (mineral) waste handled in the country.	
NL-5D-2019-0001	In order to improve the completeness and the comparability of the inventory, the TERT recommends that the Netherlands include an estimate of NMVOC emissions from NFR 5D in its next submission. If there are no resources to develop a country specific methodology, as emissions are expected to be very low, the Tier 1 NMVOC EF provided in the 2016 EMEP/EEA Guidebook could be applied as a first approach. Concerning NFR 5D2, the volume of industrial wastewater handled in-situ on recent years may be (very roughly) derived for instance on historical data, using a surrogate indicator (such GDP of a selection of appropriate industrial sectors).	The NMVOC-emissions from domestic waste water treatment are now reported in the NFR-table. We were not able to access all the activity data of industrial water water and develop a methodology for the historical activity data. We hope to settle this issue in the 2021 submission.
NL-5E-2019-0001	The TERT recommends that the Netherlands justifies further its country specific EF for PCDD-F in the 2020 IIR. The ERT notes that the EF used in the Dutch inventory is the one proposed in the 2016 EMEP/EEA Guidebook for open fireplaces burning wood. On the other hand, it is indicated in the IIR, that it is considered that half of the combustible material burned consists of wood and the other half of a mixture of different plastics. PCDD-F emission factor from plastics burning are expected to be high, even higher than for wood.	EF explained in Chapter 7.
NL-6A-2019-0001	The TERT disagrees with the explanation regarding those sources for which there already exist a reporting category, such as the different animals, and recommends that the Netherlands reallocate these emissions into the expected	We were not able to correct this in time for the current submission. See also 6.2.8.

EMRT-NECD Observation	Improvement made/planned	Reference into IIR
	reporting categories to increase comparability of the inventory to other reporting Member States, to the 2020 submission. This issue has been raised also under the agriculture sector observations (NFR 3B).	

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