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

Informative Inventory Report 2018

Emissions of transboundary air pollutants in the Netherlands 1990-2016

RIVM Report 2018-0013

D. Wever et al.

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

Informative Inventory Report 2018

Emissions of transboundary air pollutants
in the Netherlands 1990-2016

RIVM Report 2018-0013

Colophon

DOI 10.21945/RIVM-2018-0013

D. Wever (author), RIVM
P.W.H.G. Coenen (author), TNO
R. Dröge (author), TNO
G.P. Geilenkirchen (author), PBL
M. 't Hoen (author), PBL
B.A. Jimmink (author), RIVM
W.W.R. Koch (author), TNO
A.J. Leekstra (author), RIVM
R.A.B. te Molder (author), RIVM
C.J. Peek (author), RIVM
S.M. van der Sluis (author), PBL
W.L.M. Smeets (author), PBL
J. Vonk (author), RIVM

Contact:
Dirk Wever
RIVM - MIL/DMO
Dirk.wever@rivm.nl

This investigation has been performed by order and for the account of the Ministry of Infrastructure and Water Management, within the framework of Air and Noise (LG).

This is a publication of:
National Institute for Public Health and the Environment
P.O. Box 1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl/en

Synopsis

Informative Inventory Report 2018
Emissions of transboundary air pollutants in the Netherlands 1990-2016

Decrease in ammonia emissions; entire time series adjusted downwards
With a total 127.4 Gg in 2016, slightly more ammonia was emitted than in 2015 and the ceiling set by the European Union was met (128 kilotons). The increase in ammonia emissions was mainly caused by an increase in the number of dairy cows. This increase in emissions was partly countered by an increase in low-emission housing systems for pigs and poultry.
The total ammonia emissions for the period between 1990 and 2015 have been adjusted downwards. This is because of new insights gained into several emission factors that have been used to calculate emissions. These new insights are: the new digestibility of feed (pasture, fodder and silage) for dairy cows causes lower total ammoniacal nitrogen (TAN) levels in the manure; the emission factor for the surface application of manure has decreased and different digestibilities are used for the periods cows spend in animal houses and grazing, respectively.
However, this decrease in ammonia emission is partly countered by new insights into the emission factors from two low-emission manure application techniques.

Decrease in nitrogen oxide emissions; yet the entire time series adjusted significantly upwards
Emissions of nitrogen oxides continue to decrease slightly; the Netherlands is, therefore, complying with the emission ceilings set in this regard. The total nitrogen oxides emissions for the period between 1990 and 2015 were adjusted significantly upwards by 29.2 Gg in 2015 as result of the new emission source crop residues applied to soil and the reallocation of the nitrogen oxide emissions from several (agricultural) sources, from the memo-category 11C to the agriculture sector.
Emissions of sulphur dioxides and non-methane volatile organic compounds continue to decrease slightly; which means the Netherlands is complying with the emission ceilings set in this regard.
Besides the substances mentioned above, the report also includes emissions of carbon monoxide, particulate matter, heavy metals and persistent organic pollutants. The emissions of most of these substances decreased during the 1990 – 2016 period. This downward trend may, especially, be attributed to cleaner fuels, cleaner car engines and to emission reductions in industry as a whole.

This report is concluded by the Informative Inventory Report 2018, drawn up by RIVM and partner institutes, which collaborate to analyse and report emission data each year. This is obligatory for member states. The analyses are used to support Dutch policy.

Keywords: emissions, transboundary air pollution, emission inventory

Publiekssamenvatting

Informative Inventory Report 2018

De uitstoot van ammoniak is in 2016 gestegen ten opzichte van 2015 en ligt met 127,4 kiloton onder het maximum dat vanuit Europa voor Nederland is bepaald. De toename wordt vooral veroorzaakt doordat er meer melk- en kalfkoeien gehouden worden. De toename wordt voor een deel afgezwakt door een gemiddeld lagere uitstoot als gevolg van schonere stalsystemen.

De berekeningen voor de ammoniakemissie uit de landbouw zijn complex omdat veel factoren er invloed op hebben. Dat zijn bijvoorbeeld de diersoort, de leeftijdscategorie, de huisvesting en de wijze waarop de mest op het land wordt gebruikt. Nieuwe inzichten in deze emissiefactoren zorgen ervoor dat de totale uitstoot van ammoniak tussen 1990 en 2015 met terugwerkende kracht over de gehele linie naar beneden is bijgesteld. Zo blijkt de mate waarin rundveevoer wordt verteerd, voor een lagere hoeveelheid ammoniakaal stikstof (TAN) in de rundveemest te zorgen dan eerder was berekend. Daardoor komt er minder ammoniak vrij als de mest op het land wordt gebruikt.

Binnen de gestelde periode waren een paar veranderingen te zien als gevolg van de nieuwe inzichten. Zo is de emissiefactor voor bovengrond gebruik van mest naar beneden bijgesteld, waardoor de uitstoot in de eerste helft van de jaren negentig omlaag is gegaan. Daar staat tegenover dat de emissiefactoren voor een aantal emissiearme manieren van mest op het land verspreiden (uitrijden), hoger zijn geworden. Desondanks blijft het emissiearme uitrijden van mest nog altijd een effectieve maatregel om de uitstoot van ammoniak zoveel mogelijk te beperken.
De uitstoot van stikstofoxiden, zwaveldioxiden en niet-methaan vluchtige organische stoffen blijven net als in voorgaande jaren licht dalen. Voor deze stoffen blijft Nederland voldoen aan de gestelde ‘plafonds’. Ook is de uitstoot van koolmonoxide, fijnstof, zware metalen en persistente organische stoffen tussen 1990 en 2016 bijna zonder uitzondering gedaald. Dit komt vooral door schonere brandstoffen, schonere automotoren en door emissiebeperkende maatregelen in de industrie, met apparatuur om stof, stikstofdioxide en zwaveldioxide af te vangen.

Dit en meer blijkt uit de Informative Inventory Report (IIR) 2018. Het RIVM analyseert en rapporteert hierin jaarlijks met diverse partnerinstituten de uitstoot van stoffen. Lidstaten van de Europese Unie zijn hiertoe verplicht. Nederland gebruikt de analyses om beleid te onderbouwen.

Kernwoorden: emissies, grootschalige luchtverontreiniging, emissieregistratie

Contents

1 Introduction

The United Nations Economic Commission for Europe's 1979 Geneva Convention on Long-Range Transboundary Air Pollution (CLRTAP) was accepted by the Netherlands in 1982. Furthermore, the European Community adopted the National Emission Ceiling Directive (NECD) in 2001 to set national emission-reduction commitments for EU Member States. Additionally, the European Community adopted the Revised National Emission Ceiling Directive in 2016.
Parties under the CLRTAP and European member states for the NECD are obligated to report their emission data annually. Under the CLRTAP, these data are reported to the Conventions' Executive Body in compliance with the implementation of the Protocols to the Convention (accepted by the Netherlands) and for the NECD these are reported to the European Commission. For both the CLRTAP and the NECD, reports must be prepared using the Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution 2014 (UNECE, 2014).

The Informative Inventory Report 2018 (IIR 2018) comprises the national emissions reporting obligation for both the CLRTAP and the NECD with respect to the pollutants SO_x, NO_X, NMVOC, NH_3, $PM_{2.5}$, other particulate matter (PM10, TSP and Black Carbon (BC)), CO, priority heavy metals (Hg, Pb and Cd), heavy metals (As, Cr, Cu, Ni, Se and Zn) and several persistent organic pollutants (POP).

The Dutch IIR 2018 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 2016, including descriptions of methods, data sources, QA/QC activities carried out and a trend analysis. The inventory covers all anthropogenic emissions to be reported in 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 national Pollutant Release and Transfer Register (PRTR). This PRTR database is the national database for the sectorial 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 report to the framework of National Emission Ceilings (EU), the CLRTAP, the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (National System). The PRTR encompasses keeping abreast of the state of the art, the process of data collection, processing and registration, and reporting on emission data for some 350 compounds. Emission data (for the most significant pollutants) and documentation can be found at www.prtr.nl.
Instead of using the defaults from the EMEP/EEA air pollutant emission inventory guidebook 2016 (EMEP/EEA, 2016), the Netherlands often applies country-specific methods with associated activity data and

emission factors. The emission estimates are based on the official statistics of the Netherlands (e.g. on energy, industry and agriculture) and on environmental reports issued by companies in the industrial sectors. Both nationally developed and internationally recommended emission factors have been used.

1.2 Institutional arrangements for inventory preparation

The Dutch Ministry of Infrastructure and Water Management (IenW) bears overall responsibility for the emission inventory and submissions made to CLRTAP and NECD. A Pollutant Release and Transfer Register (PRTR) system has been in operation in the Netherlands since 1974. Since 2010, the Ministry of 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. Emission data are produced in annual (project) cycles. In addition to the RIVM, various external agencies/institutes contribute to the PRTR by performing calculations or submitting activity data:

- Netherlands Environmental Assessment Agency (PBL);
- Statistics Netherlands (CBS);
- Netherlands Organisation for Applied Scientific Research (TNO);
- Rijkswaterstaat (RWS):
    - Centre for Water Management (RWS-WD);
    - Centre for Transport and Navigation (RWS-DVS);
    - Water, Traffic and Environment (RWS-WVL);
    - Human Environment and Transport Inspectorate (RWS-ILT).
- Deltares;
- Wageningen Environmental Research;
- Wageningen UR Livestock Research;
- Wageningen Economic Research;
- Fugro-Ecoplan, 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 RIVM and in annual project plans.

1.3 The process of inventory preparation

1.3.1 Data collection

For the collection and processing of data (according to pre-determined methods), the PRTR is organized according to task forces. The task forces consist of sector experts from the participating institutes. Methods are compiled on the basis of the best available scientific views. Changes in scientific views lead to changes in methods and to the recalculation of historical emissions. The following task forces are recognized (see Figure 1.1):

- Task Force on Agriculture and Land Use - TgL;
- Task Force on Energy, Industry and Waste Management - ENINA;
- Task Force on Traffic and Transportation;
- Task Force on Water - MEWAT;
- Task Force on Service Sector and Product Use - WESP.

Every year, after the emission data have been collected, several quality control checks are performed by the task forces during a yearly 'trend analysis' workshop. After being approved by participating institutes, emission data are released for publication (www.prtr.nl). Subsequently, these data are disaggregated to regional emission data for national use (e.g. 5 x 5 km grid, municipality scale, provincial scale and water authority scale).

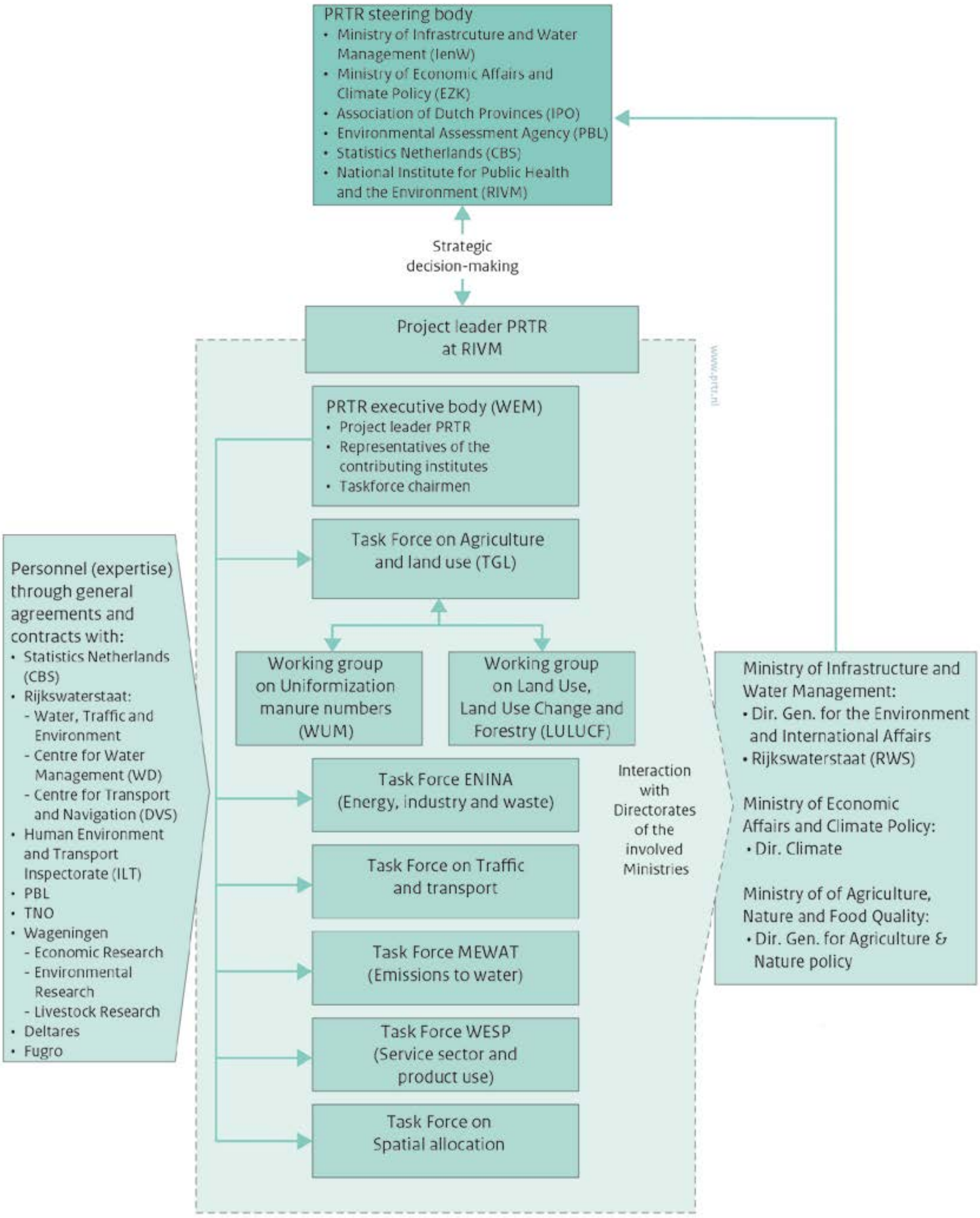

Figure 1.1 The organizational arrangement of the Netherlands Pollutant Release and Transfer Register (PRTR)

Point-source emissions
As result of the Netherlands' 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. For some pollutants, the Dutch implementation of the E-PRTR directive (VROM, 2008) has set lower thresholds. As a consequence, the total amount of the main pollutants reported for each subsector meets approximately 80% of the subsector total. This criterion was set as a safeguard for the quality of the supplementary estimate for Small and Medium-sized Enterprises (SMEs).

As from 1 January 2010, the above-mentioned companies can only submit their emissions as a part of an Annual Environmental Report (AER) electronically. All these companies have emission monitoring and registration systems with specifications that correspond with those of the competent authority. Usually, 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 formally remains the property of the companies involved.

Data on point-source emissions in the AER database are checked for consistency by the task forces. 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, 2018). The ER-I data is combined with supplementary estimates for Small and Medium-sized Enterprises (SMEs). Several methods are applied for calculating these emissions. TNO has derived emission factors for NO_x emissions from small installations, such as Van Soest-Vercammen *et al.* (2002); while, for other substances, the Implied Emission Factors (IEFs) derived from the AERs are applied to calculate sector emissions.

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

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

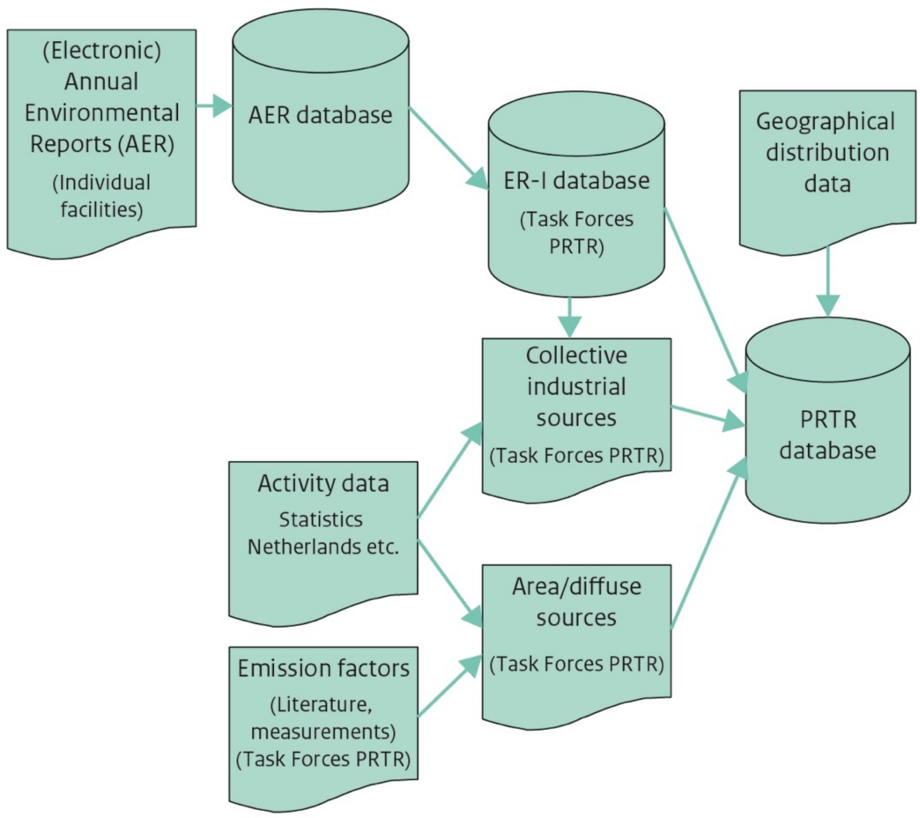

Figure 1.2 The data flow in the Netherlands Pollutant Release and Transfer Register (PRTR)

1.4 Methods and data sources

Methods used in the Netherlands are documented in several reports and protocols, and in meta-data files available from www.prtr.nl. However, some reports are only available in Dutch. For greenhouse gases (http://english.rvo.nl/nie), particulate matter (PM) and all emissions related to mobile sources, the documentation has been translated into English.

In general, two emission 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 with 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.
- A model for emissions from *diffuse sources* (e.g. road transport, agriculture), which are calculated from activity data and emission factors from sectorial emission inventory studies in the Netherlands (e.g. SPIN documents produced by the ‘Cooperation project on industrial emissions’).

In addition, these assumptions are important to consider:
- Condensable emissions are only included for transport emissions, not for emissions from domestic wood burning or industrial emissions.
- Road transport emissions have been calculated using 'on-road' measured emission factors, so emission data are insensitive to 'the diesel scandal'.

1.5 Key source analysis

A trend assessment was carried out for the emission inventory of all components, in addition to a level assessment, in order to identify key source categories. In both approaches, key source categories were identified using a cumulative threshold of 80%. Key categories are those which, when summed together in descending order of magnitude, add up to more than 80% of the total level (EMEP/EEA, 2016). The level assessments were performed for both the latest inventory year (2015), as well as for 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 1 for the actual analysis.

1.6 Reporting, QA/QC and archiving

1.6.1 Reporting

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

1.6.2 QA/QC

The RIVM has an ISO 9001:2015 based QA/QC system in place. The PRTR quality management is fully in line with the RIVM QA/QC system. Part of the work for the PRTR is done by external agencies (other institutes). QA/QC arrangements and procedures for the contributing institutes are described in an annual project plan (RIVM, 2017). The general QA/QC activities meet the international inventory QA/QC requirements described in Part A, Chapter 6 of the EMEP inventory guidebook (EMEP/EEA, 2016).

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

Quality Assurance (QA)

QA activities can be summarized 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 the annual quality assurance;
- As part of the RIVM quality system, internal audits are performed at the Department for Data and environment (DMO) of the RIVM Centre for Environmental Quality (MIL);

- Furthermore, there are annual external QA checks 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 2018 inventory, the PRTR task forces filled in a standard-format database with emission data from 1990 to 2016. After an automated first check of the emission files by the data exchange module (DEX) for internal and external consistency, the data becomes available to the specific task force for checking 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 facilitated 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 organized by the RIVM (see Text box 1.1). The results of this workshop, including actions for the task forces to resolve the identified clarification issues, are documented at RIVM. Required changes to the database are then made by the task forces.

Table 1.1 Key items of the verification actions on data processing 2017 and NFR/IIR 2018

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 hanging issues for this inventory	28-06-2017	RIVM-PRTR	List of remaining issues/actions from last inventory	“Actiepunten voorlopige cijfers 2016 v 28 juni 2017.xls”
Input for checking allocations from the PRTR-database to the NFR tables	06-11-2017	RIVM-NIC	List of allocations	“NFR-ER-Koppellijst-2017-11-06-dtt54.xlsx”
Input for error checks PM fractions	05-12-2016	RIVM-PRTR	Updated list of required actions	“Controle PM fracties.xlsx”
Input for trend analysis	05-12-2017	RIVM-PRTR	Updated list of required actions	“Actiepunten definitieve cijfers v 5 december 2017.xls”; “Verschiltabel_LuchtActueel 05-12-2017.xlsx”

Trend analysis workshops	07-12-2017	Sector specialists, RIVM-PRTR	Explanations for observed trends and actions to resolve before finalizing the PRTR dataset	– “Emissies uit de landbouw reeks 1990-2016.pptx”; – “Presentatie ENINA TrendAnalyse reeks 1990-2016_v1.pptx”; – Trendanalyse verkeer 2017.pptx”; – WESP Trendanalyse reeks 7-12-2017.pptx”; – TA-dag NEC plafonds NL v1.pptx”.
Input for resolving the final actions before finalizing the PRTR dataset	14-12-2017	RIVM-PRTR	Updated Action list	Actiepunten definitieve cijfers v 14 december 2017.xls”
Request to the contributing institutes to endorse the PRTR database	20-12-2017 till 21-12-2017	PRTR project secretary, representatives of the contributing institutes	Reactions of the contributing institutes to the PRTR-project leader	– Email (20-12-2017 10:17) with the request to endorse the PRTR database; – “Actiepunten definitieve cijfers v 19 december 2017.xls”; Emails with consent from PBL, Deltares and CBS (CBS 21-12-2017 17:15; PBL 21-12-2017 18:35; Deltares 20-12-2017 10:24).
Input for compiling the NEC report (in NFR-format)	15-12-2017	RIVM-NIC	List of allocations for compiling from the PRTR-database to the NFR-tables	“ NFR-ER-Koppellijst-2017-12-15-dtt54_BJenBL.xlsx”
List of allocations for compiling from the PRTR database to the NFR tables	13-03-2018	RIVM	Input for compiling the EMEP/LRTAP report (NFR format)	“NFR-ER-Koppellijst-2018-03-08-dtt54-DW.xlsx”

* All documentation (e-mails, data sheets and checklists) are stored electronically on a data server at RIVM.

Text box 1.1 ***Trend verification workshops***

About a week in advance of a trend analysis meeting, a snapshot from the database is made available by the RIVM in a web-based application (Emission Explorer, EmEx) for checks by the institutes involved, 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 for relevant gases and sectors. The totals for the sectors are then compared with the previous year's data set. Where significant differences are found, the task forces evaluate 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.
Furthermore, the PRTR team provides the task forces with time series of emissions for each substance for the individual sub-sectors. The task forces examine these time series. During the trend analysis for this inventory, the emission data were checked in two ways: 1) emissions from 1990 to 2015 from the new time series were compared with the time series of last years' inventory and 2) the data for 2016 were compared with the trend development for each gas since 1990. The checks of outliers are performed on a more detailed level of the sub-sources in all sector background tables:

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

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

Archiving and documentation

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

1.6.3 *Quantitative uncertainty*

Uncertainty estimates of total national emissions are calculated using a tier 2 method (Monte Carlo analysis). Most uncertainty estimates were based on the judgement of emission experts from the task forces ENINA (energy/industry/waste), Traffic and Transport, Agriculture, and WESP (product use). For agriculture, the judgement of experts was combined with a Tier 1 uncertainty calculation. In the tier 1 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). These judgements of experts were made for activity data and emission factors separately on 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 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 number 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. In some cases part of the input data for calculating EFs is the same or EFs are derived from other animal categories.

The results of the Monte Carlo analysis are presented in Table 1.2. For agriculture, the result of the tier 1 error propagation result was included in this table (instead of the Monte Carlo analysis result) because the correlations between the agricultural emission sources need further investigation.

Table 1.2 Uncertainty (95% confidence ranges) for NH_3, NO_x, SO_2, NMVOC, PM_{10} and $PM_{2.5}$ for each NFR category and for the national total, calculated for emissions in 2016.

NFR-Category	**NH_3**	**NO_x**	**SO_2**	**NMVOC**	**PM_{10}**	**$PM_{2,5}$**
1	156%	15%	29%	81%	28%	27%
2	49%	68%	91%	33%	35%	35%
3	25%	120%		88%	23%	36%
5	100%	100%	102%	96%	100%	99%
6	94%	28%			68%	68%
Total	**24%**	**17%**	**29%**	**40%**	**18%**	**21%**

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

2016. The uncertainty for SO_2 in 2016 increased compared with the studies of van Gijlswijk et al (2004) and RIVM (2001). This can be explained by the fact that the uncertainty of the SO_x emission factor from chemical waste gas, coal and cokes is assumed to be rather uncertain.

Table 1.3 Uncertainty (95% confidence ranges) in earlier studies for NH_3, NO_x and SO_2 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_2	± 8%	± 6%	± 6%

1.7 Explanation on the use of notation keys

The Dutch emission inventory covers all relevant sources specified in the CLRTAP that determine the emissions to air in the Netherlands. Because of the long history of the inventory, it is not always possible to specify all sub-sectors in detail. This is the why notation keys are used in the emission tables (NFR). These notation keys will be explained in Table 1.4 up to Table 1.6. For most cases in which 'NE' has been used as a notation key, the respective source is assumed to be negligible and sometimes there is also no method available for estimating the respective source. IE notation keys have been included in the category listed under Notes in NFR-tables, see column D.

Table 1.4 The Not Estimated (NE) notation key explained

NFR code	Substance(s)	Reason for not estimated
All	PCBs	respective sources are assumed negligible
1A1b	NH_3, Pb-Zn, PAHs, HCBs	respective source is assumed negligible; not method available
1A1c	All, except SO_x and NO_x	respective sources are assumed negligible
1A2a	NH_3, As, Cu, Ni, Se, PAHs HCBs	respective sources are assumed negligible
1A2b	HCBs	respective sources are assumed negligible
1A2c	Pb, Cd, As, Se, PAHs, HCBs	respective sources are assumed negligible
1A2d	Pb, Cd, As, Se, PAHs, HCBs	respective sources are assumed negligible
1A2e	Pb-Zn	respective source is assumed negligible; not method available
1A2gvii	HCBs	respective source is assumed negligible
1A3b-d	HCBs	respective sources are assumed negligible
1A4aii	HCBs	respective source is assumed negligible
1A4bi	NH_3	respective source is assumed negligible
1A4bii	HCBs	respective source is assumed negligible
1A4ci	NH_3, Pb-Zn	respective source is assumed negligible
1A4cii	HCBs	respective source is assumed negligible
1A4ciii	Pb-As, Se, HCBs	respective source is assumed negligible
1A5a	NH_3, Pb-Zn, HCBs	respective source is assumed negligible

NFR code	Substance(s)	Reason for not estimated
1A5b	HCBs	respective source is assumed negligible
1B1a	NMVOC, SO_x, CO, Pb-Zn, HCBs	respective source is assumed negligible
1B2	SO_x	respective sources are assumed negligible
1B2c	Pb-Zn, PCDD/PCDF, PAHs, HCBs	respective sources are assumed negligible
1B2d	All, except NO_x	respective sources are assumed negligible
2D3b, 2D3c	All	respective sources are assumed negligible
3B	NMVOC	respective sources are assumed negligible
3D, except 3Dc, 3Df	TSP, PM_{10}, $PM_{2.5}$	respective sources are assumed negligible
3Da4	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	respective source is assumed negligible
3De	NO_x, SO_x	respective source is assumed negligible
3Df	NO_x, NMVOC, SO_x, NH_3, CO, Pb-Se	respective source is assumed negligible
3F	All	respective sources are assumed negligible
3I	All	respective sources are assumed negligible
6A	All, except NH_3, TSP, PM_{10}, $PM_{2.5}$	respective sources are assumed negligible

Table 1.5 The Included Elsewhere (IE) notation key explained

NFR13 code	Substance(s)	Included in NFR code
1A2f	All	1A2gviii
1A3aii(i)	All	1A3ai(i)
1A3ei	All	1A2f, 1A4cii, 1B2b
1B1a	TSP, PM_{10}, $PM_{2.5}$	2H3
1B1b	NO_x, NMVOC, SO_x, TSP, PM_{10}, $PM_{2.5}$	1A2a
1B2ai	NMVOC	1B2b
1B2c	NMVOC, TSP, PM_{10}, $PM_{2.5}$, CO	1B2b
	NO_X and SO_x	1A1C
2A2	NO_x, NMVOC, SO_x	2A6
2A5a	NMVOC	2H3
2A5b	NO_x, NMVOC, SO_x	2A6
2A5c	NO_x, NMVOC, SO_x	2A6
2B1	NMVOC, NH_3	2B10a
2B2	NMVOC, NH_3	2B10a
2B5	NMVOC, NH_3	2B10a
2B6	NMVOC, NH_3	2B10a
2B7	NMVOC, NH_3	2B10a
2B10b	NMVOC, NH_3	2B10a
2C4	All	2C7c
2C7d	All	2H3
2D3g	NMVOC	2B10a
2G	All	2D3i
2L	All	2H3
5A	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A1a
5B2	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A4ai
5D1	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A4ai
5D2	NO_x, SO_x, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A4ai

Table 1.6 Sub-sources accounted for in reporting 'other' codes

NFR13 code	Substance(s) reported	Sub-source description
1A2gviii		Combustion in industries not elsewhere reported, machineries, services and product making activities.
1A5a		Combustion gas from landfills.
1A5b		Recreational navigation and ground machinery at airports.
2A6		Processes, excl. combustion, in building activities and production of building materials.
2B10a		Production of chemicals, paint, pharmaceutics, soap, detergents, glues and other chemical products.
2C7c		Production of non-ferrous metals.
2D3i		Smoking tobacco products, burning candles, air conditioning, the use of pesticides, cosmetics, fireworks, preservation and cleaning of wood and other materials.
2H3		Making products 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.
5E		Accidental building and car fires, Waste Preparation for recycling, scrapping fridges and freezers.
6A		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

The Dutch NH_3 emission series are dangling about the national emission ceiling set for the year 2010 (NEC2010). For NO_x, SO_x and NMVOC, the Netherlands was in compliance with the respective ceilings in 2016. The emissions of all substances showed a downward trend in the 1990-2016 period (see Table 2.1). The major overall drivers for this trend were:

- emission reductions in the industrial sectors;
- cleaner fuels;
- cleaner cars.

Road transport emissions have decreased by 87% since 1990 for NMVOC, by 77% for PM, by 72% for NO_x and by 99% for SO_x, despite a growth in road transport of 13%. The decrease is mainly attributable to European emission regulations for new road vehicles. For PM and NO_x, standards have been set for installations by tightening up the extent of the emission stocks of heating installations (BEES). In meeting these requirements, Dutch industrial plants have realized a reduction of 93% in PM emissions and 62% in NO_x emissions since 1990. Sections 2.2-2.8 elaborate in greater detail on the drivers for the downward emission trend for specific substances.

Table 2.1 Total national emissions, 1990-2016

	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	**656**	**498**	**197**	**350**	**52**	**75**	**98**	**13**	**1142**
1995	555	357	136	223	39	56	74	11	915
2000	464	252	78	175	29	44	52	10	750
2005	406	190	67	153	22	36	44	8	722
2010	334	175	35	133	17	30	37	5	675
2015	268	149	31	126	13	27	34	3	569
2016	**254**	**141**	**28**	**127**	**13**	**26**	**33**	**3**	**559**
1990-2016 period[1)]	-401	-357	-169	-223	-39	-49	-65	-10	-583
1990-2016 period[2)]	-61%	-72%	-86%	-64%	-76%	-65%	-66%	-76%	-51%

-61[1)] Absolute difference in Gg
[2)] Relative difference to 1990 in %

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	**332**	**2.1**	**3.6**	**744**	**20**	**1.3**	**12**	**37**	**73**	**0.4**	**224**
1995	153	1.1	1.5	68	10	0.9	8.5	38	84	0.3	146
2000	27	1.0	1.1	33	5.1	0.9	5.0	39	19	0.5	95
2005	30	1.8	1.0	31	5.1	1.3	4.3	41	10	2.6	88
2010	38	2.6	0.6	33	4.8	0.6	3.8	45	2	1.5	102
2015	9	0.6	0.6	23	4.7	0.6	3.4	45	2	1.0	103
2016	**9**	**0.7**	**0.6**	**23**	**4.8**	**0.7**	**3.7**	**41**	**2**	**0.6**	**100**
1990-2016 period [1)]	-323	-1.5	-3.0	-721	-15	-0.6	-8.1	4.7	-71	0.3	-124
1990-2016 period [2)]	-97%	-70%	-83%	-97%	-76%	-45%	-69%	13%	-97%	65%	-55%

1) Absolute difference in Gg
2) Relative difference to 1990 in %

2.2 Trends in sulphur dioxide (SO_x)

The Dutch SO_x emissions (reported as SO_x) decreased by 169 Gg in the 1990-2016 period, corresponding to 86% of the national total in 1990 (Figure 2.1). The main contributions to this decrease came from the energy sector, industry and the transport sector. The use of coal declined and major coal-fired electricity producers installed flue-gas desulphurization plants. The sulphur content in fuels for the (chemical) industry and traffic was also reduced. At present, industry and the energy and refining sectors (IER) is responsible for 97% of the national SO_x emissions.

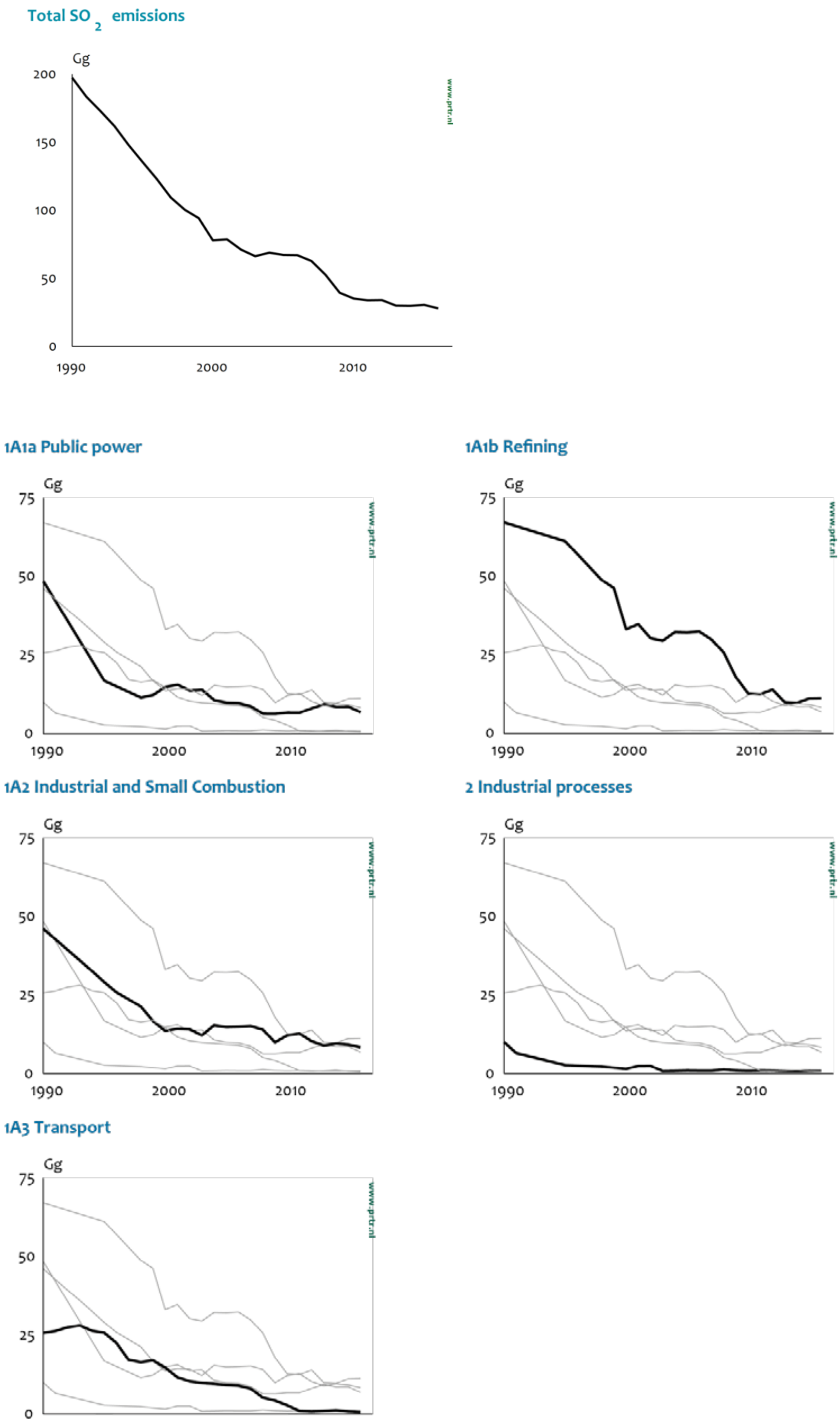

Figure 2.1 SO_x, emission trends 1990-2016

2.3 Trends in nitrogen oxides (NO_x)

The Dutch NO_x emissions (NO and NO_2, expressed as NO_2) decreased by 376 Gg in the 1990-2016 period, corresponding to 61% of the national total in 1990 (Figure 2.2). The main contributors to this decrease were road transport and the energy sector. Although emissions per vehicle decreased significantly in this period, an increase in the number and the miles travelled by vehicles partially negated the effect on total road transport emissions. The shares of the different NFR categories in the national total did not change significantly.

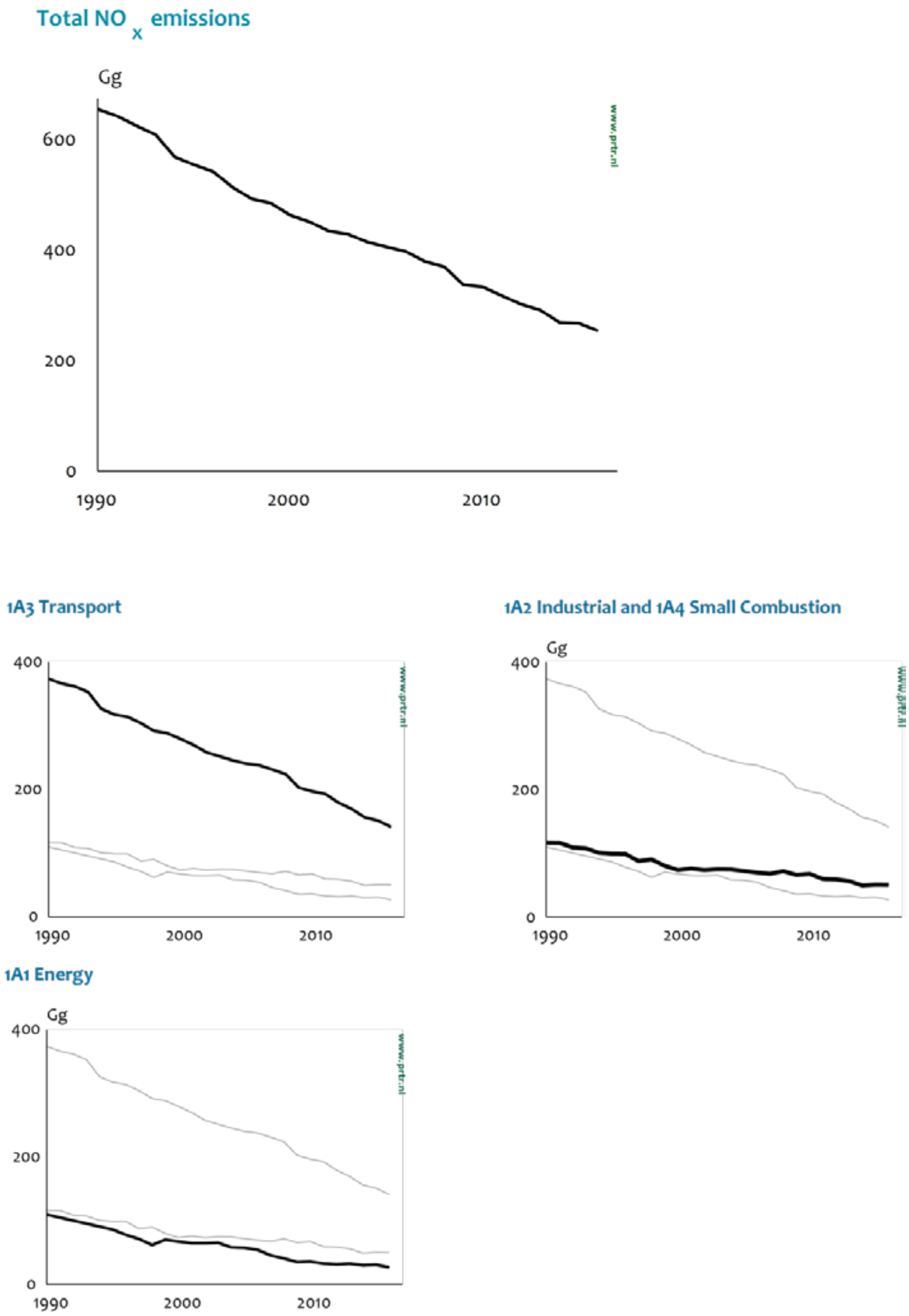

Figure 2.2 NO_x, emission trends 1990-2016

2.4 Trends in ammonia (NH_3)

Most of the NH_3 emissions (at present, 86%) come from agricultural sources. From 1990 to 2013, the decreasing trend in NH_3 due to emission reductions from agriculture also showed up in the decreasing trend of the national total. From 2014 onwards, however, NH_3 emissions rose to a national total of just around 128 Gg, which is the maximum level set for this by the European Union for 2010 on. As a result of the abolishment of milk quotas in 2015, breeding and dairy cattle numbers increased. Despite higher implementation grades of low-emission housing, also in pigs and poultry, total NH_3 emissions have increased in recent years.

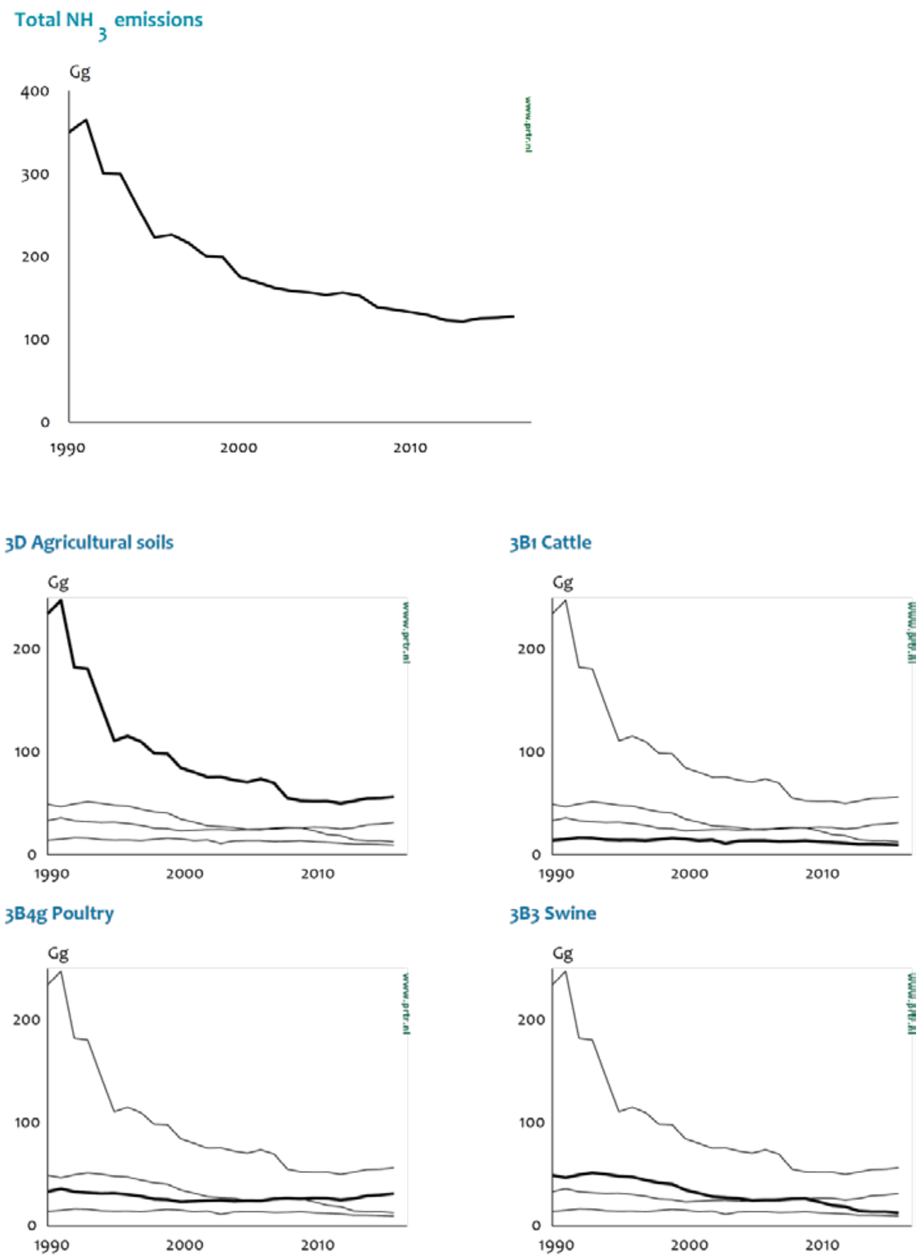

Figure 2.3 NH_3, emission trends 1990-2016

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

The Dutch NMVOC emissions decreased by 351 Gg in the 1990-2016 period, corresponding with 72% of the national total in 1990 (Figure 2.4). 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).

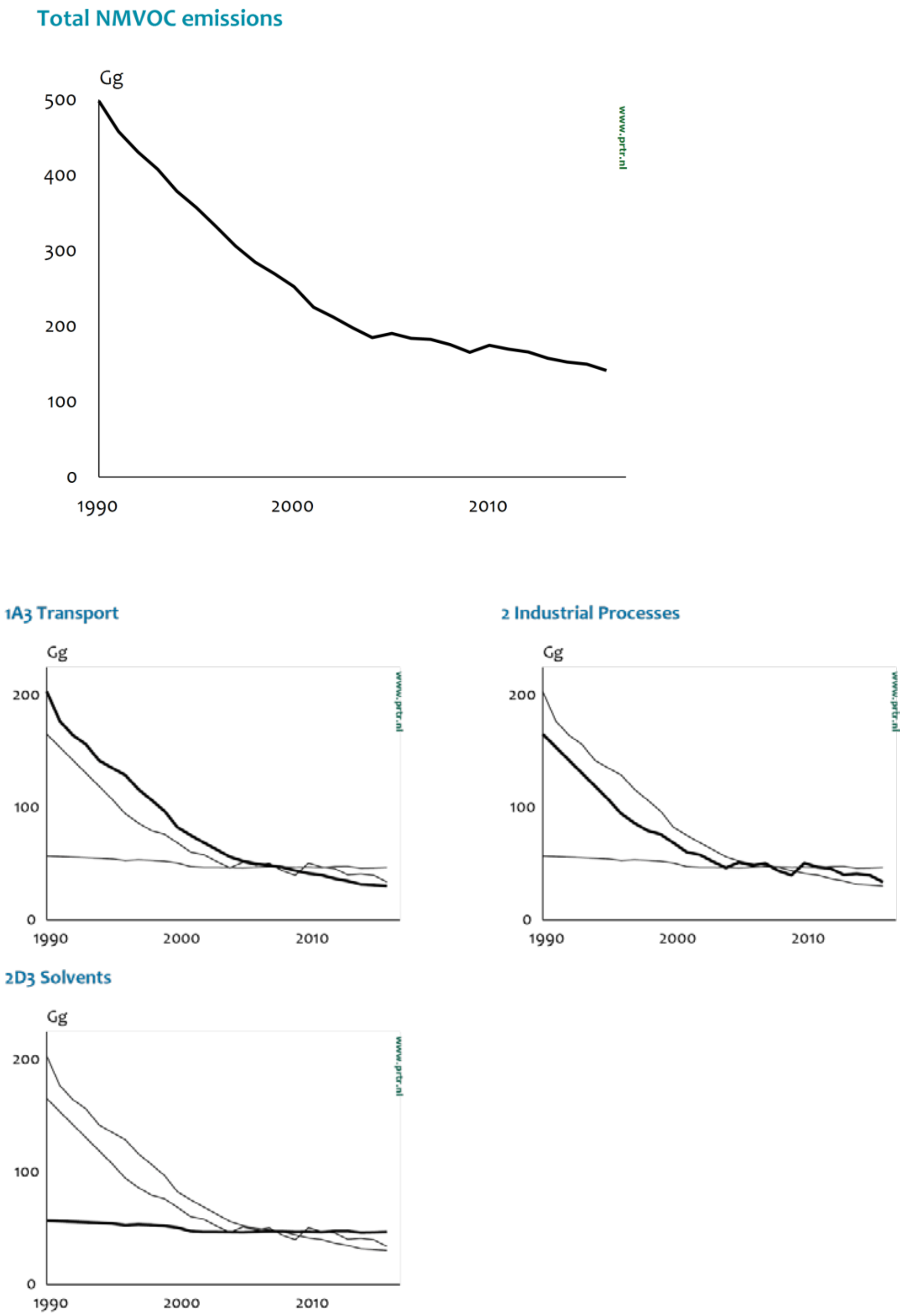

Figure 2.4 NMVOC, emission trends 1990-2016

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 39 Gg in the 1990-2016 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), which was due to cleaner fuels in refineries and the side effect of emission abatement for SO_x and NO_x, and the transport sector.

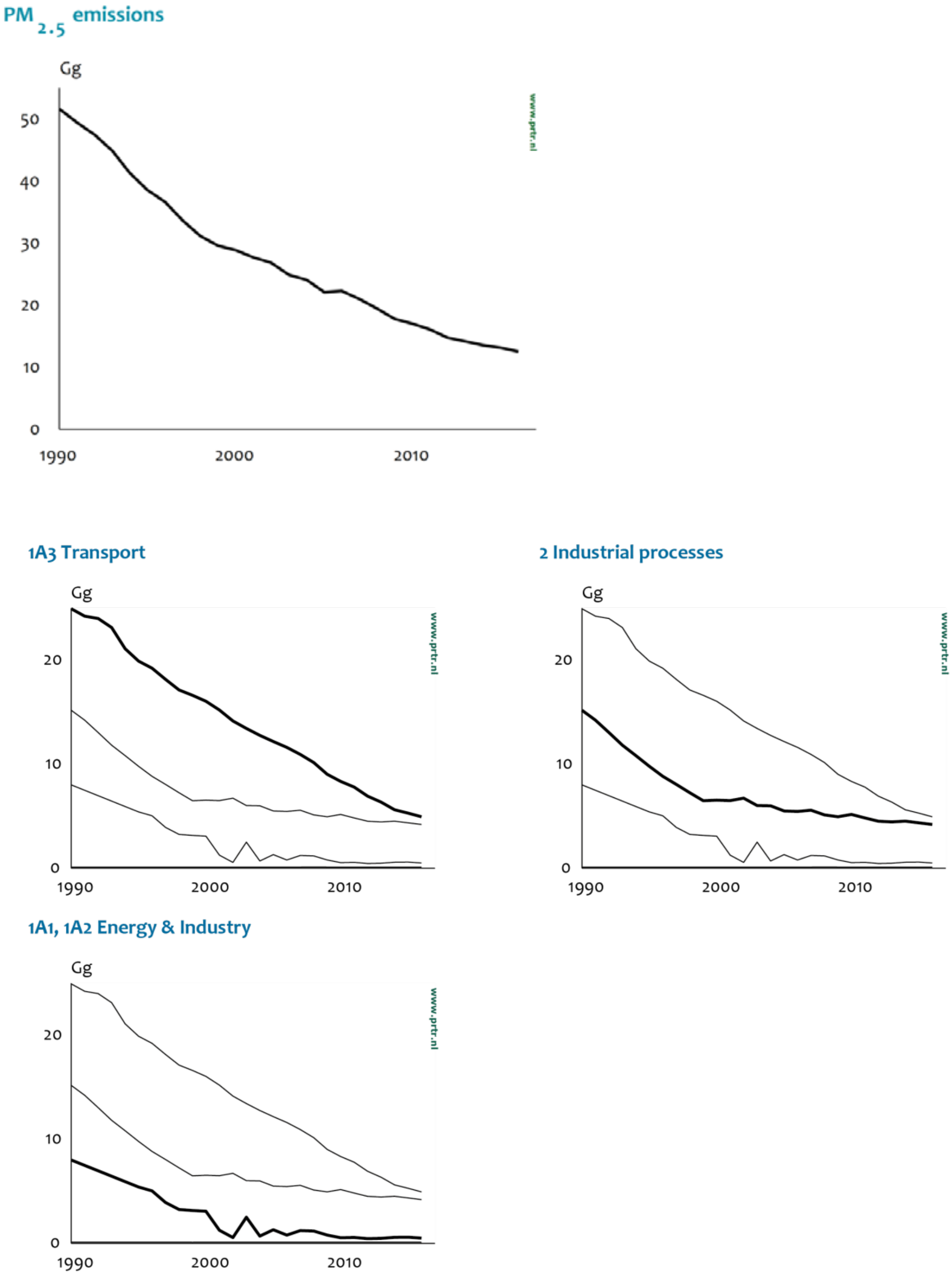

Figure 2.5 $PM_{2.5}$, emission trends 1990-2015

2.7 Trends in PM_{10}

Dutch PM_{10} emissions decreased by 49 Gg in the 1990-2016 period, corresponding to 65% 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.

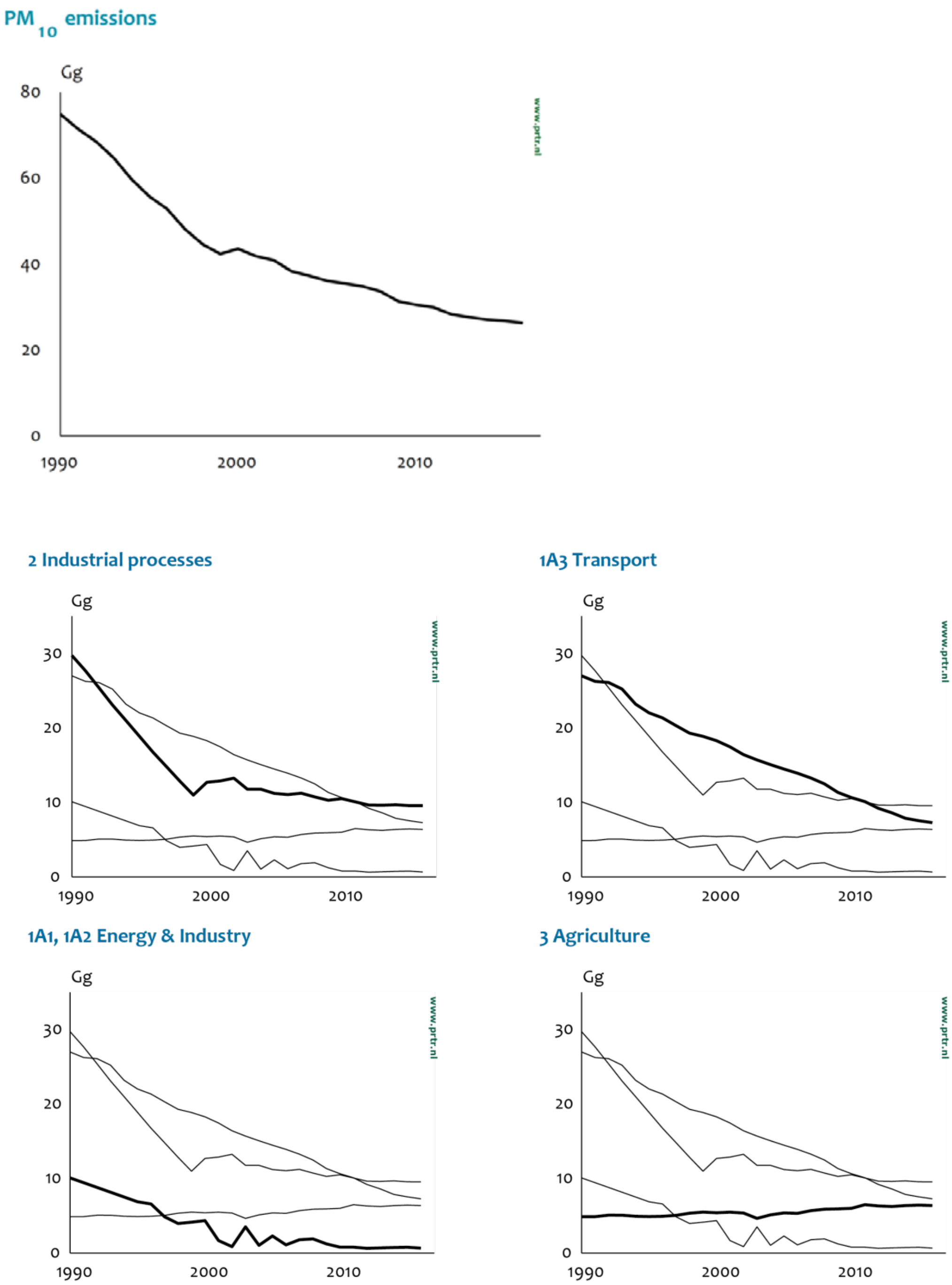

Figure 2.6 PM_{10}, emission trends 1990-2016

PM_{10} emissions from animal husbandry in agriculture did not change significantly; neither did the emissions from consumers (1A4bi).

2.8 Trends in Pb

Lead (Pb) emissions in the Netherlands decreased by 323 Mg in the 1990-2016 period, corresponding to 97% of the national total in 1990 (Figure 2.7). This decrease is attributable to the transport sector, where, due to the removal of Pb from gasoline, the Pb emissions collapsed. The remaining sources are industrial process emissions, particularly from the iron and steel industry.

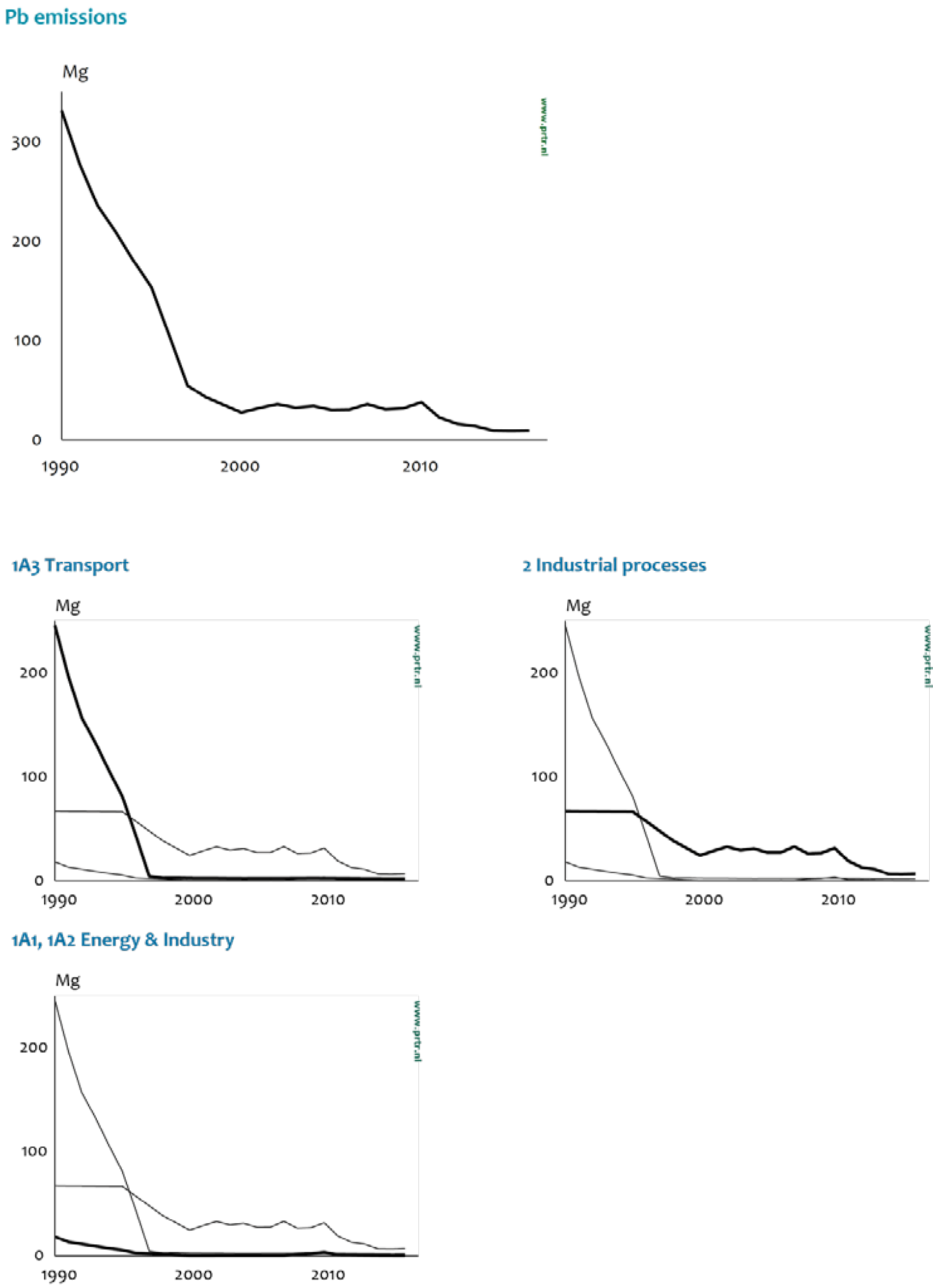

Figure 2.7 Pb, emission trends 1990-2016

3 Energy

3.1 Overview of the sector

Emissions from this sector include all energy-related emissions from stationary combustion. Furthermore, it includes fugitive emissions from the energy sector.

Part of the emissions from stationary combustion for electricity production and industry (NFR categories 1A1 and 1A2) are reported based on environmental reports made by large industrial companies. For SO_x and NH_3, 98% of the emissions were reported based on environmental reports, while for other pollutants this was 65% (NMVOC), 73% (NO_x) and 47% (PM_{10}) in 2016. 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 Annual Environmental Reports (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 with energy statistics and default emission factors.

As it is for most developed countries, the energy system in the Netherlands is largely driven by the combustion of fossil fuels. In 2016, natural gas supplied about 38% of the total primary fuels used in the Netherlands, followed by liquid fuels (46%) and solid fossil fuels (16%). The contribution of non-fossil fuels, including renewables and waste streams, is rather limited (5%). 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 2016. Using the button “Change selection” on the website, it is possible to select the data for another year.

Energy statistics of 2016:
https://opendata.cbs.nl

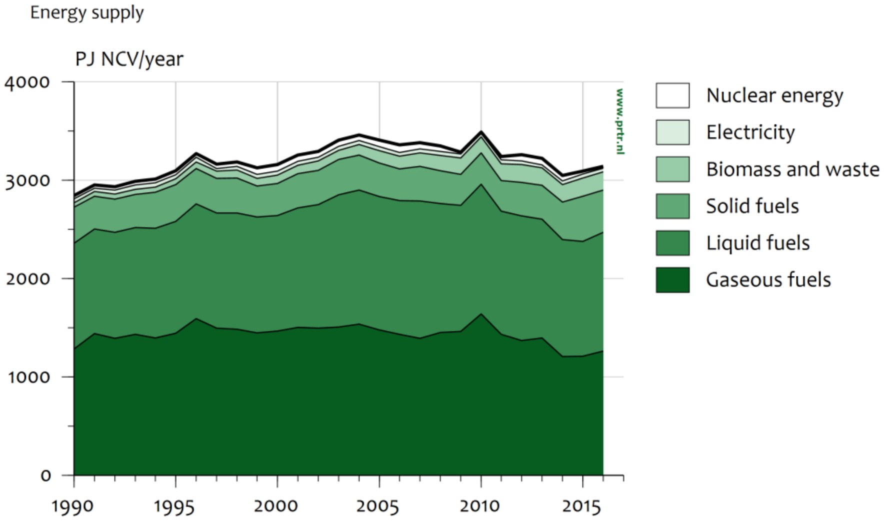

Figure 3.1 Energy supply in the Netherlands (only the total fuel used is shown)

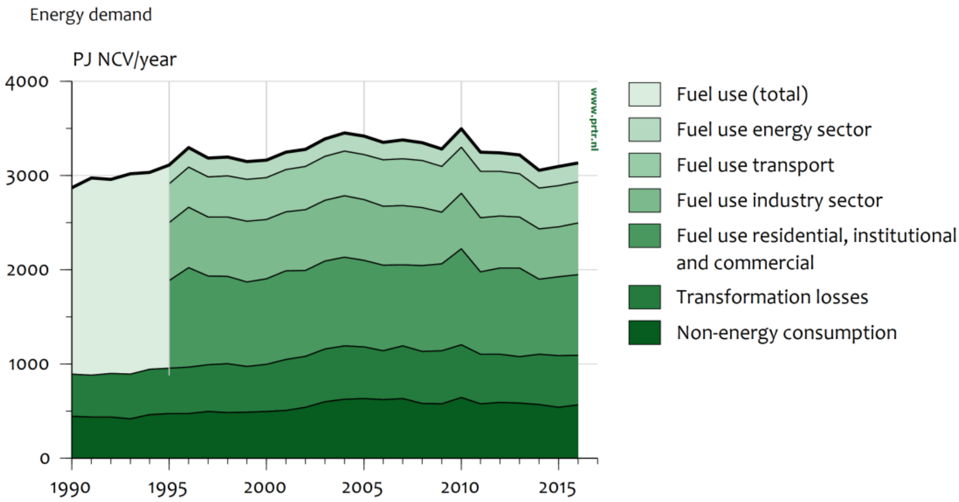

Figure 3.2 Energy demand in the Netherlands (only the total fuel used is shown)

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, with 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 also Peek et al. 2018. All waste incineration plants recover energy and are included in NFR category 1A1a. Relative to 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 mentioned in Table 3.1.

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

Category / Sub-category	Pollutant	Contribution to national total of 2016 (%)
1A1a Public electricity and heat production	SO_x	25
	NO_x	7.1
	$PM_{2.5}$	1.8
	Hg	36

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 2016, while fuel consumption increased over the same period.
The NO_x and SO_x emissions decreased by 78% and 86%, respectively. Other pollutant emissions decreased by 35% to 88%. The decrease in emissions was partly caused by a shift in energy use. Furthermore, the decrease in emissions was due to technological improvements. The only pollutant for which the emissions have increased is NH_3, due to an increase in activity rate. For Se, the increase by a factor of 28 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	**83**	**0.7**	**48**	**0**	**1.9**	**2.2**	**2.3**	**0**	**8.2**
1995	62	1.1	17	0.039	0.4	0.5	0.5	0	7.4
2000	51	2.2	15	0.038	0.3	0.3	0.3	0	15.8
2005	43	0.6	10	0.252	0.4	0.5	0.5	0	8.2
2010	26	0.3	7	0.074	0.2	0.3	0.4	0	5.0
2015	20	0.5	9	0.090	0.3	0.4	0.5	0	4.2
2016	**18**	**0.5**	**7**	**0.099**	**0.2**	**0.3**	**0.4**	**0**	**4.1**
1990-2016 period[1)]	-65	-0.2	-42	0.099	-1.6	-1.9	-1.9	0	-4.1
1990-2016 period[2)]	-78%	-35%	-86%		-88%	-88%	-83%		-50%

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**	**0.95**	**1.9**	**568**	**0.17**	**0.50**	**0.62**	**2.05**	**2.49**	**0.02**	**40.7**
1995	2	0.16	0.4	6.0	0.05	0.20	0.37	0.44	1.41	0.05	3.3
2000	0.2	0.08	0.4	0.1	0.00	0.08	0.19	0.17	0.08	0.45	0.3
2005	0.2	0.09	0.4	0.7	0.01	0.16	0.33	0.28	1.91	1.68	0.5
2010	0.3	0.18	0.2	1.2	0.01	0.11	0.14	0.15	0.16	1.33	3.9
2015	0.2	0.03	0.2	1.0	0.03	0.06	0.16	0.18	0.17	0.91	4.1
2016	**0.1**	**0.04**	**0.2**	**1.1**	**0.02**	**0.04**	**0.20**	**0.21**	**0.12**	**0.57**	**4.3**
1990-2016 period[1)]	-16	-0.9	-1.7	-567	-0.16	-0.46	-0.4	-1.8	-2.4	0.6	-36.4
1990-2016 period[2)]	-99%	-96%	-89%	-100%	-90%	-92%	-68%	-90%	-95%	2803%	-89%

[1)] Absolute difference
[2)] Relative difference to 1990 in %

3.2.4 *Activity data and (implied) emission factors*

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

3.2.5 *Methodological issues*

Emissions are based on data in Annual Environmental Reports (AERs) from individual facilities (Tier3 methodology). The emissions and fuel consumption data in the AERs are systematically examined for inaccuracies by checking the resulting implied emission factors (IEFs). If environmental reports provide data of high enough quality, the information is used for calculating an 'implied emission factor' for a cluster of reporting companies (aggregated by NACE code). These emission factors are fuel- and sector-dependent and are used to calculate the emissions from companies that are not individually assessed.

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

where:
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 implied emission factor. If the data from the individual companies are insufficient to calculate an implied emission factor, then a default emission factor is used (see Table 3.3).

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

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

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

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

Substance name	Natural gas	Biogas	Cokes	Diesel	LPG	Petroleum	Coal	Fuel oil	Wood
Hydrocarbons	12	9	91	15	2	10	3	7	120
Sulphur dioxide		2	370	87		46	300	450	10
Nitrogen oxides as NO_2	37	27	100	60	27	50	45	64	120
Carbon monoxide	15	20	12,437	30	10	10	50	10	70
PM_{10}	0.15	2	6	4.5	2	1.8	60	22.5	1
Total Suspended Particles (TSP)	0.15	2	10	5.0	2	2.0	100	25.0	1

3.2.6 *Uncertainties and time series consistency*

Uncertainties are explained in Section 1.7.

3.2.7 *Source-specific QA/QC and verification*

The emissions and fuel consumption data in the AERs are systematically examined for inaccuracies by checking the resulting implied emission factors. 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*

Source-specific recalculations:

- Revision of activity data on biogas.

3.2.9 *Source-specific planned improvements*

There are no source-specific planned improvements.

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

3.3.1 *Source category description*

This source category consists of 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, machinery.

3.3.2 *Key sources*

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

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

Category / Sub-category	Pollutant	Contribution to total of 2016 (%)
1A1b Petroleum refining	SO_x	40
1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	SO_x NO_x CO	10.1 2.3 12
1A2c Stationary combustion in manufacturing industries and construction: Chemicals	NO_x	3.8
1A2gviii Stationary combustion in manufacturing industries and construction: Other	SO_x Hg	9.2 5.4

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 emission of 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 the emissions of SO_x and $PM_{10}$is mainly due to a shift in fuel use by refineries, i.e. from oil to natural gas.

Table 3.5 Overview of trends in emissions

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**101**	**6.3**	**110**	**0.57**	**6.1**	**7.9**	**8.3**	**0.37**	**266**
1995	78	6.9	89	0.32	5.0	6.4	6.6	0.36	215
2000	49	2.1	46	0.05	2.8	4.0	4.7	0.29	160
2005	49	2.6	46	0.06	0.9	1.8	2.0	0.11	153
2010	40	3.9	24	0.43	0.35	0.5	0.8	0.02	124
2015	35	2.9	20	0.40	0.30	0.4	0.6	0.01	96
2016	**33**	**2.5**	**19**	**0.43**	**0.27**	**0.4**	**0.5**	**0.01**	**92**
1990-2016 period[1)]	-67	-3.8	-91	-0.14	-5.9	-7.5	-7.8	-0.36	-174
1990-2016 period[2)]	-67%	-61%	-83%	-25%	-96%	-95%	-93%	-98%	-65%

	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	**1.9**	**0.14**	**0.18**	**0.01**	**0.99**	**0.17**	**2.5**	**1.4**	**64**	**0.04**	**2.9**
1995	3.9	0.17	0.08	1.02	0.38	0.15	3.1	2.3	79	0.05	3.5
2000	0.04	0.01	0.11	0.35	0.004	0	0.51	0.15	17	0.002	0.84
2005	0.01	0.003	0.004	0.94	0.10	0.78	0.08	0.09	7	0.08	0.51
2010	3.1	1.28	0.02	5.79	0.13	0.013	0.14	1.13	0.02	0.12	9.8
2015	0.09	0.001	0.05	0.19	0.10	0.001	0.01	0.00	0.11	0.0001	1.2
2016	**0.04**	**0.001**	**0.04**	**0.19**	**0.10**	**0.001**	**0.01**	**0.00**	**0.11**	**0.0001**	**0.6**
1990-2016 period[1)]	-1.84	-0.14	-0.14	0.18	-0.89	-0.17	-2.47	-1.39	-64	-0.04	-2.29
1990-2016 period[2)]	-98%	-99%	-77%	2,118%	-90%	-100%	-100%	-100%	-100%	-100%	-78%

[1)] Absolute difference
[2)] Relative difference to 1990 in %

3.3.4 *Activity data and (implied) emission factors*

Petroleum refining (1A1b)

All emission data have been based on Annual Environmental Reports (AERs).

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

Iron and steel (1A2a)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 1% of the SO_x emissions were collectively estimated (in 2016), thus 99% were based on the AERs.

Non-ferrous metals (1A2b)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 21% of the NMVOC emissions, 9% of the NO_x emissions and 29% of the SO_x emissions were collectively estimated (in 2016).

Chemicals (1A2c)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 4% of the NO_x emissions, 3% of the SO_x emissions and 3% of the NMVOC emissions and 1% of the PM_{10} emissions were collectively estimated (in 2016).

Pulp, paper and print (1A2d)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 31% of NMVOC emissions and 11% of NO_x emissions were collectively estimated (in 2016).

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

Non-metallic minerals (1A2f)
Emission data have been based on AERs and collectively estimated industrial sources. Emissions from non-metallic minerals were allocated to 1A2gviii.

Other (1A2gviii)
This sector includes all combustion emissions from the industrial sectors that do not belong to the categories 1A2a to 1A2e. Emission data have been 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 implied emission factors from the environmental reports or default emission factors (see Table 3.6).

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 implied emission factors. If environmental reports provide data of high enough quality, the information is used to calculate an ‘implied emission factor’ for a cluster of reporting companies (aggregated by NACE code). These emission factors are fuel- and sector-dependent and are used to calculate the emissions from companies that are not individually assessed.

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

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

Next, combustion emissions from the companies that are not individually assessed in this NACE category are calculated from the energy use according to the Energy Statistics (from Statistics Netherlands), multiplied by the implied emission factor. If the data from the individual companies are insufficient to calculate an implied emission factor, then a default emission factor is used (see Table 3.6).

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

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

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

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

Substance name	Natural gas	Biogas	Cokes	Diesel	LPG	Petro-leum	Coal	Fuel oil	Wood
Hydrocarbons	12	9	91	15	2	10	3	7	120
Sulphur dioxide		2	370	87		46	300	450	10
Nitrogen oxides as NO_2	37	27	100	60	27	50	45	64	120
Carbon monoxide	15	20	12437	30	10	10	50	10	70
PM_{10}	0.15	2	6	4.5	2	1.8	60	22.5	1
Total Suspended Particles (TSP)	0.15	2	10	5.0	2	2.0	100	25.0	1

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

3.3.7 *Source-specific QA/QC and verification*
The emissions and fuel consumption data in the AERs were systematically examined for inaccuracies by checking the resulting implied emission factors. 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

Source-specific recalculations:

- Revision of activity data on biogas.

3.3.9 Source-specific planned improvements

There are no source-specific planned improvements.

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, such as banks, schools and hospitals, trade, retail and communication. It also includes the production of drinking water and miscellaneous combustion emissions from waste handling activities and from waste-water treatment plants;
- 1A4bi Residential: Stationary. This sector refers to domestic fuel consumption for space heating, water heating and cooking. About three-quarters of the sector’s consumption of natural gas is used for space heating;
- 1A4ci Agriculture/Forestry/Fisheries: Stationary. This sector comprises stationary combustion emissions from agriculture, horticulture, greenhouse horticulture, cattle breeding and forestry;
- 1A5a Other stationary. This sector includes stationary combustion of waste gas from dumping sites.

3.4.2 Key sources

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

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

Category / Sub-category	Pollutant	Contribution to total of 2016 (%)
1A4ai Commercial/institutional, Stationary	NO_x	2.8
1A4bi Residential, stationary	NO_x	3.1
	NMVOC	8.1
	CO	14
	PM_{10}	7.9
	$PM_{2.5}$	16
	BC	20
	Cd	9.3
	Hg	6.0
	Dioxine	30
	PAH	87
1A4ci Agriculture/forestry/fishing, Stationary	NO_x	4.2

3.4.3 Overview of shares and trends in emissions

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

Table 3.8 Overview of trends in emissions

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	**43**	**16.3**	**3.2**	**0**	**2.7**	**2.8**	**5.5**	**0.9**	**81**
1995	46	17.0	1.4	0	2.5	2.7	5.2	0.9	86
2000	40	15.6	0.9	0	2.3	2.4	4.8	0.9	83
2005	37	15.2	0.7	0	2.3	2.4	4.7	0.8	85
2010	38	15.3	0.6	0	2.2	2.3	4.5	0.7	85
2015	26	13.9	0.6	0	2.1	2.1	4.4	0.7	83
2016	**26**	**14.0**	**0.6**	**0**	**2.1**	**2.2**	**4.5**	**0.7**	**84**
1990-2016 period[1)]	-17	-2.3	-2.6	0	-0.6	-0.6	-1.0	-0.3	3
1990-2016 period [2)]	-40%	-14%	-81%		-23%	-23%	-19%	-28%	4%

Year	Priority Heavy Metals			POPs		Other Heavy Metals					
	Pb	Cd	Hg	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	**0.78**	**0.07**	**0.12**	**108**	**3.8**	**0.05**	**3.5**	**0.72**	**2.7**	**0.0036**	**2**
1995	0.12	0.05	0.04	8.1	4.0	0.02	0.05	0.34	0.5	0.0018	0.77
2000	0.08	0.05	0.03	7.3	3.9	0.01	0.00	0.32	0.01	0.0000	0.70
2005	0.08	0.05	0.03	7.0	4.1	0.00	0.01	0.35	0.2	0.0001	0.76
2010	0.09	0.05	0.03	6.8	4.1	0.01	0.00	0.38	0.02	0.0000	0.82
2015	0.09	0.06	0.04	7.0	4.2	0.00	0.00	0.41	0.01	0.0000	0.86
2016	**0.09**	**0.06**	**0.04**	**7.1**	**4.3**	**0.00**	**0.00**	**0.42**	**0.01**	**0.0000**	**0.89**
1990-2016 period[1)]	-0.68	-0.01	-0.08	-101	0.5	-0.04	-3.5	-0.31	-2.7	-0.0036	-1.1
1990-2016 period[2)]	-88%	-11%	-69%	-93%	13%	-94%	-100%	-42%	-100%	-100%	-55%

[1)] Absolute difference
[2)] Relative difference to 1990 in %

3.4.4 Activity data and (implied) emission factors

Commercial/institutional (1A4ai)

Combustion emissions from the commercial and institutional sectors have been 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	LPG	Petroleum	Coal	Fuel oil	Wood
Hydrocarbons	12	8	15	2	10	3	7	40
Sulphur dioxide		2	87		46	300	450	10
Nitrogen oxides as NO_2	1)	80	60	40	50	45	64	120
Carbon monoxide	15	20	30	10	10	50	10	70
PM_{10}	0.15	2	4.5	2	1.8	60	22.5	1
Total Suspended Particles (TSP)	0.15	2	5.0	2	2.0	100	25.0	1

1) see table on NO_x emission factors in Van Soest-Vercammen *et al.* (2002) for the services sector and in Kok (2014) for the agriculture sector

Residential (1A4bi)

Combustion emissions from central heating, hot water and cooking have been 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 to the amount of natural gas used. Combustion emissions from (wood) stoves and fireplaces have been calculated by multiplying the fuel consumption per apparatus type and fuel type (Statistics Netherlands) by emission factors per household (Jansen & Dröge, 2011).

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

Substance name	Natural gas	Diesel	LPG	Petroleum	Coal
Hydrocarbons	6.3	15	2	10	60
Sulphur dioxide	0.22	87	0.22	4.6	420
Nitrogen oxides as NO_2	1)	50	40	50	75
Carbon monoxide	15.8	60	10	10	1,500
PM_{10} 2,3)	0.3	4.5	2	1.8	120
Total Suspended Particles (TSP) 2,3)	0.3	5.0	2	2.0	200

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

2) See table on dust emissions from Visschedijk *et al.* (2007).

3) See table on dust emissions from Jansen *et. al.* (2016).

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

Table 3.11 Emission factors for stationary combustion emissions from the Agriculture/Forestry/Fishing sectors (g/GJ)

Substance name	Natural gas	Diesel	LPG	Petroleum	Coal	Fuel oil
Hydrocarbons	30	10	2	10	35	10
Sulphur dioxide	0.22	87	0.22	4.6	460	450
Nitrogen oxides as NO_2	1)	50	40	50	300	125
Carbon monoxide	10	10	10	10	100	10
PM_{10} 2,3)	0.15	4.5	2	1.8	120	45
Total Suspended Particles (TSP) 2,)	0.15	5.0	2	2.0	200	50

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

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

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

3.4.7 *Source-specific QA/QC and verification*
General QA/QC is explained in Section 1.3.

3.4.8 *Source-specific recalculations*
Source-specific recalculations:
- Revision of activity data on burning of natural gas by households (1990 – 1994);
- Revision of activity data on the burning of fuel oil by commerce, services and government;
- Revision of activity data on the burning of natural gas by commerce, services and government in 2012 and 2015;
- Improvement on the use of natural gas and coal by the construction sector for 2015;
- Improvement on the emission of methane from the burning of natural gas by households in 1998, 1999, 2007, 2008 and 2014.

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

3.5 Fugitive emissions (1B)

3.5.1 *Source category description*

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

- 1B2aiv Fugitive emissions oil: refining / storage
- 1B2av Fugitive emissions oil: products distribution
- 1B2b Fugitive emissions from natural gas
- 1B2d Other fugitive emissions from energy production

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

3.5.2 *Key sources*

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

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

Category / Sub-category	Pollutant	Contribution to total of 2016 (%)
1B2aiv Refining	NMVOC	2.6
1B2av Distribution of oil products	NMVOC	2.7
1B2b Fugitive emissions from natural gas	NMVOC	3.7

3.5.3 *Overview of shares and trends in emissions*

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

Table 3.13 Overview of trends in emissions.

	NMVOC	PAH
Year	Gg	Mg
1990	**47**	**0.006**
1995	34	0.025
2000	29	0
2005	21	0.039
2010	15	0
2015	14	0
2016	**13**	**0**
1990-2016 period[1)]	-35	-0.006
1990-2016 period[2)]	-73%	-100%

[1)] Absolute difference
[2)] Relative difference to 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 the Netherlands Energy Statistics.

3.5.5 *Methodological issues*

The fugitive NMVOC emissions from category 1B2av comprise process emissions from oil refining and storage. The emissions are derived from the companies' e-AER's (electronic Annual Environmental Report) (Tier 3 methodology).
The fugitive NMVOC emissions from category 1B2aiv comprise dissipation losses from gasoline service stations, leakage losses during vehicle and airplane refuelling and refinery processes. Emissions were calculated based on annual fuel consumption (Tier 2 methodology).
The 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).
The NMVOC emissions from gas transmission were derived from data in the annual reports of the gas transmission company Gasunie (Tier 3 methodology). The NMVOC emissions from gas distribution were calculated on the basis of a NMVOC profile with the CH4 emission from annual reports of the distribution sector as input (Tier 2 methodology).
Detailed information on activity data and emissions can be found in the Methodology Report on the Calculation of Emissions to Air from the Sectors Energy, Industry and Waste (Peek, 2018).

3.5.6 *Uncertainties and time series consistency*

Uncertainties are explained in Section 1.6.3.

3.5.7 *Source-specific QA/QC and verification*

General QA/QC is explained in Section 1.6.

3.5.8 *Source-specific recalculations*

No source-specific recalculations have been made for this sector.
In previous submissions, emissions from the extraction of oil and gas, as reported by the operators in their e-AER (electronic Annual Environmental Report), were allocated within category 1B2ai Fugitive emissions oil. As the extraction in the Netherlands is mainly gas extraction these emissions are reallocated to 1B2b. Also, the emissions from the distribution of oil products were allocated within category 1B2aiv Fugitive emissions oil: refining/storage but are reallocated to category 1B2av Distribution of oil products now.

3.5.9 *Source-specific planned improvements*

No source-specific planned improvements.

4 Transport

4.1 Overview of the sector

The transport sector is a major contributor to the emissions of NO_x, NMVOC, CO, TSP, PM_{10} and $PM_{2.5}$. Emissions of most substances have decreased throughout the time series, mainly due to the introduction of increasingly stringent European emission standards for new road vehicles. The source category *Transport* (1A3) comprises the following subcategories: *Civil aviation* (1A3a), *Road Transport* (1A3b), *Railways* (1A3c) and *Waterborne navigation* (1A3d). Table 4.1 provides an overview of the source categories within the transport sector and the methodologies used for calculating emissions within the sector. For all four source categories, national activity data and (mostly) country-specific emission factors were used. Emissions from civil aviation and waterborne navigation were calculated based on fuel used, whereas emissions from railways and road transport were calculated using fuel sales data.
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. The emissions from non-road mobile machinery were reported in several different source categories within the inventory (i.e. 1A2gvii, 1A4aii, 1A4bii, 1A4cii), as shown in Table 4.1. Emissions from non-road mobile machinery were calculated using a Tier 3 method based on fuel used, using national activity data and a combination of country-specific and default emission factors. Emissions from recreational craft and vehicles operating at airports were reported under 1A5b ‘Other, mobile’ and were calculated using a Tier 3 and Tier 2 methodology respectively. Emissions from fisheries were reported under 1A4ciii ‘National fishing’ and were calculated using a Tier 3 method.

This chapter describes shares and trends in emissions for the different source categories within the transport sector. The methodologies used for emission calculations are also described in general. A detailed description of these methodologies is provided in Klein *et al*. (2018), which also includes tables with detailed emission and activity data, and the emission factors used in the emission calculations.

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 used
1A5b	Other, Mobile (including military, land-based and recreational boats)	Tier 3	NS	CS	Fuel used

NS = National Statistics
CS = Country-Specific

4.1.1 *Key sources*

The source categories within the transport sector are the key sources for different pollutants, as is shown in Table 4.2. The percentages in Table 4.2 relate to the 2016 level and the 1990-2016 trend (in italics) assessment. Some source categories are the key sources for both the trend and the 2016 level assessment. In those cases, Table 4.2 shows which of the two these source categories contribute the most. 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 italics are from the trend contribution calculation

NFR code	Source category description	SO_x	NO_x	NMVOC	CO	PM_{10}	$PM_{2.5}$	BC	Pb
1A3ai(i)	International aviation LTO (civil)		*2.1%*						8.9%
1A3aii(i)	Domestic aviation LTO (civil)								
1A3bi	Passenger cars	*5.6%*	*22.7%*	*15.9%*	39.7%	*8.0%*	*9.9%*	*15.9%*	*45.0%*
1A3bii	Light-duty vehicles	*2.6%*	7.6%		*7.8%*	3.6%	7.7%	22.3%	
1A3biii	Heavy-duty vehicles and buses	*9.2%*	13.1%	*3.4%*		*9.9%*	*13.6%*	*29.6%*	
1A3biv	Mopeds and motorcycles			5.8%	*13.6%*				

NFR code	Source category description	SO_x	NO_x	NMVOC	CO	PM_{10}	$PM_{2.5}$	BC	Pb
1A3bv	Gasoline evaporation			*8.3%*					
1A3bvi	Automobile tyre and brake wear					5.5%	*2.2%*		
1A3bvii	Automobile road abrasion					4.5%			
1A3c	Railways								
1A3di(ii)	International inland waterways		6.7%				3.6%	7.8%	
1A3dii	National navigation (shipping)		*5.4%*				*2.8%*	*7.1%*	
1A2gvii	Mobile combustion in manufacturing industries and construction		3.6%				4.4%	8.7%	
1A4aii	Commercial/Instit ution-al: Mobile								
1A4bii	Residential: Household and gardening (mobile)				*8.0%*				
1A4cii	Agriculture/Forestr y/ Fishing: Off-road vehicles and other machinery		3.2%				3.4%	6.6%	
1A4ciii	Agriculture/Forestr y/ Fishing: National fishing	*5.1%*	3.3%						
1A5b	Other, Mobile (including military, land based and recreational boats)								

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, air 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 the 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 were reported under source category *Fugitive emissions oil: Refining/storage* (1B2aiv). Cruise emissions from domestic and international aviation (i.e. emissions occurring above 3,000 feet) are not part of the national emission totals and were not estimated. Due to a lack of data, the split of LTO-related fuel consumption and resulting emissions between domestic and international aviation could not be made. However, due to the small size of the country, there is hardly any domestic aviation in the Netherlands, with the exception of general aviation. Therefore, all fuel consumption and resulting emissions in civil aviation were reported under *International aviation* (1A3i) in the NFR.

4.2.2 *Key sources*

Civil aviation is a key source for lead (2016 level and 1990-2016 trend) and for NO_x (1990-2016 trend) in the emission 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 implied emission factors for Amsterdam Airport Schiphol and for regional airports are provided in Klein et al. (2018). Fuel consumption (LTO) at Amsterdam Airport Schiphol more than doubled between 1990 and 2008. After a 9% decrease in 2009 due to the economic crisis, fuel consumption increased again in 2010 and 2011 and was approximately at pre-crisis levels in 2011. In 2016, total fuel consumption in civil aviation at Schiphol Airport increased by 5% compared with 2015. This increase corresponded with the increase in the number of flights (+6%) and the number of air passengers (+9%) at Amsterdam Airport Schiphol in 2016, as reported by Statistics Netherlands.

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

Table 4.3 Trends in emissions from 1A3a Civil aviation

	Main Pollutants			Particulate Matter				Other	Priority Heavy Metals
	NO_x	NMVOC	SO_x	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg
1990	**1.2**	**0.4**	**0.1**	**0.02**	**0.03**	**0.03**	**0.02**	**3.51**	**1.8**
1995	1.8	0.3	0.1	0.03	0.03	0.03	0.02	3.97	1.9
2000	2.4	0.3	0.2	0.03	0.04	0.04	0.02	3.73	1.5
2005	2.7	0.3	0.2	0.03	0.04	0.04	0.02	3.52	1.1
2010	2.8	0.3	0.2	0.03	0.04	0.04	0.02	3.67	1.3
2015	3.2	0.3	0.2	0.03	0.04	0.04	0.02	3.36	0.8
2016	**3.3**	**0.3**	**0.2**	**0.03**	**0.04**	**0.04**	**0.02**	**3.45**	**0.8**
1990-2016 period[1)]	2.1	-0.1	0.1	0.00	0.01	0.01	0.00	-0.06	-1.0
1990-2016 period[2)]	169%	-19%	138%	11%	45%	45%	3%	-2%	-56%

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

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 2016, following the trend in fuel consumption. PM_{10} emissions from civil aviation increased by 45% between 1990 and 2016. This increase was mainly due to the increase in tyre and brake wear emissions. PM_{10} emissions due to tyre and brake wear increased by 251% between 1990 and 2016, in line with the increase in the maximum permissible take-off weight (MTOW) of the aeroplanes (which is used to estimate wear emissions)[1]. Even though fuel consumption in civil aviation increased significantly, PM_{10} (and $PM_{2.5}$ and BC) exhaust emissions increased by 3% between 1990 and 2016. Fleet average PM_{10} exhaust emission factors (per unit of fuel) have decreased by 56% since 1990. As a result, the share of wear emissions in total emissions of PM_{10} in civil aviation increased from 17% in 1990 to 41% in 2016.
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 (11% in 2016) 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 by only 11% throughout the time series, whereas PM_{10} emissions increased by 45%.

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 increased to 8.9% in 2016, thereby being a key source in the 2016 level

[1] It should be noted that the activity data provided in

assessment. The share that civil aviation contributed to in the total emissions of NO_x (1.3%), SO_x (0.9%), BC (0.6%) and other substances (<1%) is small.

4.2.4 *Activity data and (implied) emission factors*

The exhaust emissions of CO, NMVOC, NO_x, PM, SO_x and heavy metals from civil aviation in the Netherlands were calculated using a flight-based Tier 3 method. Specific data was 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 have been 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), using four flight modes that correspond with specific engine settings (power settings) of the aircraft. These power settings result in specific fuel consumption per unit of time. For each engine type, specific emission factors were used to calculate the emissions. The fuel consumption per unit of time, along with the accompanying fuel-related emission factors, were determined as part of the certification of aircraft engines with a thrust greater than 30 kN. The emission factors used in CLEO were taken from the ICAO Engine Emissions DataBank. The CLEO model also contains a number of emission factors for smaller (piston) engines. The sources for these emission factors are a report issued by the Swiss Federal Office for Civil Aviation (Rindlisbacher, 2007) and the EPA's AP42 publication (EPA, 1985). Emission factors for aircraft with turboprop engines are also included in the model. These factors were gathered by the Swedish FFA in the so-called Hurdy-Gurdy-database (Hasselrot, 2001). Emission factors for commercial helicopters (by flight phase) were derived from Rindlisbacher (2009).

Per group of aircraft engines, the PM emission factors were calculated from 'Smoke Numbers' according to the method described in Kugele *et al*. (2005). Under this methodology, only the soot-fraction of PM is calculated. Based on results of Agrawal *et al.* (2008), it has been estimated that the soot-fraction (assumed to be equal to the EC-fraction) of PM is only half of total PM-emissions. Therefore to calculate the emission factors of PM, the results obtained by the formula of Kugele *et al*. 2005 were multiplied by a factor of two. The $PM_{2.5}/PM_{10}$ ratio for engine exhaust emissions was assumed to be 1. The PM emissions due to tyre and brake wear were calculated from the maximum permissible take-off weight and the number of take-offs according to a methodology described by British Airways (Morris, 2007). The $PM_{2.5}/PM_{10}$ ratios for tyre (20%) and brake (15%) wear were assumed to be equal to those for road transport.

Emissions of lead and SO_x are directly related to the characteristics of the fuel type used. For jet fuel, emission factors of SO_x are based on the EMEP/EEA guidebook (EMEP/EEA, 2016). For aviation gasoline, the SO_x emission factors are based on the Dutch SO_x emission factors for petrol (see Klein *et al.,* 2018). The emission factor for lead is estimated based on the lead content of AvGas 100LL, which is the most commonly used fuel type for piston engines. Emissions of different VOC and PAH species were calculated using species profiles as reported in Klein *et al*. (2018).

The duration of the different flight modes (except the Idle mode), as reported in Klein et al. (2018), was derived from US EPA (1985). The average taxi/idle time was calculated based on measurements conducted by the airports in the Netherlands (Nollet, 1993) and the Dutch national air traffic service (RLD) for taxi times per individual runway combined with the usage percentages per runway. For heavier aircraft (JUMBO class), a separate category was introduced with somewhat longer times for the flight modes Take-off and Climb-out. This information was also obtained from the RLD.

The emissions from Auxiliary Power Units (APUs) were calculated based on the estimated quantity of fuel that is consumed during power generation. Information on the type of APU that is installed in specific aircraft types was taken from a report for the Global Atmosphere Division of DEFRA (Netcen, 2004), while emission factors and fuel use for these APU types were taken from this report and data from KLM (KLM, 2016). NMVOC emissions from the storage and transfer of jet kerosene were derived from the total volume of kerosene that was delivered annually. The implied emission factor was derived from an environmental report issued by Aircraft Fuel Supply (AFS), the company which handles all aircraft fuelling and fuel handling at Schiphol airport (AFS, 2013).

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

4.2.5 *Methodological issues*

The split of fuel consumption and resulting emissions between domestic and international aviation could not be made. The activity data that is used to derive civil aviation emissions (i.e. the number of LTO cycles per airport, as derived from Statistics Netherlands) does not include the origin or destination of the flights. As a result, making a split between domestic and international LTO emissions is not straightforward. Due to the small size of the country, there is hardly any domestic aviation in the Netherlands, with the exception of general aviation. Fuel sales data for civil aviation are reported separately in the greenhouse gas inventory, which shows that only 0.3% of total fuel deliveries to civil aviation was used for domestic flights in 2016. Given the minimal share of domestic aviation, fuel consumption and (LTO) emissions from both domestic and international aviation were 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 organized to discuss and estimate the uncertainties in the activity data and emission factors used for the emission calculations for the transport sector (Dellaert & Dröge 2017).

The resulting uncertainty estimates for civil aviation are provided in the table below.

Table 4.4 Uncertainty estimates for civil aviation (Dellaert & Dröge 2017)

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

4.2.7 *Source-specific QA/QC and verification*
Trends in the estimated fuel consumption for civil aviation were compared with trends in LTOs and passenger numbers at Amsterdam Airport Schiphol and regional airports, see also Section 4.2.3. Agreement between both trends is good.

4.2.8 *Source-specific recalculations*
$PM_{2.5}$, PM_{10}, BC and TSP exhaust emissions from civil aviation in 2014 and 2015 were recalculated in this year's inventory due to the correction of an erroneous emission factor. Emissions in 2014 were 0.1/0.2% lower than they were in last year's inventory and emissions in 2015 were 0.7/1.1% lower.

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) and *PM emissions from tyre and brake wear* (1A3bvi), and *road abrasion* (1A3bvii). PM emissions caused by the resuspension of previously deposited material were not included.

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

4.3.2 *Key sources*

The different source categories within Road transport are key sources for many substances in both the 1990-2016 trend assessment and the 1990 and 2016 level assessments, as shown in Table 4.5.

Table 4.5 Key source analysis for Road transport subcategories

Source category		1990 level	2016 level	1990-2016 trend
1A3bi	Passenger cars	NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, BC, Pb	NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, BC, Cd, Hg	SO_x, NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, BC, Pb, Cd, Hg
1A3bii	Light-duty vehicles	NO_x, CO, PM_{10}, $PM_{2.5}$, BC	NO_x, PM_{10}, $PM_{2.5}$, BC	SO_x, NO_x, , CO, PM_{10}, BC
1A3biii	Heavy-duty vehicles and buses	SO_x, NO_x, NMVOC, PM_{10}, $PM_{2.5}$, BC	NO_x, $PM_{2.5}$, BC	SO_x, NO_x, NMVOC, PM_{10}, $PM_{2.5}$, BC
1A3biv	Mopeds and motorcycles	NMVOC, CO	NMVOC, CO	CO
1A3bv	Gasoline/petrol evaporation	NMVOC		NMVOC
1A3bvi	Tyre and brake wear		PM_{10}, $PM_{2.5}$	$PM_{10,}$, $PM_{2.5}$
1A3bvii	Road abrasion		PM_{10}	PM_{10}

4.3.3 *Overview of shares and trends in emissions*

Road transport is a major contributor to air pollutant emissions in the Netherlands. Taken together, the different source categories within road transport accounted for 31% of NO_x emissions (national totals), 18% of PM_{10}, 21% of $PM_{2.5}$, 42% of BC, 17% of NMVOC and 53% of CO emissions in 2016. The trends in emissions from road transport are shown in Table 4.6. The 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 2016 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**	**0.9**	**19**	**19**	**19**	**9**	**712**
1995	222	120	14	2.4	14	14	14	7	519
2000	179	67	4	4.3	10	10	10	6	397
2005	157	40	0	5.3	7	7	7	5	386
2010	128	32	0	5.1	5	5	5	3	374
2015	86	24	0	4.2	2	2	2	1	304
2016	**79**	**24**	**0**	**4.2**	**2**	**2**	**2**	**1**	**297**
1990-2016 period[1)]	-203	-164	-15	3.3	-16	-16	-16	-8	-415
1990-2016 period[2)]	-72%	-87%	-99%	350%	-88%	-88%	-88%	-85%	-58%

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

Emissions of SO_x decreased by 99% between 1990 and 2016 due to increasingly stringent EU fuel quality standards regulating the maximum allowable sulphur content of fuels used in (road) transport. Currently, all road transport fuels are sulphur free (sulphur content <10 parts per million). The share that road transport contributed to total SO_x emissions in the Netherlands decreased from 8% in 1990 to less than 1% in 2016.

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. Notwithstanding 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 2016.
Emissions of heavy metals have increased, with the exception of Pb. Cd and Hg emissions from passenger cars were key sources in the 2016 level assessment and in the 1990-2016 trend assessment. Passenger cars were also a key source of Pb in the 1990 level assessment. Because Pb emissions decreased significantly with the introduction of unleaded petrol, passenger cars were no longer a key source of Pb in the 2016 level assessment.

Passenger cars (1A3bi)
The number of kilometres driven by passenger cars in the Netherlands steadily increased from approximately 82 billion in 1990 to 108 billion in 2016 (see Figure 4.1).

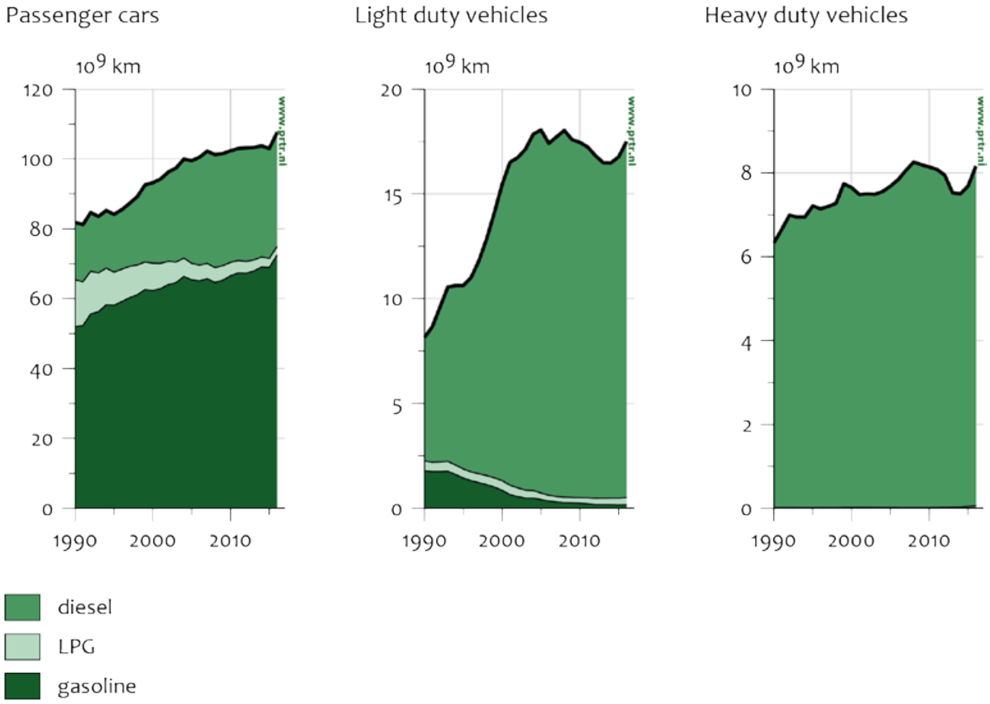

Figure 4.1 Kilometres driven per vehicle and fuel type in the Netherlands (source: Statistics Netherlands).

Since 1995, the share of diesel-powered passenger cars in the Dutch car fleet has grown significantly, leading to an increase in diesel mileage by 97% between 1990 and 2016. Petrol mileage increased by 39% between 1990 and 2016. Yet since 2008, the total diesel mileage has remained constant. The share of LPG in the passenger car fleet decreased significantly, from 16% in 1990 to 3% in 2016. 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 from 1990 to 2016, mostly at the expense of LPG.

NO_x emissions from passenger cars decreased significantly throughout the time series: from 145 Gg in 1990 (24% of total NO_x emissions in the Netherlands) to 25 Gg in 2016 (10% of total NO_x). This decrease can mainly be attributed to the introduction of the three-way catalyst, which led to a major decrease in NO_x emissions from petrol-driven passenger cars. NO_x emissions from petrol-driven passenger cars decreased significantly between 1990 and 2016, even though traffic volumes increased. NO_x emissions from diesel-powered passenger cars increased from 16 Gg in 1995 to 25 Gg in 2007. 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. Since 2007, NO_x emissions from diesel cars have decreased. Due to the decrease of NO_x emissions from petrol-driven passenger cars, NO_x has become mostly a diesel-related issue. The share that petrol contributes to total NO_x emissions from passenger cars decreased from 76% in 1990 to 27% in 2016, whereas the share of diesel increased from 11% to 71% between 1990 and 2016.

The introduction of the three-way catalyst for gasoline passenger cars also led to a major reduction in NMVOC and CO emissions. NMVOC exhaust emissions from petrol-driven passenger cars decreased from 100 Gg in 1990 to 12 Gg in 2016, whereas CO emissions decreased from 588 to 222 Gg. NMVOC and CO emissions from diesel- and LPG-powered passenger cars also decreased significantly, but both are minor sources of NMVOC and CO. In 2016, passenger cars (not including evaporative NMVOC emissions) were responsible for 9% of NMVOC emissions (down from 21% in 1990) and 40% of CO emissions (down from 52% in 1990) in the Netherlands.
Passenger cars (source category 1A3bi, only including exhaust emissions) were responsible for 7% of $PM_{2.5}$ emissions and 3% of PM_{10} emissions in the Netherlands in 2016. PM_{10} exhaust emissions from passenger cars decreased by 85% between 1990 and 2016. Emissions from both petrol-driven and diesel-powered cars decreased significantly throughout the time series due to the increasingly stringent EU emission standards for new passenger cars. Exhaust emissions in 2016 were 0.9 Gg, down by 0.3 Gg (26%) from 2013. 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 entered into force at the start of 2011. DPFs entered the Dutch fleet much earlier though, helped by a subsidy that was instated by the Dutch government in 2005. In 2007, more than 60% of new diesel-powered passenger cars were equipped with a DPF. In 2008, the share of new diesel passenger cars with a DPF was above 90%. $PM_{2.5}$ exhaust emissions from passenger cars (and other road transport) are assumed to be equal to PM_{10} exhaust emissions.

NH_3 emissions from passenger cars increased from 0.9 Gg in 1990 to 5.3 Gg in 2006, resulting from the introduction of the three-way catalyst. From 2007, emissions decreased to 4.0 Gg in 2016. 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 from 230 Mg in 1990 to 0.5 Mg in 2016 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 (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 subsequently increased slightly in 2016 (+2%). These fluctuations in recent years can probably be attributed to the economic situation. The proportion of petrol-driven trucks in the fleet decreased steadily throughout the time series. In recent years, diesel engines have dominated the light-duty truck market, 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 2016 were 18% lower than they were in 1990, even though the number of vehicle kilometres driven more than doubled during this time span. The EU emission standards for light-duty trucks and the subsequent market penetration of light-duty diesel engines with lower NO_x emissions caused a decrease in the fleet average NO_x emissions per vehicle kilometre. However, because of the poor NO_x-emission performance of Euro-5 light-duty trucks, the fleet average NO_x emission factor for diesel light-duty trucks has stabilized in recent years.

Light-duty trucks are a minor source of both CO an NMVOC emissions, accounting for less than 1% of the national totals for both substances in 2016. The exhaust emissions of NMVOC and CO from light-duty trucks decreased significantly throughout the time series. NMVOC emissions decreased from 11 Gg in 1990 to 0.6 Gg in 2016, whereas CO emissions decreased from 48 to 2.9 Gg over the same time period. The increasingly stringent EU emissions standards for both substances have led to a major (85-87%) decrease in the fleet average emission factors for both gasoline and diesel trucks between 1990 and 2016. Gasoline-powered trucks emit far more NMVOC and CO than diesel-powered trucks per kilometre; 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 in the earlier years this decrease was offset by the increase in vehicle kilometres driven. Diesel-powered trucks were dominant in the 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 diesel particulate filter (DPF). Combined with the stabilization in the number of vehicle kilometres driven since 2005, PM_{10} exhaust emissions decreased by 62% between 2005 and 2016.

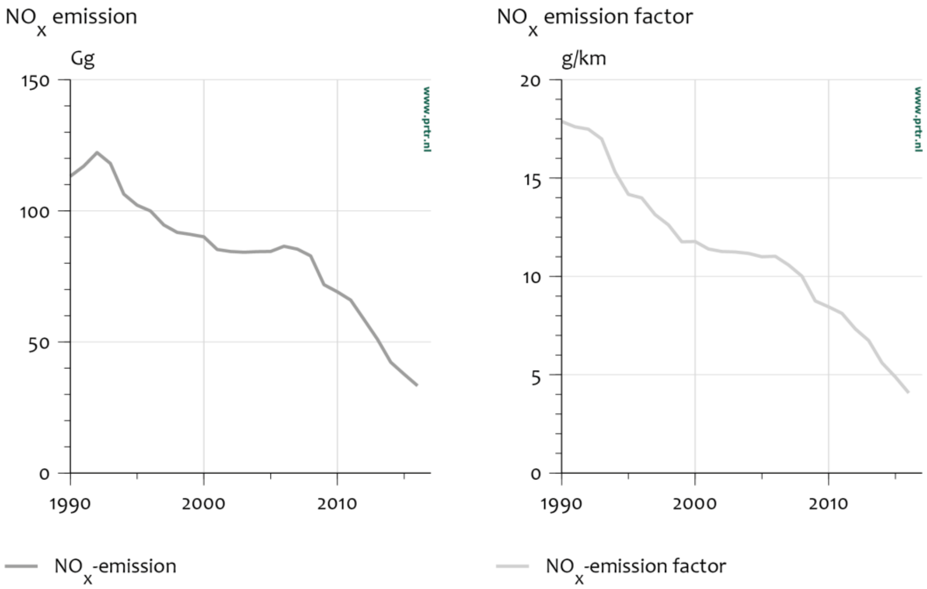

Figure 4.2 NO_x emissions and NO_x implied emission factors of heavy-duty vehicles in the Netherlands

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 vehicle fleet with a share of 99%.

NO_x emissions from heavy-duty vehicles decreased from 113 Gg in 1990 to 33 Gg in 2016 (see Figure 4.2). Emissions have decreased significantly in recent years due to the decrease in vehicle mileages between 2008 and 2014 (Figure 4.1) and a decrease in the fleet averaged NO_x emission factor (Figure 4.3). The latter decreased by 69% between 1990 and 2016, 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 an SCR catalyst (Selective Catalytic Reduction), resulting in very low real-world NO_x emission levels (Kadijk *et al.*, 2015).

NMVOC exhaust emissions decreased by 94%, from 16 Gg in 1990 to 1 Gg in 2016, whereas PM_{10} and $PM_{2.5}$ exhaust emissions decreased by 94%, from 7 Gg to 0.4 Gg. These decreases have also been caused by EU emission legislation. Heavy-duty vehicles were only a minor source of NMVOC and PM_{10} emissions in 2016. Their share in $PM_{2.5}$ emissions was slightly higher at 3.5% of national totals.

Heavy-duty trucks and buses are a minor source of NH_3 emissions in the Netherlands (0.1% of national totals). Yet NH_3 emissions from heavy-duty vehicles increased significantly between 2005 (29 Mg) and 2013 (109 Mg). 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 is 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 is shown in Table 3.17 of Klein *et al.* (2018). Emission factors were derived from Stelwagen *et al*. (2015). Emission factors for Euro-VI trucks and buses are lower. As a result, NH_3 emissions of heavy-duty trucks and buses have decreased again since 2013 due to the market introduction of Euro-VI vehicles. In 2016, emissions amounted to 87 Mg, which amounted to a decrease of 11% compared with 2015. It should be noted that NH_3 emission factors for Euro-VI trucks are rather uncertain and require further research.

Motorcycles and mopeds (1A3biv)
Motorcycles and mopeds are a small emission source in the Netherlands, being responsible for less than 1% of national totals for most substances. They were a key source, however, for NMVOC and CO in both the 1990 and 2016 level assessment and in the trend assessment (CO only). Motorcycles and mopeds were responsible for 6% of NMVOC emissions and 10% of CO emissions in the Netherlands in 2016. Even though the number of vehicle kilometres driven almost doubled between 1990 and 2016, exhaust emissions of NMVOC decreased significantly due to the increasingly stringent EU emissions standards for two-wheelers. NMVOC exhaust emissions decreased from 25 to 8.2 Gg between 1990 and 2016. CO emissions from motorcycles and mopeds increased from 45 to 56 Gg between 1990 and 2016.
NO_x emissions increased from 0.4 to 0.9 Gg between 1990 and 2016, but the share of motorcycles and mopeds in NO_x emissions in the Netherlands was still small (<1%) in 2016. The share in $PM_{2.5}$ emissions was approximately 1% in 2016, with emissions decreasing from 0.4 to 0.1 Gg in the 1990-2016 timespan.

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 from 36 Gg in 1990 to 2 Gg in 2016. As a result, evaporative emissions are no longer a key source in the level assessment, accounting for only 1% of total NMVOC emissions in the Netherlands in 2016 (down from 7% in 1990). Gasoline 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 around 50% in 2016 (motorcycles and mopeds were responsible for approximately 50% as well in 2016).

PM emissions from tyre and brake wear and road abrasion (1A3bvi and 1A3bvii)
Car tyre and brake wear (1A3bvi) and car road abrasion (1A3bvii) were key sources for PM_{10} emissions in the Netherlands in 2016, being

responsible for 5% and 4% of PM_{10} emissions, respectively. PM_{10} emissions from brake wear, tyre wear and road abrasion increased throughout most of the time series, as shown in Figure 4.3, due to the increase in vehicle kilometres driven by light- and heavy-duty vehicles. PM_{10} emission factors were constant throughout the time series. $PM_{2.5}$ emissions were derived from PM_{10} emissions using $PM_{2.5}/PM_{10}$ ratios of 0.2 for tyre wear and 0.15 for both brake wear and road surface wear. Therefore, the trend in $PM_{2.5}$ wear emissions were similar to the trend in PM_{10} emissions. The share of tyre and brake wear (2%) and road abrasion (1%) in total $PM_{2.5}$ emissions in the Netherlands was smaller than it was for PM_{10}.

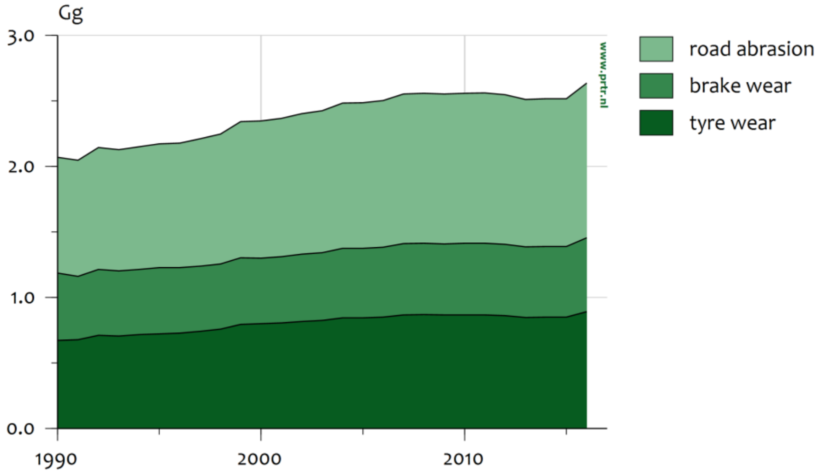

Figure 4.3 Emissions of PM10 resulting from Brake and tyre wear and Road abrasion

4.3.4 *Activity data and (implied) emission factors*

The 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 for 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 calculated total vehicle mileage per vehicle type using data on:

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

Data on the size and composition of the Dutch vehicle fleet (1) were derived from RDW, which has information on all vehicles registered in the Netherlands, including vehicle weight, fuel type and year of manufacture. The annual mileage for different types of road vehicles (2) were calculated from odometer readings derived from RDW. This database contains odometer readings from road vehicles (excluding mopeds) that have been to a garage for maintenance or repairs. Every year, Statistics Netherlands acquires the database and uses the data combined with RDW-data on vehicle characteristics to derive average annual mileages for different vehicle types (age classes and fuel types). This methodology was applied to derive average annual mileage for passenger cars, light-duty and heavy-duty trucks and buses. The resulting mileages were corrected for the number of kilometres driven abroad, using different statistics as described in Klein *et al*. (2018). The average annual mileage for motorcycles and mopeds were derived by Statistics Netherlands using a survey conducted among owners, as described in detail in Jimmink *et al*. (2014).

The vehicle kilometres driven in the Netherlands by foreign passenger cars (3) were estimated by Statistics Netherlands using different tourism-related data, as described in Klein *et al*. (2018). Vehicle kilometres driven by foreign trucks were derived from statistics on road transport in the Netherlands and in other EU countries collected by Eurostat. The vehicle kilometres driven by foreign buses in the Netherlands were estimated using different (inter)national statistics on buses and tourism, such as the Dutch Accommodations Survey, the UK Travel Trends and the Belgian Travel Research (Reisonderzoek), as described in Molnár-in ‘t Veld & Dohmen-Kampert (2010).

For the emission calculations, a distinction was made between three road types: urban, rural and motorway. The road type distributions for different vehicle types were derived from Goudappel Coffeng (2010). In this study, a national transport model was used to estimate the distribution of vehicle kilometres driven on urban roads, rural roads and motorways for passenger cars and light- and heavy-duty trucks. Subsequently, data from number plate registrations, alongside different road types throughout the Netherlands, were used to differentiate these distributions according to fuel type and vehicle age. In general, it was concluded that the proportion of petrol-driven passenger cars on urban roads is higher than it is on motorways. Also, the vehicles driving on motorways is younger on average than those on urban roads. These differences can mainly be related to differences in average annual mileage: a higher mileage generally results in a higher proportion of motorway driving in the total mileage of all vehicles. The road type distribution for different vehicle categories is reported in detail in Table 3.12 of Klein *et al.* (2018).

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

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

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

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

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

VERSIT+ takes into account additional emissions during the cold start of the vehicles. The additional emissions are expressed in grams per cold start. Data on the number of cold starts is derived from the Dutch Mobility Survey (OViN); see also Klein *et al.* (2018). The effects of vehicle aging on emission levels are also incorporated in VERSIT+, using data from the in-use compliance programme that TNO runs for the Dutch Ministry of Infrastructure and the Environment. A detailed overview of the emission factors per vehicle type and road type is provided in Klein *et al*. (2018). The methodology used for the in-service testing programmes by TNO and the subsequent analysis of measurement data and the calculation of representative emissions factors for over 300 different vehicle types are described in detail in Spreen *et al*. (2016).

Emissions of SO_x and heavy metals (and CO_2) are dependent on fuel consumption and fuel type. These emissions were calculated by multiplying fuel consumption with fuel and year-specific emission factors (grams per litre of fuel). The emission factors for SO_x and heavy metals were based on the sulphur, carbon and heavy metal content of the fuels, as described in Klein *et al*. (2018). It is assumed that 75% of the lead is emitted as particles and 95% of the sulphur is transformed to sulphur dioxide. NMVOC evaporative emissions are estimated using the methodology from the EEA Emission Inventory Guidebook (EEA, 2007). The NH_3 emission factors were derived from (Stelwagen *et al*., 2015).

PM emission factors
PM_{10} emission factors and $PM_{2.5}/PM_{10}$ ratios for brake and tyre wear and for road abrasion were derived from literature (Ten Broeke *et al*., 2008; Denier van der Gon *et al*., 2008; RWS, 2008). An overview of these emission factors is provided in Klein *et al.* (2018) in Tables 3.20 and 3.35. For tyre wear, the emission factors are calculated as the total mass loss of tyres resulting from the wear process and the number of tyres per vehicle category. $PM_{2.5}$ emission factors are derived from $PM_{10,}$ using ratios of 15% (brake wear and road abrasion) and 20% (tyre wear) respectively. It should be noted that PM_{10} emission factors for tyre and brake wear and for road abrasion, and specifically the $PM_{2.5}/PM_{10}$ ratios, are highly uncertain due to a lack of data.

Lubricant oil
Combustion of lubricant oil is estimated based on vehicle kilometres driven and specific consumption per kilometre. The consumption factors per vehicle type are provided in table 3.21 of Klein *et al.* (2018). 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 therefore are calculated separately by multiplying the consumption of lubricant oil and the lubricant oil profile (see Table 3.26B of Klein *et al*., 2018).

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 4.4 shows both the bottom-up estimates for fuel used by road transport and reported fuel sold to road transport per fuel type for the 1990-2016 time series.

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 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 show similar trends, but there is a bigger difference in absolute levels, with the fuel sold being substantially higher than the fuel used throughout the time series. The difference between the fuel used and the 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, with 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. With 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 the diesel fuel sold and the 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 the diesel fuel used and the fuel sold decreased substantially between 2013 (23%) and 2016 (8%). This can, for the most part, be attributed to differences in diesel fuel prices between the Netherlands and surrounding countries as well, as described in Geilenkirchen *et al.* (2017).

The time series for LPG show similar trends, with both the fuel used and the 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.

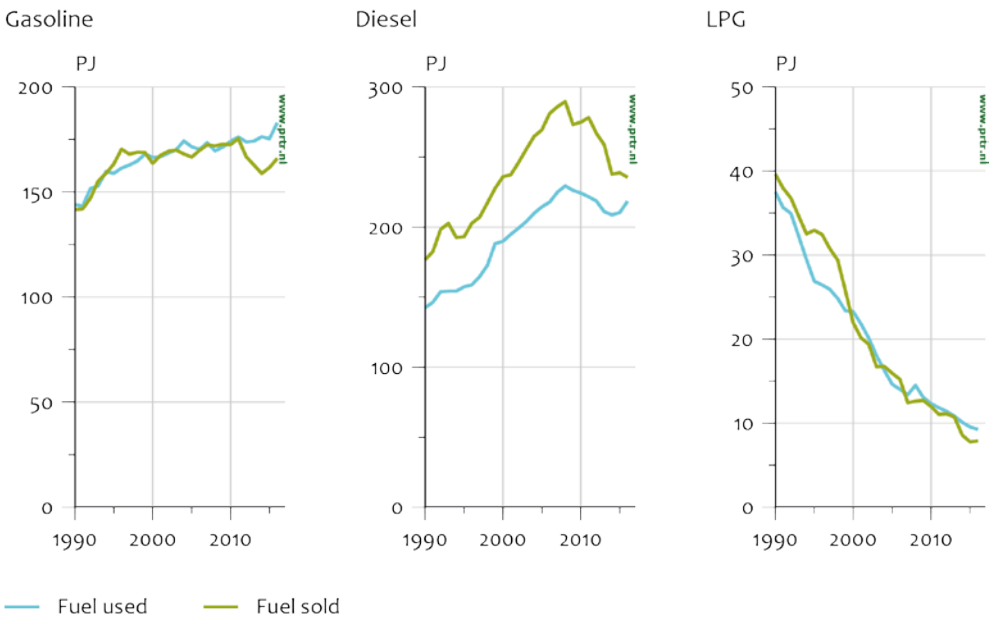

Figure 4.4 Fuel used vs. fuel sold trends, for gasoline (petrol), diesel and LPG fuelled road transport in the Netherlands

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 4.7. NMVOC emissions in road transport mostly stem from petrol-driven vehicles. Since the difference between the fuel used and the fuel sold for petrol is small, fuel-used and fuel-sold NMVOC emission totals do not differ much, as shown in Figure 4.5. PM emissions from brake and tyre wear and from road abrasion were not adjusted for differences between the fuel used and the fuel sold, since these emissions are not directly related to fuel use.

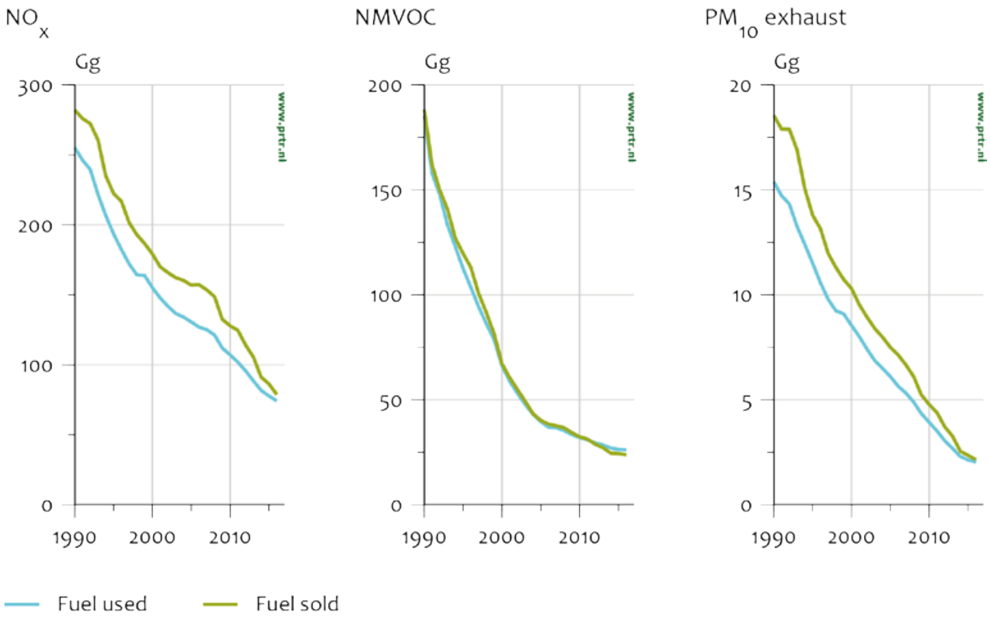

Figure 4.5 NO_x, NMVOC and PM_{10} exhaust emissions from road transport in the Netherlands based on the fuel used and the fuel sold.

Biofuels

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

4.3.5 Methodological issues

There are several parts of the emission calculations for road transport that require improvement:

- The PM_{10} and $PM_{2.5}$ emission factors for brake and tyre wear and for road abrasion are rather uncertain due to a lack of measurements.
- NH_3 emission factors for SCR equipped Euro-VI trucks and buses and Euro-6 diesel passenger cars and light duty trucks are uncertain and need verification based on new measurements.
- The road type distribution for all vehicle categories were last updated in 2010 and need 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 the fuel used and the fuel sold may 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 their knowledge of the uncertainties concerning pollutant emissions from road transport (Kraan *et al.*, 2014). Using a

jackknife 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, the 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 the years. 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 organized to discuss and estimate the uncertainties in the activity data and emission factors used for the emission calculations for the transport sector (Dellaert & Dröge 2017). The resulting uncertainty estimates for road transport are provided in Table 4.7.

Table 4.7 Uncertainty estimates for road transport (Dellaert & Dröge 2017)

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

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 compared with trends in fuel used, as described in Section 4.3.4. Differences in trends can, for the most part, be explained.
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:

- PM_{10} and $PM_{2.5}$ exhaust emission factors for Euro-3, -4, -5 and -6 petrol-driven passenger cars were adjusted downwards by 50% based on recent measurements (Kadijk et al., 2018);
- NO_x emission factors for Euro-6 diesel light-duty trucks were adjusted downwards by 14-73% (depending on weight class and road type) based on recent measurements (Kadijk et al. 2017). The proportion of Euro-6 in the light-duty truck fleet was also adjusted downwards, though based on vehicle registration data. In last year's inventory, the proportion of Euro-6 in new vehicle registrations in 2015 was overestimated. This has been corrected in this year's inventory;
- NO_x and CO emission factors for Euro-V and Euro-VI heavy-duty trucks have been re-estimated based on a study conducted on driving behaviour by these vehicles (Heijne & Ligterink, 2018). Driving behaviour is particularly important for NO_x emission levels because it influences the temperature of the SCR catalyst. At low velocities in urban areas and in congestion on motorways, the operating temperature of the catalyst is too low to function optimally, resulting in higher NO_x emission levels. On average though, NO_x and CO emission factors for heavy-duty trucks decreased for urban and rural driving and increased for motorways;
- The data on vehicle kilometres driven in the Netherlands were adjusted for 2013-2015 based on updated statistics from Statistics Netherlands;
- The proportions of the different Euro classes per year of first registration were adjusted using new data by RDW on the composition of the Dutch car fleet;
- Heating values for transport fuels have been updated (Swertz *et al.*, 2017) based on the results of recent measurement campaigns (Ligterink, 2016). This change affects both fuel-used and fuel-sold activity data in the same manner and, as a result, does not influence emission estimates. The (fuel-sold) activity data in the NFR has been adjusted downwards by 3-4% (passenger cars) and upwards by approximately 1% (light-duty trucks and heavy-duty trucks and buses) compared with last year's inventory.

Besides these recalculations, the time series for the different source categories within road transport show minor changes (<1%) for different years and different substances, for the most part due to error corrections or minor adjustments in underlying data (e.g. the proportion of Euro classes per year).

4.3.9 *Source-specific planned improvements*

In next year's inventory, the road type distribution for passenger cars, light-duty trucks and heavy-duty trucks and buses will we improved using insight from a recent study (Ligterink, 2017). Also, studies are planned to be conducted on improving the fuel-sold emission calculation and on tampering vehicles equipped with SCR catalysts and DPF.

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 due to wear, which result from friction and spark erosion of the current collectors and the overhead contact lines. Among other things, this results in emissions of particulate matter, copper and lead from trains, trams and metros.

4.4.2 *Key sources*

Railways are not a key source in the 2016 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 2016. Between 1990 and 2000, diesel fuel consumption by railways increased from 1.2 to 1.5 PJ due to an increase in freight transport. Since 2001, fuel consumption has fluctuated around 1.4 PJ. Transport volumes have increased since 2001, especially in freight transport, but this has been compensated by the ongoing electrification of rail transport. In 2016, diesel fuel consumption by rail transport amounted to 1.4 PJ. 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 4.6. 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. NO_x emissions from railways fluctuated around 1.9 Gg in the earlier years of the time series and were around 1.8 Gg in 2016. PM_{10} emissions have fluctuated around 0.07 Gg. Pb emissions increased by 14% between 1990 and 2016. Pb emissions from railways result from the wear on carbon brushes. Wear emissions were estimated based on 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 tonnes and 14% of the total copper emissions in the Netherlands. Emissions of other heavy metals are very low and are therefore not included in Table 4.6. SO_x emissions from railways decreased by 99% between 2007 and 2012 due to the decrease in the sulphur content of diesel fuel for non-road applications and the early introduction of sulphur-free diesel fuel in the Netherlands (required from 2011 onwards but already applied in 2009 and 2010).

Table 4.6 Trends in emissions from 1A3c Railways

	Main Pollutants				Particulate Matter				Other	Priority Heavy Metals
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg
1990	**1.6**	**0.07**	**0.10**	**0.0003**	**0.05**	**0.06**	**0.06**	**0.02**	**0.26**	**0.22**
1995	1.7	0.08	0.10	0.0003	0.06	0.06	0.06	0.02	0.27	0.26
2000	2.1	0.09	0.12	0.0004	0.07	0.07	0.07	0.03	0.32	0.28
2005	1.9	0.08	0.11	0.0003	0.06	0.06	0.06	0.02	0.29	0.27
2010	1.9	0.08	0.02	0.0003	0.06	0.06	0.06	0.02	0.29	0.29
2016	1.8	0.08	0.00	0.0003	0.06	0.06	0.06	0.03	0.30	0.25
2016	**1.8**	**0.08**	**0.00**	**0.0003**	**0.06**	**0.06**	**0.06**	**0.03**	**0.30**	**0.26**
1990-2016 period[1)]	0.19	0.01	-0.10	0.0000	0.01	0.01	0.01	0.00	0.03	0.04
1990-2016 period[2)]	12%	13%	-99%	12%	14%	14%	14%	13%	13%	18%

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

4.4.4 *Activity data and (implied) emission factors*

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

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

PM_{10} emissions due to wear on overhead contact lines and carbon brushes from railways are calculated using a study conducted by NS-CTO (1992) on the wear on overhead contact lines and the carbon brushes of the collectors on electric trains. For trams and metros, the wear on the overhead contact lines has been assumed to be identical to that on railways. The wear on current collectors has not been included, because no information was available on this topic. Carbon brushes, besides copper, contain 10% lead and 65% carbon. Based on the NS-CTO study, the percentage of particulate matter in the total quantity of wear debris was estimated to be 20%. Because of their low weight, these particles probably remain airborne. It is estimated that approximately 65% of the wear debris ends up in the immediate vicinity of the railway, while 5% enters the ditches alongside the railway line (Coenen & Hulskotte, 1998). According to the NS-CTO study, the remainder of the wear debris (10%) does not enter the environment, but attaches itself to the train surface and is captured in the train washing facilities.

4.4.5 *Methodological issues*

Emission factors for railways have not been updated recently and therefore are rather uncertain.

4.4.6 *Uncertainties and time series consistency*

Consistent methodologies have been used throughout the time series. In 2016, an experts' workshop was organized to discuss and estimate the uncertainties in the activity data and emission factors used for the emission calculations for the transport sector (Dellaert & Dröge 2017). The resulting uncertainty estimates for railways are provided in Table 4.8.

Table 4.8 Uncertainty estimates for railways (Dellaert & Dröge 2017)

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	Electricity						200%	200%	

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 ton.kms increased by 4% according to data from Statistics Netherlands. The diesel consumption decreased by 6% in that 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 and Rail Cargo, 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.

4.4.8 *Source-specific recalculations*

There were a few minor adjustments (<1%) to the activity data based on updated figures from the National Energy Statistics. The emission factors have been adjusted accordingly, so that the historical figures on emissions have remained unchanged. The emissions for the 2007-2014 period changed slightly (<1%) and decreased for 2015 by almost 2% as a result of the adjusted activity data.

4.4.9 *Source-specific planned improvements*

There are no source-specific planned improvements for railways. Emission factors remain uncertain, but since railways are a small emission source and not a key source for any substance, updating the emission factors is currently not a priority.

4.5 Waterborne navigation and recreational craft

4.5.1 *Source-category description*

The source category *Waterborne navigation* (1A3d) includes emissions from *National* (1A3dii) and *International* (1A3di(ii) *inland navigation* in the Netherlands and from *international maritime navigation* (1A3di(i)). Emissions from international maritime navigation are reported as a memo item and are not part of the national emission totals. National (domestic) inland navigation includes emissions from all trips that both depart from and arrive in the Netherlands, whereas international inland navigation includes emissions from trips that either depart from or arrive abroad. Only emissions on Dutch territory are reported. For maritime navigation, this includes emissions on the Dutch continental shelf. All three categories include both passenger and freight transport. The 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).

4.5.2 *Key sources*

Both the source categories 1A3di(ii) *International inland waterways* and 1A3dii *National navigation (shipping)* are key sources for NO_x, $PM_{2.5}$ and BC emissions. The source category 1A5b *Other Mobile* is not a key source.

4.5.3 *Overview of emission shares and trends*

In total, (inter)national inland navigation was responsible for 11% of NO_x emissions and 6% of $PM_{2.5}$ emissions in the Netherlands in 2016. 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 in national emissions of PM_{10} (3.2%), NMVOC (0.8%), CO (1%) and SO_x (0.05%) was small in 2016.

Emissions from international maritime navigation are not included in the national totals, but maritime navigation is a major emission source in the Netherlands, with 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 more than 100 Gg in 2016 and were higher than the combined NO_x emissions from all road transport in the Netherlands. PM_{10}

emissions amounted to 3.2 Gg in 2016. 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 2016.

Table 4.9 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	**29**	**2.0**	**1.8**	**0.005**	**1.25**	**1.31**	**1.31**	**0.56**	**8**
1995	25	1.8	1.9	0.005	1.25	1.32	1.32	0.57	7
2000	28	1.7	2.0	0.006	1.24	1.31	1.31	0.56	7
2005	26	1.5	1.9	0.006	1.07	1.13	1.13	0.48	6
2010	25	1.2	0.6	0.006	0.86	0.91	0.91	0.44	5
2015	27	1.2	0.0	0.006	0.82	0.87	0.87	0.46	6
2016	**27**	**1.2**	**0.0**	**0.006**	**0.79**	**0.84**	**0.84**	**0.44**	**5**
1990-2016 period[1)]	-2	-0.8	-1.8	0.001	-0.45	-0.47	-0.47	-0.12	-3
1990-2016 period[2)]	-7%	-40%	-99%	19%	-36%	-36%	-36%	-21%	-32%

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

The trends in emissions from inland navigation in the Netherlands are shown in Table 4.9. Since 2000, fuel consumption in inland navigation has fluctuated between 22 and 38 PJ. The economic crisis led to a decrease of transport volumes and fuel consumption in 2009. Since then, transport volumes have increased again, resulting in an increase in fuel consumption from 22 PJ in 2009 to 27 PJ in 2016. Emissions of NO_x, CO, NMVOC and PM from inland navigation follow, for the most part, the trends in the activity data. Combined NO_x emissions from inland navigation increased from 25 Gg in 2010 to 27 Gg in 2016. 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 2016.

SO_x emissions from inland navigation decreased by 99% between 2009 and 2016 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. Sulphur-free diesel fuel was introduced back in 2009 to inland navigation in the Netherlands, therefore SO_x emissions have 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 decreased by 0.07 Gg between 2009 and 2016.

Fuel consumption from passenger ships is around 1.5 PJ. Since fuel consumption by recreational craft has remained fairly constant in recent years, trends in emissions follow the trend in fleet average emission factors. The fleet average emission factors of most substances decreased slightly from 2015 to 2016, resulting in small decreases in emissions. PM_{10} and $PM_{2.5}$ emissions decreased by 3%. NO_x emissions showed a minor increase (2%) from 2014 to 2016.

Energy use and resulting emissions from maritime navigation showed an upwards trend between 1990 and 2008. Since the start of the economic crisis, transport volumes have decreased, resulting in a reduction of energy use and emissions. This decrease was enhanced by *slow steaming*, resulting in lower energy use and thus further lowering emissions (MARIN, 2011). In 2016, total fuel consumption by maritime navigation in Dutch territory decreased by 5% compared with 2015.

Recreational shipping is reported under source-category 1A5b *Other Mobile*. This source-category is not a key source for any of the emissions. The share of emissions from recreational shipping in the total emissions in the Netherlands in 2016 was less than 1% for all pollutants.

4.5.4 *Activity data and (implied) emission factors*

Fuel consumption and resulting emissions from inland navigation (both national and international) were calculated using a Tier 3 method. The methodology was developed as part of the *Emissieregistratie en Monitoring Scheepvaart (EMS)* project. The EMS methodology distinguishes between 32 vessel classes. For each class, annual power demand (kWh) is calculated for all inland waterways in the Netherlands. A distinction is made between loaded and unloaded vessels. In addition, the average speed of the vessels has been determined (in relation to the water), depending on the vessel class and the maximum speed allowed on the route that is travelled. The general formula for calculating emissions is the following:

*Emissions = Number of vessels * Power * Time * Emission factor*

Data on the number of vessel kilometres per ship type were derived from Statistics Netherlands. The distribution of these kilometres over the Dutch inland waterway network was estimated using data from the IVS90 network, which registers all ship movements at certain points (e.g. sluices) of the Dutch waterway network. The distribution was estimated during the development of the EMS methodology and has been used since. In 2012, the distribution of vessel kilometres per ship type over the waterway network was re-estimated by TNO using a modelling approach.

Emissions from propulsion engines =

the sum of vessel classes, cargo situations, routes and directions of:
{**number of vessel passages** *times*
average power used *times*
average emission factor *times*
length of route *divided by* **speed**}

or

$$E_{v,c,b,r,s,d} = N_{v,c,b,r,d} \cdot Pb_{v,b,r} \cdot L_r / (V_{v,r,d} + V_r) \cdot EF_{v,s} \quad (1)$$

Where:
$E_{v,c,b,r,s,d}$ = Emission per vessel class, (kg)
$N_{v,c,b,r,d}$ = Number of vessels of this class on the route and with this cargo situation
sailing in this direction
$Pb_{v,b,r}$ = Average power of this vessel class on the route (kW)
$EF_{v,s}$ = Average emission factor of the engines of this vessel class (kg/kWh)
L_r = Length of the route (km)
$V_{v,r}$ = Average speed of the vessel in this class on this route (km/h)
V_r = Rate of flow of the water on this route (km/h), (can also be a negative value)

v,c,b,r,s,d = indices for vessel class, aggregated cargo capacity class, cargo situation, route, substance, and direction of travel, respectively

The formula in the text box is used for calculating the emission of substance (s) in one direction (d), specifically for one vessel class (v,c), carrying a cargo or not of (b), on every distinct route (r) of the Dutch inland waterway network. The combination of the number of vessel movements, their power and their speed results in the total power demand (kWh). Emission factors are expressed in g/kWh. The emission factors depend on the engine's year of construction and are reported in Hulskotte & Bolt (2013). Fleet average emission factors are estimated using the distribution of engines in the fleet over the various year-of-construction classes. Due to a lack of data on the actual age distribution of the engines in the inland waterway fleet, a Weibull function is used to estimate the age distribution of the engines. The values of the Weibull parameters (κ and λ) have been derived from a survey carried out by TNO among 146 vessels. The median age of the engines in the survey was 9.6 years and the average age was 14.9 years. The resulting fleet average emission factors throughout the time series are reported in Klein *et al*. (2018). 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 required 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 by 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 from recreational craft were calculated by multiplying the number of recreational craft (allocated to open motor boats/cabin motor boats and open sailing boats/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 various types of boats are equipped with a specific allocation of engine types that determine the level of the emission factors. The applied emission factors are reported in Klein *et al.* (2018).

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). AIS transmits information about the position, speed and course of the ship every 2 to 10 seconds. Information about the ship itself, such as its IMO number, ship type, size and destination, is transmitted every few minutes. Sailing speed of the ship is an important factor in determining energy use and resulting emissions. Therefore, AIS data can be used to estimate fuel consumption and emissions from maritime shipping bottom-up, taking into account specific ship and voyage characteristics.
To estimate emissions from a specific ship in Dutch waters, the IMO number of the ship is linked to a ship characteristics database that was acquired from Lloyd's List Intelligence (LLI). This database contains the vessel characteristics – such as year of construction, installed engine power, service speed and vessel size – of more than 100,000 seagoing merchant vessels operating worldwide. Emission factors for each individual 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 more detail in MARIN (2018).

4.5.5 *Methodological issues*

There are several points for improvement in the emission calculation 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 recently and need to be improved;
- 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 need to be improved, preferably using AIS data. The current methodology does not take into account the (differences in) sailing speeds. Also, movements of empty vessels might not be fully included in current statistics, resulting in a potential underestimation of emissions;
- The methodology for calculating required engine power depending on speed and other ship characteristics needs to be verified for both inland and maritime 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 organized to discuss and estimate the uncertainties in the activity data and emission factors used for the emission calculations for the transport sector (Dellaert & Dröge 2017). The resulting uncertainty estimates for waterborne navigation and recreational craft are provided in Table 4.10.

Table 4.10 Uncertainty estimates for waterborne navigation and recreational craft (Dellaert & Dröge 2017)

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

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 (ton.kms of inland shipping within and across borders) and are reasonably well comparable.

4.5.8 *Source-specific recalculations*

In this year's inventory, two recalculations were performed. The first concerns the NO_x-emission factors for inland shipping engines newer than 2008. The emission factor was adjusted from 6 to 7 g/kWh, following the TREMOD model of IFEU (2014). This leads to increased NO_x emissions from 2005 (+0.1%) to 2015 (+4%).

The second recalculation concerns the BC emission factor, which is now calculated using a fixed fraction of the PM-emission factors before adjusting the PM-emission factors for the impact of lower sulphur content. In previous inventories, BC emissions were also calculated as a fixed fraction of PM emissions, but only after adjusting PM emissions for the impact of lower fuel sulphur content. This was deemed to be incorrect, since lower sulphur content was not expected to decrease BC emissions. The effect of the recalculation is shown in Figure 4.6. The resulting BC emissions from inland navigation increased by 8% (2008) to 20% (2015).

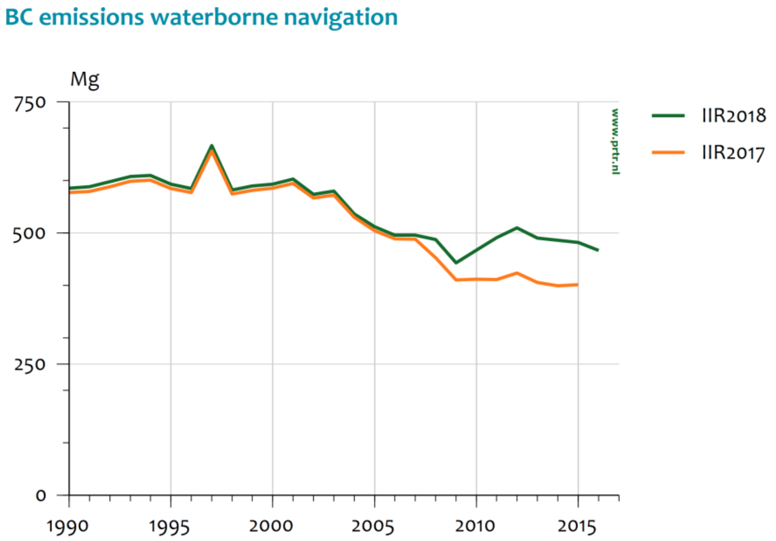

Figure 4.6 BC emissions from inland navigation (both domestic and international)

4.5.9 *Source-specific planned improvements*

Statistics Netherlands, TNO and RWS are performing a study to determine whether AIS data can be used to calculate emissions from inland navigation in Dutch territory. In the current inventory, AIS data is only used for maritime navigation, but in recent years most inland ships have also been fitted with an AIS transponder. In theory, emissions from inland navigation can also be estimated using AIS data. The pilot study should determine whether or not AIS is a valuable option for inland navigation emission calculations. Results are expected in 2018.

4.6 Non-road mobile machinery (NRMM)

4.6.1 Source category description

Mobile machinery covers a variety of equipment that is used in different economic sectors and by households in the Netherlands. Mobile machinery is typified as all machinery equipped with a combustion engine which is not primarily intended for transport on public roads and which is not attached to a stationary unit. The most important deployment of NRMM in the Netherlands is in agriculture and construction. The largest volumes of fuel are used in tillage, harvesting and earthmoving. Furthermore, NRMM is used in nature and green maintenance, such 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 latter source category is used for emissions from ground support equipment at airports. 1A5b also includes emissions from recreation craft.

4.6.2 Key sources

Mobile machinery in manufacturing industries and construction (1A2gvii) is a key source for NO_x, $PM_{2.5}$ and BC emissions in the 2016 level assessment. Source category 1A4bii Residential: Household and gardening (mobile) is a key source of emissions of CO in both the 2016 level and the trend assessment, whereas source category 1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery is a key source for NO_x, $PM_{2.5}$ and BC emissions in the 2016 level assessment and for NO_x emissions in the trend assessment. Source categories 1A4ii Commercial and 1A5b Other Mobile aren't key sources.

4.6.3 Overview of shares and trends in emissions

NRMM was responsible for 9% of CO emissions, 8% of NO_x and $PM_{2.5}$ emissions and 5% of PM_{10} emissions in the Netherlands in 2016. CO emissions mainly resulted from the use of petrol-driven equipment by households (lawn mowers) and for public green maintenance. NO_x, PM_{10} and $PM_{2.5}$ emissions were, for the most part, related to diesel machinery used in agriculture (tractors) and construction.

Total energy use in NRMM has fluctuated between 38 PJ and 46 PJ throughout the time series. Energy use in 2016 decreased by 1% compared with 2015, mainly due to a reduction in energy use by construction machinery. Since the start of the economic crisis, energy use by construction machinery decreased from 26 PJ in 2008 to 21.3 in 2016. Figure 4.7 shows total energy use within the different sectors in which mobile machinery is applied. Construction and agricultural machinery were responsible for 88% of total energy use by NRMM in 2016.

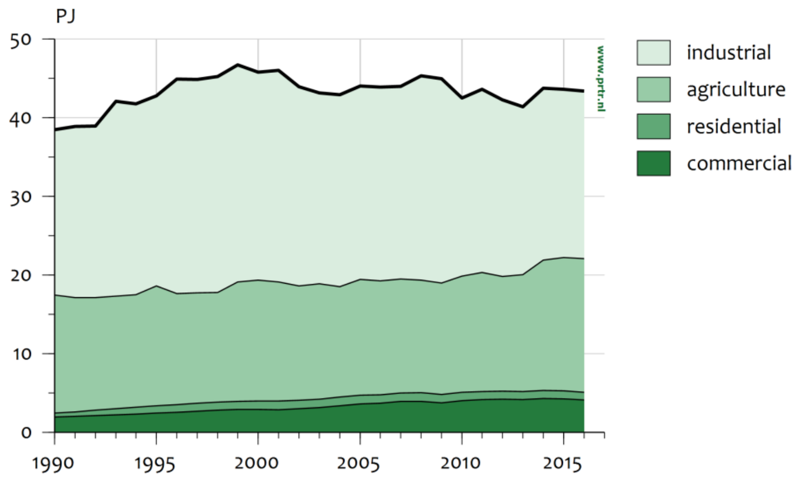

Figure 4.7 Fuel consumption in non-road mobile machinery in different sectors in the Netherlands

The trends in emissions from NRMM in the Netherlands are shown in Table 4.11. With the introduction of EU emission standards for NRMM in 1999 and the subsequent tightening of the emission standards in later years, NO_x emissions from NRMM have steadily decreased, as shown in Figure 4.9. Since 1990, NO_x emissions have decreased by 48%, whereas fuel consumption has increased by 13%.

Table 4.11 Trends in emissions from Non-road mobile machinery in the Netherlands

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**37**	**8.0**	**3.0**	**0.008**	**3.6**	**3.8**	**3.8**	**1.8**	**37**
1995	41	8.4	3.0	0.009	3.1	3.3	3.3	1.6	54
2000	43	8.0	3.2	0.010	2.8	3.0	3.0	1.4	58
2005	35	6.1	3.1	0.009	2.3	2.5	2.5	1.2	54
2010	26	4.5	0.3	0.009	1.7	1.7	1.7	0.8	51
2015	21	3.2	0.0	0.009	1.2	1.3	1.3	0.6	49
2016	**19**	**3.0**	**0.0**	**0.009**	**1.1**	**1.2**	**1.2**	**0.6**	**48**
1990-2016 period[1)]	-18	-5.1	-3.0	0.001	-2.5	-2.6	-2.6	-1.3	11
1990-2016 period[2)]	-48%	-63%	-99%	11%	-69%	-69%	-69%	-69%	30%

[1)] Absolute difference in Gg
[2)] Relative difference to 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 NRMM emission legislation as well. SO_x emissions have decreased due to the EU fuel quality standards that reduced the sulphur content of the diesel fuel used by non-road mobile machinery. Since 2011, the use of sulphur-free diesel fuel has been required in NRMM. Consequently, SO_x emissions have been reduced significantly. CO emissions have increased throughout the time series.

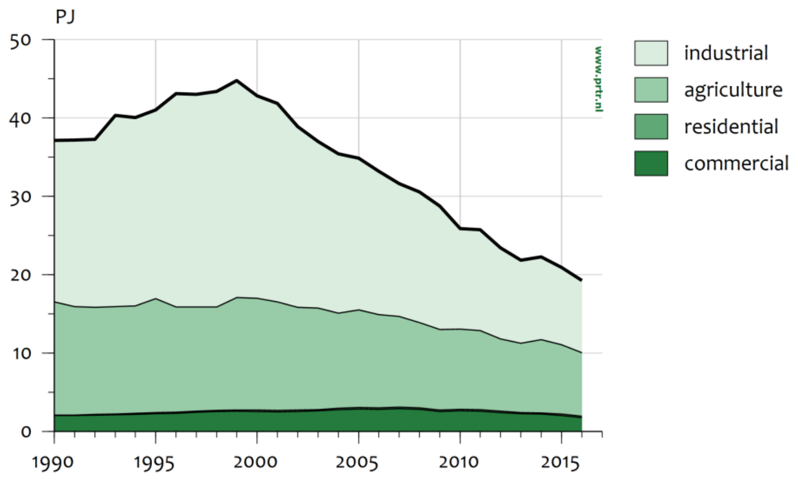

Figure 4.8 NO_x emissions by Non-road mobile machinery in different sectors in the Netherlands

Emissions from ground service equipment (GSE) at airports are reported under source-category 1A5b *Other Mobile*. This source-category is not a key source for any of the emissions. The share of emissions from GSE at airports as a percentage of the total emissions in the Netherlands in 2016 was less than 1% for all pollutants.

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 specific fuel consumption per hour of operation for 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 organizations such as BMWT and Federatie Agrotechniek. Fuel consumption and resulting emissions of CO, NO_x, PM and VOC 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 = adjustment factor applied to the average emission factor to correct the deviation from the average use of this type of machine due to varying power demands.

The report on the EMMA model (Hulskotte & Verbeek, 2009) provides the emission factors of the various technologies and the different stages in the European emission standards. The emission factors are linked to the different machine types for each sales year. Emissions of SO_x were calculated based on total fuel consumption and sulphur content per fuel type as provided in Klein *et al*. (2018). 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 ofWageningen University and Research Centre. Fuel consumption by agricultural contractors was derived from the trade organization 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 based on 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 non-road mobile machinery. The resulting fuel consumption (energy use) is also reported by Statistics Netherlands in the Energy Balance. The annual correction factors used to adjust the energy use, as reported by EMMA, are provided in Klein *et al*. (2018).

The 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 on 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.

4.6.5 Methodological issues

The current methodology to estimate 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 sector and private households, 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 declinations 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 the 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.

4.6.6 Uncertainties and time series consistency

The EMMA model has been used to calculate fuel consumption and emissions for the time series since 1994. For the earlier years, there were no reliable machinery sales data 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 organized to discuss and estimate the uncertainties in the activity data and the emission factors used for the emission calculations for the transport sector (Dellaert & Dröge, 2017). The resulting uncertainty estimates for NRMM are provided in Table 4.12.

Table 4.12 Uncertainty estimates for NRMM (Dellaert & Dröge 2017)

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

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 recalculations for non-road mobile machinery. The revision of the energy statistics in 2015 was not yet fully implemented in the NFR submission of 2017, but it is included in the 2018 submission. The activity data in 1A2 and 1A4 for the years 1991-1994 have been revised. In part, this is because the heating values and CO_2 emission factors of gasoline and diesel oil have been updated. The emission factors were adjusted accordingly so that emissions were not affected by this methodological change. The update of the heating values is described in more detail in the NIR 2018 submission (Section 3.2.6.5).

The energy statistics on the use of gas oil in the services and construction sectors have been updated for the complete time series. For the construction sector, this was the result of economic growth in the sector affecting the activity data for the 2014-2016 period. This correction also affects the emissions (see Figure 4.9).

For commercially used NRMM, the NO_x, NMVOC, $PM_{2.5}$, PM_{10}, TSP and BC emissions increased after 2000, up to 7-11% in 2015 because the emission factor was increased (see Figure 4.9). Fuel consumption was not adjusted. This was the result of the implementation of the observed trend of new generators in this sector.

Finally, fuel consumption from household mobile machinery decreased by 5% for the 1990-2015 period as a result of updated energy statistics, but emissions remained the same.

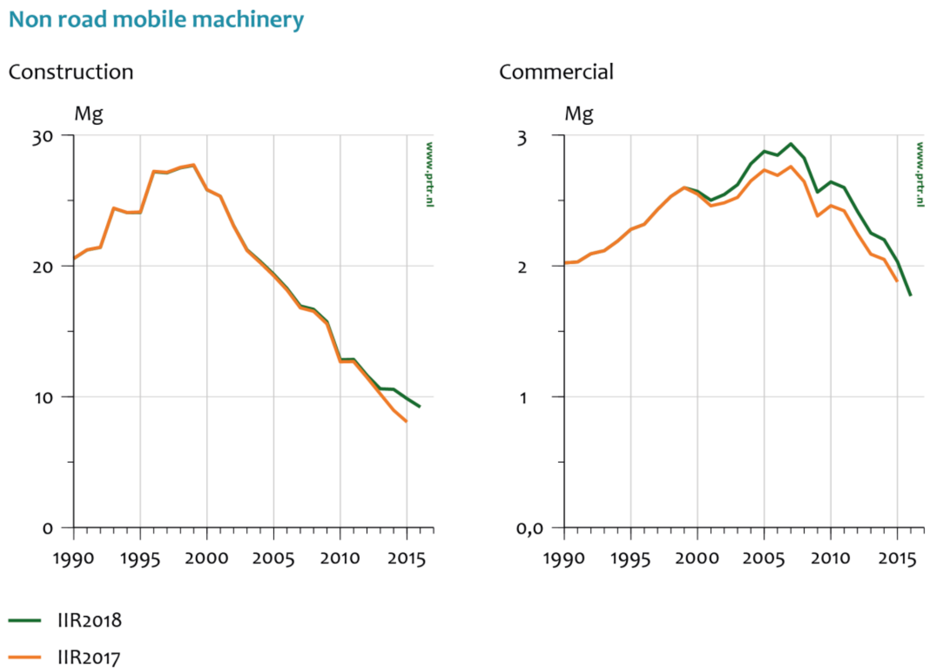

Figure 4.9 NO_x and $PM_{2.5}$ emissions from non-road mobile machinery.

4.6.9 *Source-specific planned improvements*

Emissions from cooling units on trucks are currently not estimated in the EMMA model. In 2018, 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 organizations, but recently those data have become unavailable. In 2018, 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.

4.7.2 *Key sources*

National fishing is not a key source in the emission inventory.

4.7.3 *Overview of emission shares and trends*

National fishing is a small emission source in the Netherlands. In 2016, national fishing was responsible for 2-3% of total NO_x, $PM_{2.5}$ and BC emissions and 1% of PM_{10} emissions. The contribution to the national totals for other substances was less than 1%. Fuel consumption by national fishing has been decreasing since 1999, as is shown in Figure 4.10.

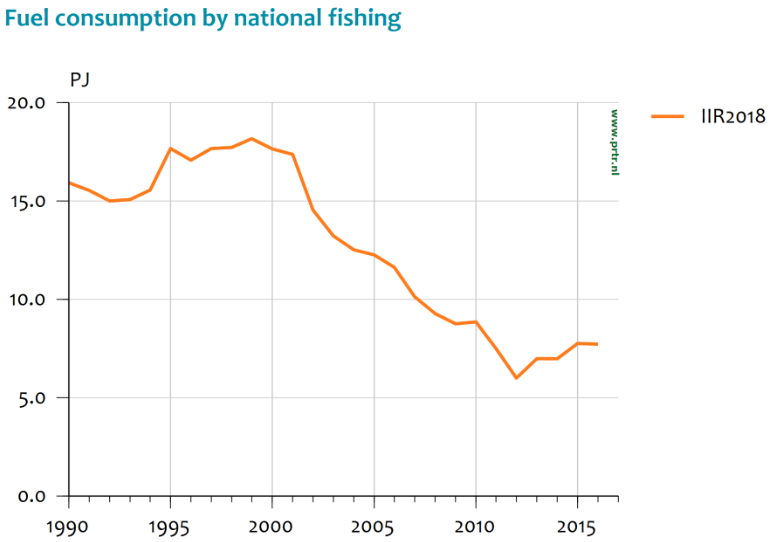

Figure 4.10 Fuel consumption by the fishing fleet in the Netherlands

The trends in emissions from national fishing are shown in Table 4.13. For the most part, emissions from national fishing show similar trends to fuel consumption. NO_x emissions decreased from 20.6 to 8.5 Gg between 1990 and 2016, whereas PM_{10} emissions decreased from 1.16 to 0.30 Gg. SO_x emissions decreased by over 97% due to the use of sulphur-free diesel fuel.

Table 4.13 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	**20.6**	**1.4**	**5.2**	**0.004**	**1.10**	**1.16**	**1.16**	**0.33**	**1.46**
1995	23.1	1.4	6.1	0.004	1.22	1.28	1.28	0.36	1.52
2000	22.5	1.3	5.4	0.004	1.13	1.19	1.19	0.34	1.41
2005	15.5	0.8	3.6	0.003	0.70	0.73	0.73	0.21	0.91
2010	10.9	0.5	1.4	0.002	0.47	0.49	0.49	0.14	0.60
2015	8.8	0.4	0.3	0.002	0.31	0.33	0.33	0.10	0.45
2016	**8.5**	**0.3**	**0.1**	**0.002**	**0.29**	**0.30**	**0.30**	**0.09**	**0.43**
1990-2016 period[1]	-12.1	-1.0	-5.0	-0.002	-0.81	-0.85	-0.85	-0.24	-1.03
1990-2016 period[2]	-59%	-75%	-97%	-52%	-74%	-74%	-74%	-72%	-71%

[1] Absolute difference
[2] Relative difference to 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 derived according to the fuel sold in the country and implied emission factors calculated using AIS-data. Two methodologies based on AIS-data are applied from 2016 onwards. For deep-sea trawlers, the same methodology that is used for maritime navigation is 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 used for maritime shipping. For the other fishing vessel categories (rather small vessels, mostly cutters), the methodology is described in detail by Hulskotte and ter Brake (2017). This is essentially an energy-based method whereby 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 Klein *et al.* (2018).

4.7.5 Methodological issues

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

4.7.6 Uncertainties and time series consistency

The AIS-based approach to calculating emissions from fisheries has been applied to the calculation of emissions in 2016. The implied emission factors 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 the fleet renewal data and the age class of engines for inland shipping.

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

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).

Compared to the previous uncertainty estimates were for fisheries and recreational shipping in the Netherlands, most notable is the large decrease in uncertainty in activity data and the NO_x emission factor for fisheries and the SO_x emission factor for all sectors. The decrease in certainty for the activity data for fisheries is related to the Automatic Identification Systems (AIS), which register the location of (fishing) ships and are used to determine activity data for the emission calculations.

Table 4.14 Uncertainty estimates for national fishing (Dellaert & Dröge 2017)

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

4.7.7 *Source-specific QA/QC and verification*

Trends in total fuel consumption in cutter fishery, 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. Both trends show good agreement.

4.7.8 *Source-specific recalculations*

In this year's inventory, the activity data for fisheries was derived from the Energy Balance by Statistics Netherlands and includes all fuel sold for fishing purposes in the Netherlands. In previous years, the activity data for fisheries was estimated using a bottom-up approach based on the number of days at sea and the installed engine power of the Dutch fleet. The new activity data for fisheries are higher than previously reported, as is shown in Figure 4.11. Activity data are 2-7 PJ higher in this year's inventory.
Also, in previous inventories, the implied emission factors were constant throughout the time series. As a result, trends in emissions followed trends in activity data. In this year's inventory, the emission factors are derived from AIS-based calculations of emissions and energy use in Dutch national waters, taking into account sailing speeds and the installed engines in the fleet, as described in Section 4.7.4. This affects emission factors of all pollutants. The resulting emissions of NMVOC increased by 90% (1990) to 67% (2015), for SO_x by 440% (1990) to 19,500% (2015), for NH_3 by 33% (1990) to 100% (2015), for CO a decrease by 35-38% for 1990-2015. Figure 4.11 also shows the previous and current time series for NO_x and $PM_{2.5}$ implied emission factors.

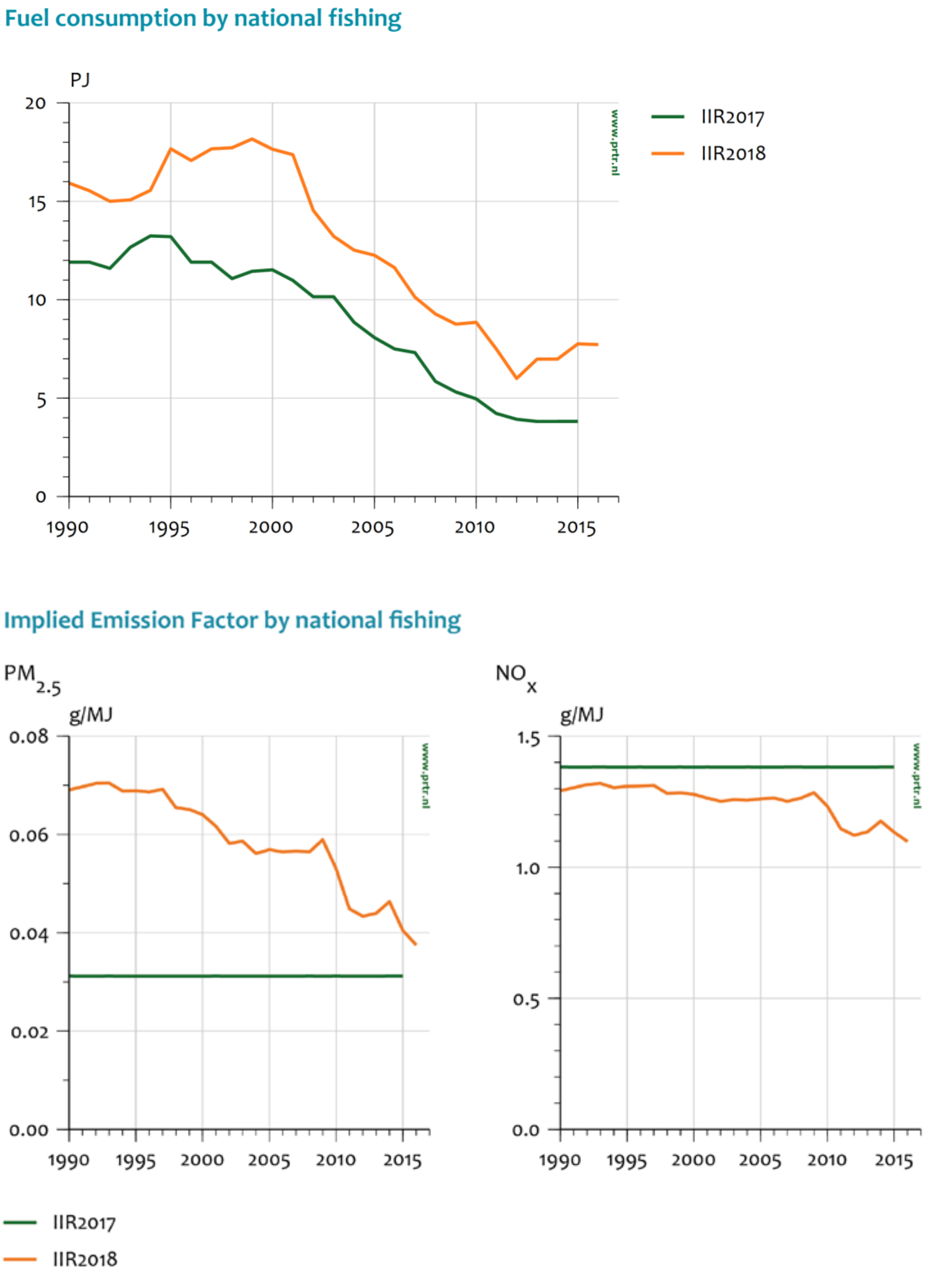

Figure 4.11 Fuel consumption, NO_x and $PM_{2.5}$ implied emission factors of the fishing fleet in the Netherlands

4.7.9 *Source-specific planned improvements*

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

5 Industrial Processes and Product Use (NFR 2)

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. Fugitive emissions in the energy sector (i.e. not related to fuel combustion) are included in NFR sector 1B.

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).

Table 5.1 provides an overview of the emissions from the Industrial Processes and Product Use (NFR 2) sector.

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

Year	Main Pollutants				Particulate Matter		
	NO_x	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$
	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**5.2**	**222**	**10.0**	**5.4**	**50**	**30**	**15**
1995	3.3	162	2.8	5.2	35	19	9.8
2000	1.9	119	1.5	4.0	18	12.7	6.5
2005	0.6	98	1.0	3.6	17	11.2	5.5
2010	0.5	98	0.9	2.6	15	10.5	5.2
2015	0.7	86	0.9	2.2	14	9.6	4.4
2016	**1.0**	**81**	**0.9**	**2.4**	**14**	**9.6**	**4.2**
1990–2016 period[1)]	-4.2	-142	-9.2	-3.0	-35	-20	-11.0
1990–2016 period[2)]	-81%	-64%	-91%	-56%	-71%	-68%	-72%

Year	Priority Heavy Metals			POPs	
	Pb	Cd	Hg	DIOX	PAHs
	Mg	Mg	Mg	g I-Teq	Mg
1990	**67**	**0.9**	**1.2**	**63**	**13**
1995	67	0.7	0.8	49	4.5
2000	24	0.8	0.4	21	0.4
2005	27	1.5	0.4	19	0.4
2010	32	1.0	0.2	17	0.3
2015	7	0.4	0.1	13	0.2
2016	**6**	**0.4**	**0.1**	**12**	**0.1**
1990–2016 period[1)]	-60	-0.5	-1.0	-50	-13
1990–2016 period[2)]	-90%	-53%	-83%	-80%	-99%

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

More than 57% of the total NMVOC emissions in the Netherlands originate from the Industrial Processes and product use (NFR 2) sector.

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 were not included in Sections 5.2 to 5.6. Incomplete time series will be repaired, as much as possible, in future submissions.

5.1.2 *Activity data and (implied) emission factors*

Industrial processes

Data on production levels were derived from Statistics Netherlands. Up to 2007, implied emission factors were determined (see Section 5.1.3).

Product Use
The Activity data and (implied) emission factors of the product use categories are included in 5.5, Solvents and Product Use (5.D).

5.1.3 *Methodological issues*

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

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

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

Whereby
IEF = the implied emission factor;
TP = Total production (Production Statistics, Statistics Netherlands);
P_IF = Production of individual facilities (Production Statistics, Statistics Netherlands).

The implied emission factors were calculated as follows:

IEF = Em IF / P_IF

Whereby
Em_IF = the sum of emissions from individual facilities (since 1999, most of the emissions from individual facilities were derived from the Annual Environmental Reports (AER)).

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 $non\text{-}IF_{(n-1)}$

Whereby
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)

Whereby
IEF = the implied emission factor;
TP = Total production in (sub)category (Production Statistics, Statistics Netherlands);

P_IF = Production in individual facilities (Production Statistics, Statistics Netherlands).

The implied emission factors were calculated as follows:

IEF = Em IF / P_IF

Whereby Em_IF = the sum of the data on the individual facilities.

Since 2000, due to the 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))

Whereby:
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)

Whereby:
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 5.5, Solvents and Product use (5D).

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

5.1.5 *Source-specific QA/QC and verification*
The source categories of this sector are covered by the general QA/QC procedures, as discussed in in Section 1.6.2. of Chapter 1.

5.1.6 *Source-specific recalculations*
In comparison with the previous submission, NMVOC emissions from 2D3a and 2D3i have been recalculated. More information about these recalculations can be found in Section 5.5.6 and Jansen 2018 for a description of the methodology of the emission sources.

5.1.7 *Source-specific planned improvements*

Industrial processes

The CO time series from 2D3i will be corrected in the next submission. Furthermore, the incomplete TSP and Cd time series will be repaired, 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 (please specify in the IIR).

Emissions from lime production (2A2) were included in the subcategory of food and drink process emissions (2H2).
Because of allocation problems, the emissions from 2A5a, 2A5b and 2A5c were reported in the category of other mineral products (2A6). Only emissions from glass production (2A3) and cement production (2A1) could be reported separately, because emissions in this category could be derived from the environmental reports by the corresponding companies.
The emission totals of 2A3 and 2A6 consist of the sum of the reported emissions from individual facilities, supplemented with estimated emissions from the non-reporting facilities. Most of the data on emissions from 2A and 2A6 (more than 90%) are obtained from Annual Environmental Reports (AER's) 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 (AD). For this reason, it is not possible to provide activity data and determine/calculate IEF's.
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 5.2.

Table 5.2 Key sources of Mineral products (2A)

	Category / Subcategory	Pollutant	Contribution to total of 2016 (%)
2A3	Glass production	Pb	8.5
2A6	Other Mineral Products	PM_{10}/$PM_{2.5}$	4.1/2.9

5.2.3 *Overview of emission shares and trends*

Table 5.3 gives an overview of the emissions from the key sources of this category.

Table 5.3 Overview of emissions from the key sources of Mineral products (2A)

NFR Code: NFR NAME: Pollutant: Unit: Year	2A3 Glass production Pb Mg	2A6 Other mineral products PM_{10} Gg	$PM_{2.5}$ Gg
1990	7.3	2.0	0.9
1995	6.5	1.6	0.7
2000	2.9	1.0	0.3
2005	1.4	1.0	0.3
2010	0.8	1.1	0.4
2015	1.0	1.1	0.4
2016	0.8	1.1	0.4

From 1990 to 2016, Pb emissions from 2A3 decreased from 7.3 to 0.8 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, the PM_{10} emission from 2A6 decreased from 2.0 Gg in 1990 to 1.1 Gg in 2016 and the $PM_{2.5}$ emissions from 0.9 Gg to 0.4 Gg.

5.2.4 *Methodological issues*

Method 1-IP was used for estimating the emissions from Glass production (2A3) and Other mineral products (2A6). The 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 (please specify in the IIR)

- 2B10b Storage, handling and transport of chemical products (please specify in the IIR)

Adipic acid (included in 2B3) and calcium carbide (included in 2B5) are not produced in the Netherlands. So emissions from these sources do not occur (NO). Because of allocation problems and for confidential reasons, the emissions from 2B1, 2B2, Silicon Carbide (2B5) 2B6, 2B7 and 2B10b are included in 2B10a, Chemical industry, Other.

The emission total of the Chemical sector consists of the sum of the reported emissions from individual facilities, supplemented with estimated emissions from the non-reporting facilities.
Most of the data on emissions from the Chemical sector (ca 80-90%) are obtained from Annual Environmental Reports (AER's) 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 used solvents, if they are included, are confidential information. However, in most cases companies do not include any production data or the amounts of used solvents (AD). For this reason, it is not possible to provide activity data and determine/calculate IEF-s 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 5.4Table 5.4 *Key sources of Chemical industry (2B)*.

Table 5.4 Key sources of Chemical industry (2B)

	Category / Subcategory	**Pollutant**	**Contribution to total of 2016 (%)**
2B10a	Chemical industry: Other	NMVOC $PM_{10}/PM_{2.5}$	3.4 4.7/6.7

5.3.3 *Overview of emission shares and trends*

Table 5.5Table 5.5 *Overview of emission from the key sources of the Chemical industry(2B)*provides an overview of the emissions from the key sources of this category.

Table 5.5 Overview of emission from the key sources of the Chemical industry(2B)

NFR Code:	**2B10a**		
NFR NAME:	**Chemical industry: Other**		
Pollutant:	**NMVOC**	**PM_{10}**	**$PM_{2.5}$**
Unit:	**Gg**	**Gg**	**Gg**
Year			
1990	33	4.1	2.6
1995	18	3.0	1.9
2000	13	1.2	0.8
2005	7.9	1.2	0.9
2010	5.7	1.3	1.0
2015	4.7	1.1	0.8
2016	4.8	1.2	0.8

From 1990 to 2016, NMVOC emissions decreased from 33 Gg to 4.8 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 5.6.

Table 5.6 Overview of indices of the Chemical sector (2010=100)

Year	**Index**
2005	90.2
2006	95.5
2007	98.9
2008	92.7
2009	89.6
2010	100
2011	98.2
2012	103.5
2013	99
2014	98.5
2015	95.9
2016	104.3

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 (please specify in the IIR);
- 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 in1A2b.
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, the 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, the $PM_{2.5}$ emissions are also reported as “NA” in 2C7a.
There are two lead, two copper and two zinc producers in the Netherlands. 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 in1A2b.
Emissions from storage and handling by companies with main activities other than those mentioned above are included in the relevant categories of this NFR sector.

5.4.2 *Key sources*

The key sources of this category are presented in Table 5.7.

Table 5.7 Key sources of Metal production (2C)

	Category / Subcategory	**Pollutant**	**Contribution to total of 2016 (%)**
2C1	Iron and Steel Production	$PM_{10}/PM_{2.5}$ Pb Hg	4.9/6.3 51.0 17.0
2C5	Lead production	Hg	14.5
2C6	Zinc production	Pb	12.0

5.4.3 *Overview of emission shares and trends*

Iron and steel production (2C1)

The Netherlands has one integrated iron and steel plant (Tata Steel, formerly known as Corus and Hoogovens). Integrated steelworks convert iron ore into steel by means of sintering, produce pig iron in blast furnaces and subsequently convert this pig iron into steel in basic oxygen furnaces.
The energy-related emissions are included under combustion emissions (categories 1A1c and 1A2a) and fugitive emissions under category 1B2. Table 5.8 provides an overview of the process emissions from the key source of Iron and steel production (category 2C1).

Table 5.8 Overview of emissions from Iron and steel production (2C1)

NFR Code:	**2C1**					
NFR NAME:	**Iron and steel production**					
Pollutant:	**PM_{10}**	**$PM_{2,5}$**	**Pb**	**Hg**	**Dioxin**	**PAH's**
Unit:	**Gg**	**Gg**	**Mg**	**Mg**	**g I-Teq**	**Mg**
Year						
1990	9.1	5.8	56	0.4	23	1.64
1995	4.8	3.1	58	0.3	26	1.62
2000	2.0	1.5	19	0.1	1.40	0.08
2005	1.7	1.1	23	0.2	1.40	0.06
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
2016	1.3	0.8	4.5	0.1	0.32	0.07

In addition to PM_{10}, $PM_{2.5}$, Pb and Hg (the key source pollutants), iron and steel production is also responsible for 1.4 % of the total in dioxins and for 1.4 % 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 rather stable. Because of the replacement of electrostatic filters and the optimization of some other reduction technologies at Tata Steel, most of the emissions decreased after 2010. Dioxin emission fluctuations were mainly caused by the varying process conditions.

Aluminium production (2C3)
Aluminium production (category 2C3) is responsible for 0.23% of all PAH emissions in the Netherlands. PAH emissions originate from 'producing anodes' and the 'use of anodes' during primary aluminium production. Up to 2011, anodes were produced in two plants (Aluchemie and Zalco) and primary aluminium was produced at two primary aluminium smelters (Zalco – previously Pechiney – and Aldel). Anode and primary aluminium producer Zalco was closed in 2011 and Aldel was closed at the end of 2013. Aldel made a restart under the name Klesch Aluminium Delfzijl in 2015.

Table 5.9 provides an overview of the PAH emissions from aluminium production (category 2C3).

Table 5.9 Overview of PAH emissions from aluminium production (2C3)

NFR Code:	**2C3**
NFR NAME:	**Aluminium production**
Pollutant:	**PAHs**
Unit:	**Mg**
Year	
1990	6.909
1995	1.664
2000	0.128
2005	0.132
2010	0.108
2011	0.290
2012	0.001

NFR Code:	2C3
NFR NAME:	Aluminium production
Pollutant:	PAHs
Unit:	Mg
Year	
2013	0.006
2014	0.006
2015	0.024
2016	0.011

Between 1990 and 2000, PAH emissions decreased from 7 Mg in 1990 to less than 0.13 Mg in 2000. These reductions were mainly caused by the implementation of technical measures.
During the 2012-2014 period, PAH emissions decreased further to 0.006 Mg in 2014, These reductions were mainly caused by:

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

For these reasons, aluminium production (category 2C3) is no longer considered a key source of PAHs.
Emission fluctuations were mainly caused by the varying process conditions, combined with a measurement 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 of the PAH emissions to 0.024 Mg.

Lead production (2C5) and zinc production (2C6)
Because of the decreased Pb and Hg emissions from 2C1 (Iron and steel production), lead production (2C5) is now a key source for Hg and Zinc production (2C6) for Pb. The Hg emissions from lead production (2C5) have remained rather stable since 2012, while the Pb and Zn emissions from zinc production(2C6) increased sharply after 2013. The reason for these increases is not known at this moment. Before the next submission, the Netherlands will try to find an explanation for this sharp increase.

5.4.4 Methodological issues

Method 1-IP was used to estimate the emissions from Iron and steel production (2C1), Aluminium production (2C3), Lead production (2C5) and Zinc production (2C6). In cases without a complete registration for the four individual PAHs, a set of specific factors was used to calculate the emissions of the other, missing individual 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 consist of 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 was available. The emissions from chemical products (category 2D3g) are included in 2B10a (see also 5.3.1).
More than 40% of the total NMVOC emissions in the Netherlands originate from Solvents and product use (2D).

5.5.2 *Key sources*

The key sources of this category are presented in Table 5.10.

Table 5.10 Key sources of Solvents and product use (2D)

	Category / Subcategory	Pollutant	Contribution to total of 2016 (%)
2D3a	Domestic solvent use including fungicides	NMVOC	18.0
2D3d	Coating applications	NMVOC	10.0
2D3i	Other solvent use	NMVOC PM_{10}/$PM_{2.5}$ DIOX	10.3 3.6/7.5 52.0

5.5.3 *Overview of emission shares and trends*

Table 5.11 provides an overview of the emissions from the key sources of this category.

Table 5.11 Overview of emission from key sources of Solvents and product use (2D)

NFR Code:	2D3a	2D3d	2D3i			
NFR NAME:	Domestic solvent use including fungicides	Coating applications	Other solvent use			
Pollutant:	NMVOC	NMVOC	NMVOC	PM_{10}	$PM_{2.5}$	Dioxin
Unit:	Gg	Gg	Gg	Gg	Gg	g I-Teq
Year						
1990	16	93	18	1.9	1.9	25
1995	19	67	17	1.8	1.8	23
2000	21	41	15	1.8	1.8	20
2005	23	26	15	1.5	1.5	18
2010	24	28	16	1.5	1.5	15
2015	25	19	14	1.1	1.1	13
2016	26	14	15	0.9	0.9	13

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

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

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

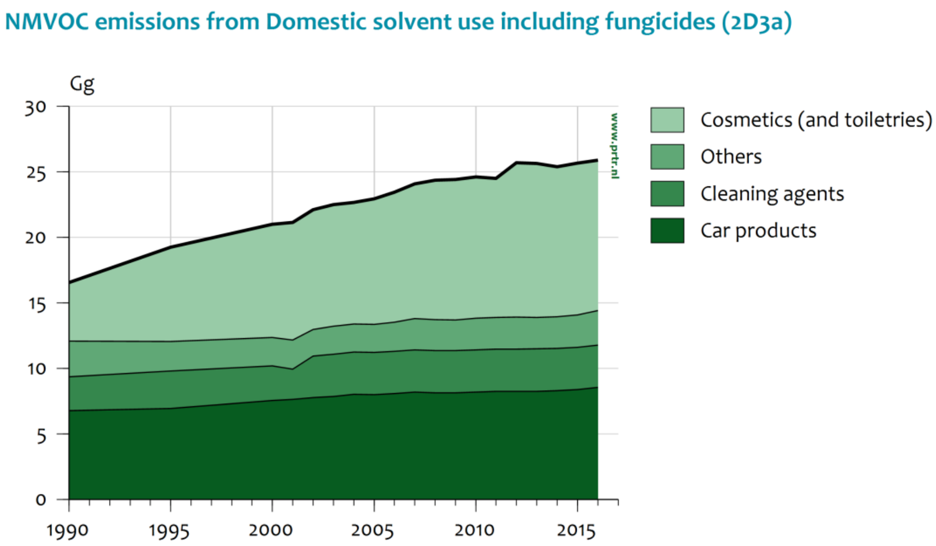

Figure 5.1 NMVOC emissions from sources of Domestic solvent use, including fungicides (2D3a)

During the period 1990-2016, NMVOC emissions increased from 16 Gg in 1990 to 26 Gg in 2016. This was mainly the result of the increase in the consumption of cosmetics.

Coating applications (2D3d)
The emission sources in this key source are:

- Industrial paint applications;
- Domestic use;
- Construction and buildings;
- Car repairing;
- Boat building;

Figure 5.2 shows the trend in NMVOC emissions from the sources of Coating applications (category 2D3d) over the 1990–2016 period.

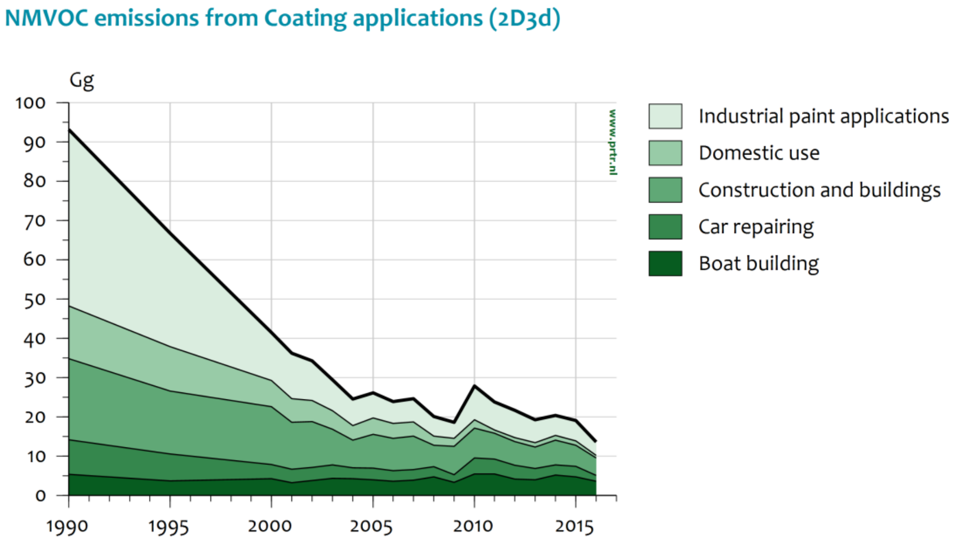

Figure 5.2 NMVOC emissions from sources of Coating applications (2D3d)

Mainly due to the lower average NMVOC content of the paints used, NMVOC emissions from Coating applications (2D3d*)* 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 high NMVOC levels, the total NMVOC emissions increased to 28 Gg in 2010. During the 2010-2013 period, paint consumption decreased again, which resulted in a decline in the NMVOC emissions to 19 Gg in 2013. A slight increase in paint consumption led to an increase in the NMVOC emissions by 1 Gg in 2014. In 2015, a lower NMVOC content of the paints resulted in a decrease of the NMVOC emissions. Due to a decreased paint consumption in 2016 (mainly in the market segments of Car repairs and Industry), the NMVOC emissions decreased to 14 Gg in 2016.

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:
  - o Cosmetics sector Trade and services;
  - o Car products (mainly windscreen cleaning fluid);
  - o Detergents: sector Trade and services;
  - o 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.

The emissions from the Use of HFC, PFC and HCFCs as refrigerants and other uses of HFCs, PFCs and HCFCs are obtained from the National Inventory Report.
Until 2000, the NMVOC emissions for most of the other sources were obtained from the Hydrocarbons 2000 project (KWS 2000). Due to a lack of more recent data after the Hydrocarbons 2000 project, the 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.

The most important source of PM_{10} and $PM_{2.5}$ emissions (approximately 75% of the emissions) in 2D3i is the smoking of cigarettes and cigars.

NMVOC emissions in this category decreased from 18 Gg in 1990 to 15 Gg in 2016. 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 13 g I-TEQ in 2016.
The most important source of PM_{10} and $PM_{2.5}$ emissions (76% of the emissions) in 2D3i is the smoking of cigarettes. As a result of the drop in the number of cigarettes smoked, the emission of 2D3i decreased from 1.9 Gg in 1990 to 0.9 Gg in 2016.

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 organizations, 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). The total paint consumption decreased from 197 Gg in 1990 to 122 Gg in 2016 and the NMVOC content decreased from 30% in 1990 to almost 13% in 2011. During the 2012-2014 period, the NMVOC content remained rather stable. In 2015, the NMVOC content decreased further to 12%. From this submission onwards, no NMVOC content figures have been available. Therefore, the NMVOC content is kept equal to the 2015 value.

Other solvent use (2D3i)
Sales data on products and the NMVOC content of products were obtained from annual reports issued by branch organizations, 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 2018.

Domestic solvent use, including fungicides (2D3a)
Total NMVOC emissions per product 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 paint sales (of paint that was both produced and sold within the Netherlands) that were provided by the Dutch Paint and Ink Producers Association (VVVF) and 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 methodology report ENINA (Peek, 2018).

Other solvent use (2D3i)
Total NMVOC emissions per product 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 both 2D3a and 2D3i, the emissions from windscreen cleaning products have been recalculated using a new emission factor of 112 mg NMVOC per km.
This resulted in an emission increase (2D3a: 3-4Gg; 2D3i; 3-5 Gg) for the entire time series.

Emissions from air fresheners had not yet been estimated in the previous submission. The emissions are now calculated with an emission factor of 46.7 g NMVOC per household and are included in 2D3a. (+0.3 Gg)

Emissions from anti-corrosive treatment of cars has been improved. In the previous submission, the emissions were assumed to be the same for the 2000-2015 period. In the current submission, it is assumed that only the cars built before 1985 are treated once every 8 years with an emission factor of 8 kg/car.
This resulted in a small emission decrease in 2D3i for the 2000-2015 period.

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 production and Meat, fish, etc., 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 5.3.1 Source-category description).

5.6.2 *Key sources*

The key sources of this category are presented in Table 5.12.

Table 5.12 Key sources of Other production industry (2H)

	Category / Subcategory	**Pollutant**	**Contribution to total of 2016 (%)**
2H2	Food and beverages industry	NMVOC $PM_{10}/PM_{2.5}$	2.0 7.1/2.7
2H3	Other industrial processes	NMVOC $PM_{10}/PM_{2.5}$ Pb	7.3 9.9/5.6 5.3

5.6.3 *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 emission from the key sources of Other Production Industry (2H)

NFR Code:	2H2		2H3		
NFR NAME:					
Pollutant:	PM_{10}	$PM_{2.5}$	NMVOC	PM_{10}	$PM_{2.5}$
Unit:	Gg	Gg	Gg	Gg	Gg
Year					
1990	4.3	0.8	25	5.4	1.6
1995	2.3	0.4	13	3.3	0.8
2000	1.9	0.3	6	3.2	0.9
2005	1.8	0.3	10	2.7	0.7
2010	1.6	0.3	10	2.6	0.7
2015	1.8	0.3	10	2.6	0.7
2016	1.9	0.3	10	2.6	0.7

Food and beverages industry (2H2)
From 1990 to 2016, PM_{10} emissions decreased from 4.3 to 1.9 Gg. These reductions were mainly caused by the implementation of technical measures.

Other industrial processes (2H3)
The 2H3 subcategory in the Dutch PRTR includes emissions from the storage and handling of bulk products and from many other different activities. 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 2016, NMVOC emissions decreased from 25 Gg to 10 Gg. The emission contribution of the storage and handling of liquid bulk products was 15 Gg in 1990 and 8 Gg in 2016.
Figure 5.3 shows the trend in PM_{10} emissions from the storage and handling of dry bulk products over the 1990–2016 period.

PM_{10} emissions decreased from 5.4 Gg to 2.6 Gg during the 1990–2016 period. The emission contribution of the storage and handling of dry bulk products was 1.4 Gg in 1990 and 0.8 Gg in 2016. Reductions in NMVOC and PM_{10} emissions were mainly caused by the implementation of technical measures. After 2005, PM_{10} emission fluctuations were caused by the varying volume of products handled.

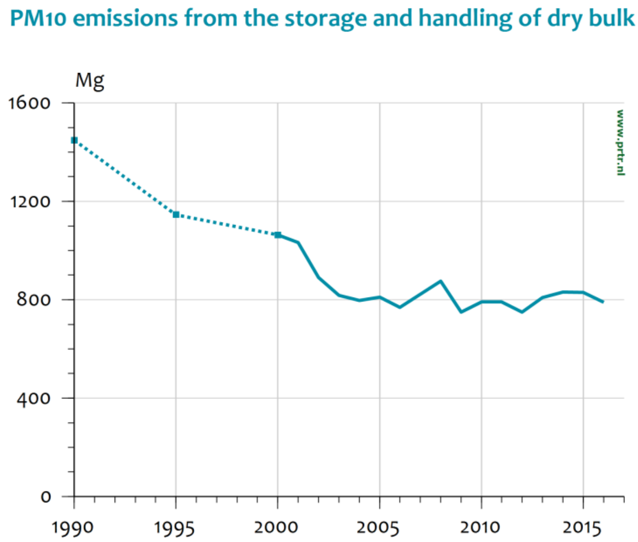

Figure 5.3 Storage and handling of dry bulk products: trend and emissions of PM_{10}

5.6.4 *Methodological issues*

Method 2-IP was used to estimate the emissions from the production of food and drink (category 2H2).
Method 1-IP was used to estimate particulate matter (PM) emissions from the storage and handling of 2H3; method 2-IP was used to estimate all other emissions of 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 from the storage and handling sector have been corrected. This has resulted in small PM_{10} emission changes for the 2005-2015 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. As the field burning of agricultural residues is prohibited by law for the entire time series, emissions in category 3F did not occur. NO_x emissions from the cultivation of organic soils are allocated to category 3I.

Emissions of the greenhouse gases methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) from the agricultural sector were reported in the annual National Inventory Report (NIR). All emissions were calculated according to the methods described in Vonk *et al.* (2018).

In 2016, the agricultural sector was responsible for 86% of all NH_3 emissions in the Netherlands. Emissions of NO_x amounted to 13% of the national total. NMVOC emissions from the handling of manure were not estimated; NMVOC emissions from crop production played a minor role in the national total (0.1%).

Agriculture accounted for 24% of the national PM_{10} emissions. Animal houses produce a relatively large amount of PM_{10} compared with $PM_{2.5}$. For this reason, the contribution of $PM_{2.5}$ from agriculture to the national total is only 5%. Although zinc is not a priority heavy metal, emissions from drift following pesticide use are reported for the sake of completeness.

The Netherlands used an N-flow model to calculate N-emissions. Figure 6.1 presents a schematic overview of NH_3 and NO_x emissions from NFR sectors 3B and 3D in relation to the N-flows.

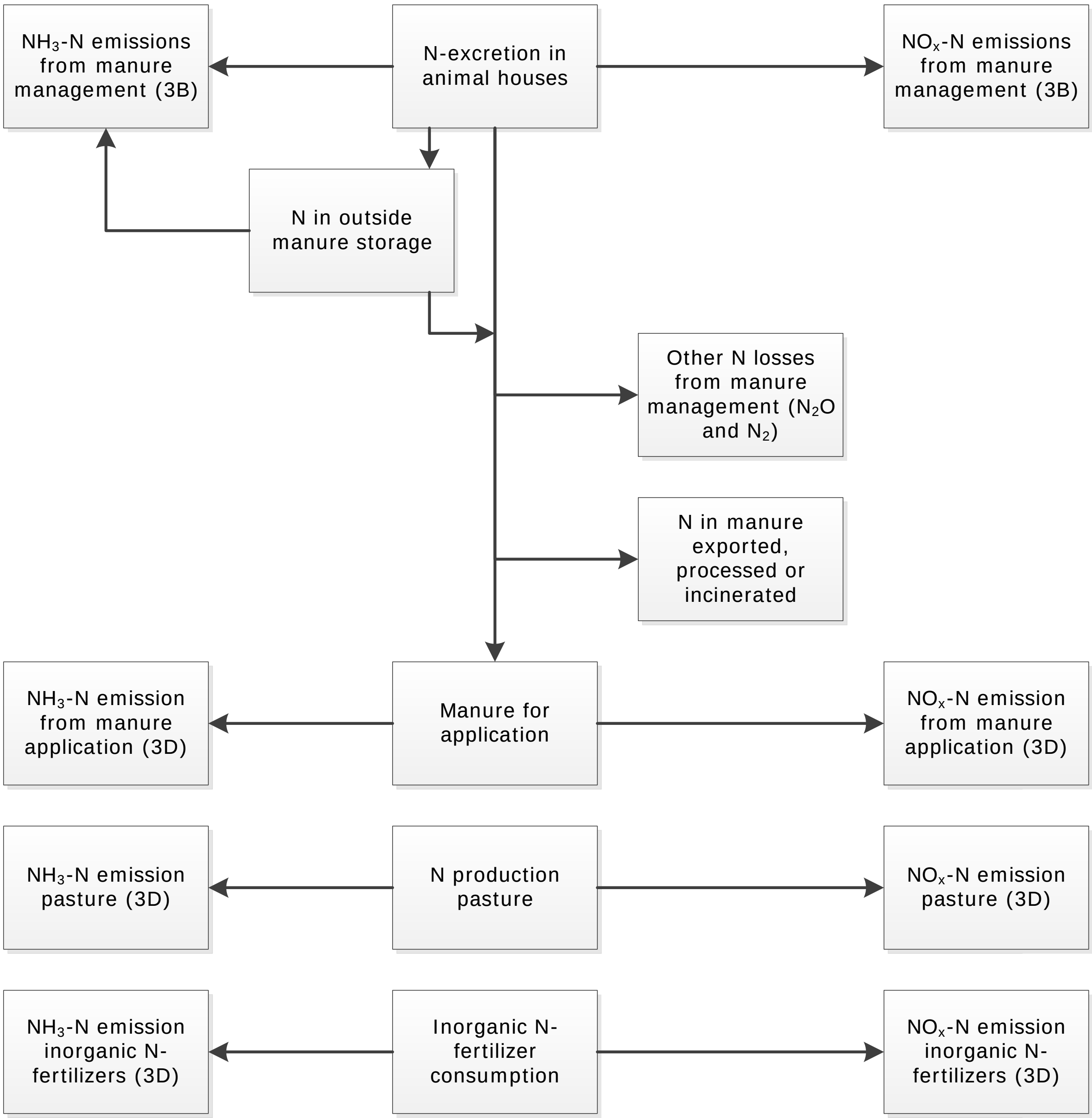

Figure 6.1 Nitrogen flows in relation to NH_3 and NO_x emissions

6.1.1 Key sources

According to the key source analysis, the key sources for NH_3 emissions from agriculture were:

- 3Da2a Animal manure applied to soils;
- 3B1a Dairy cattle;
- 3B3 Swine;
- 3Da1 Inorganic N-fertilizers;
- 3B1b Non-dairy cattle.

The NFR category 6A Other is also a key source and contributed 8% to the national total. Sector 6A included the emissions from privately owned horses and from the application of inorganic N-fertilizer, animal manure and compost outside agriculture. Calculation methods for these emissions are similar to the methods described in this chapter.

For PM_{10} emissions from agriculture, the key source were:
- 3B4gi Laying hens;
- 3B4gii Broilers;
- 3B3 Swine;
- 3Dc Farm-level agricultural operations, including the storage, handling and transport of agricultural products.

For NO_x emissions from agriculture, the key sources were:
- 3Da2a Animal manure applied to soils;
- 3Da1 Inorganic N-fertilizers.

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

6.1.2 *Trends*

NH_3 emissions decreased between 1990 and 2016, with a significant reduction in the first few years of the time series. A ban on the surface spreading of manure was enforced in 1991, making it mandatory to incorporate manure into the soil either directly or shortly after application. To a large extent, this reduced the emission of NH_3 from the application of animal manure. In addition, it became mandatory to cover manure storages. More recently the introduction of low-emission housing for animals further decreased ammonia emissions.

Maximum application standards for manure and fertilizer and systems of production rights promoted efficiency. For example, milk quotas led to an increased feeding of maize to dairy cattle in order to increase the milk production per cow. Increased production per animal led to a decrease in animal numbers and consequently lower emissions. Another example was the ongoing improvement in nutritional management, whereby a reduction of dietary crude protein resulted in lower N excretions per animal and consequently reduced NH_3 emissions.

The N excreted by animals decreased considerably between 1990 and 2016, while the amount of manure exported or incinerated increased sixfold. Other N losses from animal housing and nitrogen in manure outside agriculture also increased, leading to 21 per cent less nitrogen in manure to be applied on agricultural soils. Since the other N losses from animal housing also comprised the washing liquid of air scrubbers, which was used as an inorganic N-fertilizer, some emissions shifted to category 3D Crop production and agricultural soils. The same applied for nitrogen in manure used outside agriculture, as those emissions were allocated to category 6A Other. Since most of the NH_3 emissions originated from the agricultural sector, the decreasing trend in NH_3 emission from agriculture was also reflected in the decreasing trend of the national total.

Particulate matter

PM emissions for most animal categories decreased slightly over the 1990–2016 period due to decreased animal numbers; however, the PM emissions in laying hens 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 ground housing or aviary systems with solid manure and higher associated emission factors 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.

6.2 Manure management

6.2.1 Source category description

In the category Manure management (3B), emissions from the handling and storage of animal manure are 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.

Category 3B4a (Buffalo) does not occur in the Netherlands. Emissions from the category 3B4giv, Other poultry, include the emissions from ducks. Under category 3B4h (Other animals), rabbits and furbearing animals are being reported. From the IIR 2017 onwards, emissions from pets have been reported in category 6A Other.

Emissions resulting from the application of animal manure or during grazing were considered to be related to land use and are not reported under 3B Manure management, but are included in 3D Crop production and agricultural soils.

6.2.2 Key sources

Within sector 3B, dairy cattle (NFR category 3B1a) had the largest contribution to NH_3 emissions, amounting to 16% of the national total. Swine (NFR category 3B3, 10%) and non-dairy cattle (NFR category 3B1b, 9%) were also NH_3 key sources.

Within sector 3B, laying hens (NFR category 3B4gi) were the largest source for PM_{10} emissions, amounting to 11% of the national total. Broilers (NFR category 3B4gii; 5%) and swine (NFR category 3B3; 4%) were also key categories for PM_{10}. For emissions of $PM_{2.5}$ and NO_x, the manure management sector had no key sources.

6.2.3 Overview of emission shares and trends

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

Table 6.1 Emissions of main pollutants and particulate matter from sector 3B Manure management

Year	Main Pollutants		Particulate Matter	
	NO_x	NH_3	$PM_{2.5}$	PM_{10}
	Gg	Gg	Gg	Gg
1990	**3.6**	**98**	**0.4**	**4.1**
1995	3.6	96	0.4	4.1
2000	2.9	75	0.4	4.6
2005	2.6	65	0.4	4.6
2010	2.8	65	0.5	5.2
2015	3.1	55	0.5	5.7
2016	**3.1**	**55**	**0.5**	**5.7**
1990-2016 period [1)]	-0.5	-43	0.1	1.6
1990-2016 period [2)]	-13%	-44%	12%	38%

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

Between 1990 and 2016, NH_3 emissions from manure management were reduced by 44%. 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 except cattle.
Furthermore, NH_3 emissions decreased due to the increased proportion of low-emission housing. As NO_x emissions were also influenced by the above-mentioned developments, NO_x emissions decreased by 13% from 1990 to 2016.

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 in the poultry sector. The increased available floor space per animal added to this effect.

6.2.4 *Activity data and (implied) emission factors*

Basic input data include animal numbers as determined by the annual agricultural census (see the summary in Table 6.2 and Van Bruggen *et al.* [2015 plus subsequent updates] 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 NEMA, yet were reported under the source category Other (6A).

Table 6.2 Animal numbers in 1990-2016 (x 1,000)

Animal type	1990	1995	2000	2005	2010	2014	2015	2016
Cattle	4,926	4,654	4,069	3,797	3,975	4,068	4,134	4,251
dairy cattle	*1,878*	*1,708*	*1,504*	*1,433*	*1,479*	*1,572*	*1,622*	*1,745*
non-dairy cattle	*3,048*	*2,946*	*2,565*	*2,364*	*2,497*	*2,496*	*2,512*	*2,507*
Sheep[1]	1,702	1,674	1,305	1,361	1,130	959	946	784
Swine	13,915	14,397	13,118	11,312	12,255	12,238	12,603	12,479
Goats	61	76	179	292	353	431	470	500
Horses[1]	70	100	117	133	141	126	117	82
Mules and asses[1]	NO	NO	NO	NO	1	1	1	1
Poultry	94,902	91,637	106,517	95,190	103,371	104,685	108,558	107,312
laying hens	*51,592*	*45,734*	*53,078*	*48,418*	*56,500*	*56,019*	*57,656*	*56,431*
broilers	*41,172*	*43,827*	*50,937*	*44,496*	*44,748*	*47,020*	*49,107*	*49,188*
turkeys	*1,052*	*1,207*	*1,544*	*1,245*	*1,036*	*794*	*863*	*762*
other poultry	*1,086*	*869*	*958*	*1,031*	*1,087*	*853*	*932*	*931*
Other animals	1,340	951	981	1,058	1,261	1,324	1,404	1,286

[1] excluding privately owned animals

Source: CBS, 2017

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.*, in prep.). For instance, the agricultural census only provided implementation grades of abatement techniques in a very general manner (e.g. floor/cellar adaptation or air scrubber). Further subdivision was possible with the detailed information from environmental permits.

N-emission calculations

Emissions of NH_3 and NO_x from animal manure in animal houses and outside manure storage places were calculated using the National Emission Model for Agriculture (NEMA) at a Tier 3 level. The N excretions per animal were calculated annually by the Working group on the Uniformity of calculations of Manure and mineral data (WUM). The historic data were recalculated in 2009 (CBS, 2012a) and supplemented yearly by means of the publication series '*Dierlijke mest en mineralen*' (Animal manure and minerals, Dutch text), thereby ensuring consistency.

The total ammonia nitrogen (TAN) in manure was estimated using faecal digestibility of the N in various feed components within the rations. From N excretion data, the TAN-excretion per housing type and corresponding NH_3 emission factor was 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 ratio of these losses to 1:1. 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 emissions and other N losses of N_2O, NO_x and N_2 from animal housing were calculated and subtracted from the excreted N. The amount of manure that was stored and the corresponding NH_3 emissions from storage were calculated. The sum of emissions from both animal housing and manure storage per livestock type were reported under their respective subcategories in sector 3B Manure management. After subtracting all N losses during manure management, the net export and processing and incineration of manure, the amount of N available for application was calculated (as used for calculating emissions from manure application and from grazing, allocated to sector 3D).

The NH_3 emission per animal was reduced for all animal species due to improved efficiency. However, in cattle this effect was countered by an increased living space for each animal, which resulted in a net increase in cattle IEF. Although the living space for each animal was also increased in swine and poultry, emission reduction techniques such as air scrubbers and manure drying more than countered the effect. The fluctuating N-content of grass silage caused yearly changes in the IEF of cattle.

Implied emission factors for NH_3 emissions in sector 3B Manure management were calculated for the main NFR categories and presented in Table 6.3.

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

Animal type	**1990**	**1995**	**2000**	**2005**	**2010**	**2014**	**2015**	**2016**
Cattle	6.8	6.8	5.8	6.5	6.8	7.2	7.2	7.4
- Dairy cattle	*11.8*	*11.9*	*9.5*	*11.5*	*11.8*	*11.8*	*11.9*	*11.7*
- Non-dairy cattle	*3.7*	*3.8*	*3.5*	*3.4*	*3.8*	*4.3*	*4.3*	*4.3*
Sheep	0.4	0.4	0.4	0.2	0.1	0.1	0.1	0.1
Swine	3.5	3.4	2.7	2.2	1.9	1.1	1.1	1.0
Goats	1.6	1.6	1.4	1.2	1.2	1.2	1.3	1.3
Horses	4.5	4.5	4.5	4.3	4.0	4.0	4.0	4.1
Mules and asses	NO	NO	NO	NO	2.8	2.8	2.8	2.8
Poultry	0.15	0.16	0.14	0.15	0.12	0.10	0.09	0.09
- Laying hens	*0.16*	*0.17*	*0.17*	*0.17*	*0.15*	*0.14*	*0.13*	*0.13*
- Broilers	*0.11*	*0.12*	*0.10*	*0.09*	*0.06*	*0.04*	*0.03*	*0.03*
- Turkeys	*0.80*	*0.79*	*0.80*	*0.85*	*0.95*	*0.96*	*0.94*	*0.97*
- Other poultry	*0.31*	*0.30*	*0.28*	*0.24*	*0.21*	*0.19*	*0.19*	*0.20*
Other animals	0.40	0.38	0.32	0.28	0.22	0.23	0.24	0.24

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

Particulate matter
Emissions of PM_{10} and $PM_{2.5}$ from agriculture mainly consisted of animal skin, manure, feed and bedding particles originating from animal housing. The general input data used for these calculations were animal numbers and housing systems taken from the annual agricultural census and environmental permits.

Country-specific emission factors for PM emissions from animal housing were derived from a measurement programme conducted by Wageningen UR Livestock Research. For several livestock categories and animal housing types, PM_{10} and $PM_{2.5}$ emissions were determined and consequently published in the '*Fijnstofemissie uit stallen*' series ('Dust emission from animal houses', Dutch text with English summary that is available through www.asg.wur.nl). For housing types not included in the studies, emission factors were estimated according to housing characteristics and space per animal, proportional to the studied housing types. When emission factors had to be derived within animal categories (e.g. laying hens under and over 18 weeks of age), the excreted amount of phosphorus was used. An overview of the resulting emission factors was presented in Vonk *et al.*, 2018. Implied emission factors for PM_{10} and $PM_{2.5}$ are given in Table 6.4 and Table 6.5.

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

Animal type	1990	1995	2000	2005	2010	2014	2015	2016
Cattle	85	83	78	79	78	79	80	81
- Dairy cattle	*115*	*115*	*115*	*120*	*124*	*126*	*127*	*128*
- Non-dairy cattle	*67*	*64*	*57*	*54*	*51*	*50*	*50*	*49*
Sheep	NE	NE	NE	NE	NE	NE	NE	NE
Swine	113	112	112	110	104	81	77	74
Goats	19	19	19	19	19	19	19	19
Horses	220	220	220	220	220	220	220	220
Mules and asses	NO	NO	NO	NO	160	160	160	160
Poultry	22	23	26	32	35	41	40	41
- Laying hens	*15*	*16*	*23*	*34*	*39*	*52*	*50*	*51*
- Broilers	*27*	*27*	*27*	*27*	*27*	*26*	*26*	*26*
- Turkeys	*100*	*98*	*95*	*95*	*95*	*95*	*95*	*95*
- Other poultry	*105*	*105*	*105*	*105*	*105*	*105*	*105*	*105*
Other animals	4	5	5	6	7	6	6	6

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

Animal type	1990	1995	2000	2005	2010	2014	2015	2016
Cattle	24	23	22	22	21	22	22	22
- Dairy cattle	*32*	*32*	*32*	*33*	*34*	*35*	*35*	*35*
- Non-dairy cattle	*19*	*18*	*16*	*15*	*14*	*14*	*14*	*13*
Sheep	NE	NE	NE	NE	NE	NE	NE	NE
Swine	6	6	6	5	5	4	4	4
Goats	6	6	6	6	6	6	6	6
Horses	140	140	140	140	140	140	140	140
Mules and asses	NO	NO	NO	NO	100	100	100	100
Poultry	2	2	3	3	3	3	3	3
- Laying hens	*1*	*1*	*2*	*2*	*2*	*3*	*3*	*3*
- Broilers	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*
- Turkeys	*47*	*46*	*45*	*45*	*45*	*45*	*45*	*45*
- Other poultry	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
Other animals	2	2	3	3	3	3	3	3

Uncertainties and time series consistency

A propagation of error analysis on NH_3 emissions was performed in 2015. Using reassessed uncertainty estimates of input data (CBS, 2012) and the judgement of experts, 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 was performed in 2017 and the results are presented in Section 1.7.

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

6.2.5 *Source-specific QA/QC and verification*

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

6.2.6 *Source-specific recalculations*

A study of the digestibility of cattle feeds was performed, which led to adjustments in the TAN excretions. In the process, the separate digestibilities for the housing and grazing periods were replaced by a year-round factor. As a result, NH_3 emissions from the manure management of dairy cows increased by 0.4 Gg in 1990 and 0.3 Gg in 2015. For non-dairy cattle, the increase was 0.6 Gg in 1990 and 0.3 Gg in 2015.

An update of the emission factors for NH_3 emissions from poultry housing (Ellen *et al.*, 2017) was processed. For the manure management of poultry, NH_3 emissions decreased by 2.1 Gg in 1990 and 0.4 Gg in 2015.

NO_x emissions from privately owned animals (horses, mules and asses and sheep) were reallocated to sector 6A Other.

6.2.7 *Source-specific planned improvements*

An appropriate calculation method for NMVOC emissions from Manure management is currently being investigated. These will then be included in the emission inventory and reported in the IIR and NFR.

6.3 Crop production and agricultural soils

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.

Emissions within the categories 3Db and 3Dd do not occur in the Netherlands. 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 3De and 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 29% of the national total. Inorganic N-fertilizers (3Da1) were also a key source of NH_3, making up 9% of the national total.

Within sector 3D, farm-level agricultural operations including storage, handling and transport of agricultural products (3Dc) was a key source for PM_{10} emissions at 2% of the national total. In NO_x 3Da2a, Animal manure applied to soils (5%) and 3Da1 Inorganic N-fertilizers (4%) were key sources. For emissions of $PM_{2.5}$ and NMVOC, the crop production and agricultural soils sector contained no key sources.

6.3.3 *Overview of shares and trends in emissions*

Table 6.6 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 6.6 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}	Zn
Year	Gg	Gg	Gg	Gg	Gg	Mg
1990	**45.4**	**0.2**	**233**	**0.1**	**0.8**	**0**
1995	43.7	0.2	109	0.1	0.8	0
2000	37.0	0.2	83	0.1	0.8	0
2005	31.2	0.2	69	0.1	0.8	6.8
2010	28.4	0.2	51	0.1	0.8	4.5
2015	29.7	0.2	54	0.1	0.7	4.5
2016	**29.9**	**0.2**	**55**	**0.1**	**0.7**	**4.5**
1990-2016 period[1)]	-15.6	0.0	-178	0.0	-0.1	4.5
1990-2016 period[2)]	-34%	16%	-76%	-5%	-7%	

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

N-emissions
Emissions of NH_3 decreased by 76% between 1990 and 2016, 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.

Particulate matter
The particulate matter emissions reported in this source category originated from 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.

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

N-emission calculations
For N-emission calculations in sector 3D, activity data were calculated from N-excretion from sector 3B minus N-emissions from housing and storage. After subtracting the N in manure removed from agriculture (either exported or incinerated), the remaining N was allocated to pasture and arable land. Implementation grades of application techniques were derived from the agricultural census. The associated NH_3 emission factors were reported in Vonk *et al.* (2018). NO_x emissions related to manure, fertilizer and sewage sludge application, compost use and the grazing of animals were calculated using the EMEP default factor.

Ammonia 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. These emission factors were used in NEMA to calculate NH_3 emissions from inorganic N-fertilizers. In recent years, the amount of applied urea fertilizer has increased and a growing share is coated with urease inhibitors to reduce NH_3 emissions and/or is applied with NH_3 low-emission techniques. To account for this development, additional subcategories of urea fertilizer were specified for the 1990-2016 time series, as described in the methodology report of Vonk *et al.* (2018). The used subgroups and the emission factors for each subgroup have been published in Van Bruggen *et al.* (in prep.).

Calculations of NH_3 emissions from crop residues were based on activity data taken from the agricultural census. The emission factors used originated from research conducted by De Ruijter *et al.* (2013). Given the large uncertainty in the emissions through crop ripening, a fixed estimate of 1.5 Gg NH_3-N/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 6.7. 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 6.7 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	2014	2015	2016
Application of inorganic N-fertilizers	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05
Application of animal manure	0.50	0.20	0.19	0.18	0.13	0.13	0.12	0.12
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	0.08	0.08
Urine and dung deposited by grazing animals	0.08	0.08	0.04	0.03	0.03	0.03	0.03	0.03
Crop residues	0.05	0.05	0.04	0.03	0.03	0.03	0.03	0.03
Crop ripening	NA	NA	NA	NA	NA	NA	NA	NA

Particulate matter
Small sources of PM_{10} and $PM_{2.5}$ emissions reported under category 3D were the application of inorganic N-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 (Vonk et al., 2018). PM from other agricultural processes (e.g. the supply of concentrate feed to farms, the use of pesticides and haymaking) was estimated using fixed amounts (Van der Hoek, 2002). Crop harvesting was calculated based on acreage data from the agricultural census and EMEP default emission factors. An overview is provided in Table 6.8.

Table 6.8 Emission factors for PM_{10} and $PM_{2.5}$ from 3D Crop production and agricultural soils

Emission factor (kg/ha)	PM_{10}	$PM_{2.5}$
Wheat	1.49	0.21
Barley	1.25	0.17
Rye	1.15	0.15
Oats	1.78	0.25
Other crops	0.25	0.02
Added estimate (ton/year)	**PM_{10}**	**$PM_{2.5}$**
Haymaking	6	1.2
Supply of concentrates	90	18
Supply and use of fertilizers	105	21
Use of pesticides	125	25

6.3.5 *Uncertainties and time series consistency*
A propagation of error analysis of NH_3 emissions was performed in 2015. Using reassessed uncertainty estimates of input data (CBS, 2012) and the judgement of experts, an uncertainty of 37% was calculated for NH_3 emissions following animal manure application, 37% for inorganic N-fertilizer use and 57% 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 NH_3 emissions from agriculture comes to 25%. A Monte Carlo-analysis on the uncertainties of the total inventory was performed in 2017 and the results are presented in Section 1.7.

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

6.3.6 *QA/QC and verification*

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

6.3.7 *Recalculations*

Emission factors for NH_3 from manure application were partly reconsidered. For narrow-band application on grassland, the emission factor increased from 26 to 30.5% of TAN applied. The emission factor for slit coulter is calculated as the mean of narrow-band application and shallow injection, and is 24.8% instead of 22.5% in the more recent years of the time series. Also, the emission factor for surface application on grassland was reconsidered in order to account for application during the winter in the base year (the practice has not been allowed since 1991). The emission factor was changed from 74% to 67% for 1990 and to 71% for all subsequent years. For dairy cattle, emissions decreased by 9.4 Gg in 1990 and by 1.2 Gg in 2015. For non-dairy cattle, the decrease was by 4.0 Gg in 1990 and by 0.8 Gg in 2015.

A study on the digestibility of cattle feeds was performed which led to adjustments in the TAN excretions. In the process, the separate digestibilities for the housing and grazing period were replaced by a year-round factor. NH_3 from the grazing of dairy cows decreased by 1.5 Gg in 1990 and by 0.1 Gg in 2015, and by 1.3 Gg in 1990 and by 0.1 Gg in 2015 for non-dairy cattle.

NO_x emissions from sector 3D were not accounted for under the NEC. Therefore, emissions from animal manure application, inorganic N-fertilizer use and grazing were previously reported as a memo item under the category of Other natural emissions (11C). Only NO_x emissions from sewage sludge and compost were reported under category 3D. This categorization was reconsidered for this submission, with emissions now allocated to the source categories 3Da1 Inorganic N-fertilizers, 3Da2a Animal manure applied to soils and 3Da3 Urine and dung deposited by grazing animals.

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 or 3I Agriculture other, respectively. Emissions increased by 2.1 Gg in 1990 and by 1.6 Gg in 2015 through crop residues. Emissions from organic soils amounted to 2.3 Gg in 1990 and 2.1 Gg in 2015.

NO_x emissions from manure disposal on nature terrain and on private properties were re-allocated to sector 6A Other.

6.3.8 *Planned improvements*

Newly applied techniques for manure processing, such as anaerobic digestion and separation of manure, are currently being studied. The proportion of processed manure in the Netherlands is increasing. A new methodology to estimate emissions (or emission reductions) from the processing of manure is planned to be implemented in the next submission.

No new information was available on the use of inorganic N-fertilizers, other than on the proportions of urea types. When this information becomes available, emissions for 3Da1 Inorganic N-fertilizers will be recalculated for 2016.

An appropriate method to calculate NMVOC emissions from Crop production and agricultural soils is currently being investigated. This will then be taken up in the emission inventory and reported in the IIR and NFR.

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 from extracted landfill gas. Since the 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 produced biogas 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, 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 sector on energy (source category Public electricity and heat production (1A1a)).
NO_x and SO_x emissions from cremations (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 annual environmental reports 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 is flared. For this reason, the WWPT emissions are reported under the source category Commercial/institutional: Stationary (1A4ai).

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

7.1.1 *Key sources*

There are no relevant key sources in the Waste sector.

7.1.2 *Overview of shares and trends in emissions*

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

With the exception of NMVOC and Hg, emissions have increased since 1990. With respect to NH_3, this increase was mainly caused by an increase in the industrial composting of household organic waste in the years 1990-1994. For all other pollutants, this increase has been caused by increased activity. The increase sometimes is somewhat 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			Heavy Metals/POPs	
	NMVOC	NH_3	TSP	$PM_{2.5}$	PM_{10}	Hg	DIOX
Year	Gg	Gg	Gg	Gg	Gg	Mg	g I-Teq
1990	**1.5**	**0.05**	**0.153**	**0.146**	**0.153**	**0.06**	**1.59**
1995	1.3	0.31	0.173	0.163	0.173	0.07	2.05
2000	1.0	0.32	0.171	0.164	0.171	0.10	2.06
2005	0.8	0.34	0.158	0.151	0.158	0.09	1.88
2010	0.5	0.25	0.181	0.172	0.181	0.05	1.98
2015	0.4	0.22	0.180	0.169	0.178	0.01	1.92
2016	**0.4**	**0.23**	**0.190**	**0.172**	**0.180**	**0.01**	**1.96**
1990-2015 period [1]	-1.1	0.18	0.037	0.026	0.037	-0.04	0.37
1990-2015 period [2]	-76%	402%	24%	18%	18%	-77%	23%

[1] Absolute difference
[2] Relative difference to 1990 in %

7.1.3 *Methodological issues*

The methodology used to calculate the emissions from these source categories, with exception of the source `*Accidental building and car fires*', are described in Peek, 2018.
The methodology to calculate the emissions coming from the source *Accidental building and car fires*' is described in WESP, 2018.

There are no specific methodological issues.

7.1.4 *Uncertainties and time series consistency*

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

7.1.5 *Source-specific QA/QC and verification*

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

7.1.6 *Source-specific recalculations*

In the source category Other waste (5E), the source "Incidental building and car fires" is added (see Section 1.6).

7.1.7 *Source-specific planned improvements*

There are no source-specific planned improvements.

7.2 Solid waste disposal on land (5A)

7.2.1 *Source-category description*

The source category of Solid waste disposal on land (5A) comprises the direct emissions from landfills and from captured landfill gas.
Extracted landfill gas is mainly used as an energy source and a relatively small amount is flared. For this reason, the emissions from this source are included in the energy sector (source category Other Stationary (1A1a)).

Included in this source category are all waste landfill sites in the Netherlands that have been managed and monitored since 1945. This concerns both historical and current public landfills, plus waste landfill sites on private land. These waste sites are considered to be responsible for most of the emissions from this source category.
The total amount of landfill gas produced in the Netherlands is calculated using a first-order degradation model which calculates the degradation of DOC (degradable organic carbon) in the waste. From this information, the amount of methane is calculated using a methane conversion factor (Table 7.2). Its assumed that 10% of the non-extracted methane will be oxidized in the top layer of the landfill.

Table 7.2 Input parameters used in the landfill degradation model.

Parameter	Parameter values	References
Oxidation factor (OX)	0.1 (10%)	[Coops *et al.*, 1995]
f = fraction of degradable organic carbon (DOCf)	0.58 From 1945 through 2004; thereafter constant 0.5	[Oonk *et al.*, 1994]
Degradable speed constant k	0.094 From 1945 through 1989 (half-life time 7.5 yr); from 1990 reducing to 0.0693 in 1995; thereafter constant 0.0693 (half-life time 10 yr); from 2000 reducing to 0.05 in 2005; thereafter constant 0.05 (half-life time 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 through 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 *et al.*, 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 through 2004; thereafter constant 0.5	[Oonk, 2016]
MCF(x) = Methane correction factor for management	1	
Delay Time	6 months	

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

With regard to the direct emission of landfill gas, only NMVOCs are of relevance under the Convention on Long-Range Transboundary Air Pollution (CLRTAP). The individual compounds that form NMVOCs mainly originate from volatile organic compounds that were dumped in the past as part of waste. A small part is produced as a by-product during the biodegradation of organic materials within the waste. The direct NMVOC emissions from landfills were calculated based on fractions of individual compounds in the landfill gas (Table 7.3).

7.2.2 Overview of shares and trends in emissions

NMVOC emission levels related to this source category are relatively low (with 1.45 Gg and 0.34 Gg in 1990 and 2016, respectively). Therefore, shares and trends in these emissions are not elaborated here.

7.2.3 Emissions, activity data and (implied) emission factors

Emissions of the individual compounds of NMVOC have been calculated as fractions of the emission total using a landfill gas emission model for methane based on the IPCC guidelines. The fractions were based on measurements of the composition of landfill gas. An overview of the emission factors used is provided in Table 7.3.

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 weighing bridges. Since 2005, landfill operators have been obliged to register their waste on the basis of EURAL codes (EC-Directive 75/442/EEG).

Table 7.3 Landfill gas emission factors

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

7.3 Composting and anaerobic digestion (5B)

7.3.1 Source-category description

The source category of 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 composting and/or fermenting of separately collected organic waste for composting and/or biogas production. 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 from fruits and vegetables) separately from other (domestic) waste. The main part of the organic waste is composted on an industrial scale and a small part is turned into biogas through anaerobic digestion.

During composting and fermentation, biodegradable and other organic waste is converted into compost and/or biogas. These processes are carried out in enclosed facilities (halls, tunnels and/or fermentation tanks), 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 shifted to optimize aeration.

The domestic organic waste that is processed in an anaerobic digester results in biogas that is used in energy production. This source category (5B2) is included in the energy sector (source category of Small combustion (1A4)).

7.3.2 *Overview of shares and trends in emissions*

NH_3, NO_x and SO_x emission levels related to this source category are relatively low (for 1990 respectively 0.05 Gg, 0.0 Gg and 0.0 Gg and for 2016 respectively 0.229 Gg, 0.098 Gg and 0.005 Gg). Therefore, shares and trends in these emissions are not elaborated here.

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

The emission factors used come from sparse literature about emissions from composting and/or fermenting separated biodegradable and other organic waste. It appears that there is hardly any monitoring conducted at the biobed reactors. The literature cannot be considered relevant due to the clearly different operational methods used in the Netherlands.

Emission factors for the composting and fermentation of biodegradable 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 om a monitoring programme in the Netherlands (DHV, 1999).

The following emission factors have been used used:

- NH_3 from fermentation, 2.3 g/Mg of biodegradable and other organic waste;
- NH_3 from composting, 200 g/Mg of biodegradable and other organic waste;
- NO_x from fermentation, 180 g/Mg of biodegradable and other organic waste;
- SO_x from fermentation, 10.7 g/Mg of biodegradable and other organic waste.

The processed amount of other organic waste is based on the amount declared to the Landelijk Meldpunt Afvalstoffen (LMA), the hotline for national waste transport. A few wastestreams are selected, these are LoW-codes 020103, 020107 and 200020, and processed with the composting treatment. Table 7.4 provides an overview of the amounts composted.

LMA has no information on the amounts of other organic waste for the years before 2010. Therefore, the amounts for the period 1996-1999 are estimated based on the amounts in 2010-2012 and set to 250,000 Mg/year. Just as the separate collection of biodegradable waste, the other organic waste also started in the 1990s, so the amount is assumed to have been null Mg in 1990 and that it increased linearly to 1996, when the estimated amount was 250,000 Mg. From 2000 onwards, there was a slow decrease in the processed amounts of organic household waste. This is regarded to have resulted from a smaller share of garden waste in the total amount due to the increase in paved surfaces in home gardens.

Table 7.4 Overview of composted organic waste

Year	Amounts of composted organic wastes (Gg)	
	Horticulture	Household (garden, fruit and vegetable)
1990	0.0	228
1995	2 057	1 454
2000	2 475	1 568
2005	2 784	1 367
2010	2 437	1 220
2015	2 077	1 357
2016	2 670	1 431

7.4 Waste incineration (5C)

7.4.1 Source-category description

The source category of 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 from 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)) and, if used as fuel, they are reported under the subsequent Industry category.

Emissions from cremations (category 5C1bvi) originate from the incineration of human remains (process emissions) and from combustion emissions. The emissions of the natural gas used are reported under the energy sector (source category of Commercial and institutional services (1A4ai)). There is no incineration of carcasses and slaughter waste in the Netherlands. Carcasses and slaughter waste are processed to reusable products, amongst other biofuels.

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

7.4.2 *Key sources*

The relevant substances that are emitted during the cremation of human remains are mercury (Hg), dioxin, PM_{10} and $PM_{2.5}$.
Up to 2010, cremations were a relevant key source for Hg. Since 2012, all cremation centres have complied with the Dutch Atmospheric Emissions Guideline (NeR) and are equipped with technological measures to reduce emissions. As a result, cremations are no longer a key source.

7.4.3 *Overview of shares and trends in emissions*

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

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

Activity data

The number of cremations in the Netherlands is published online by the Dutch National Association of Crematoria (LVC), at www.lvc-online.nl (LVC, 2017).

Table 7.5 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
2013	141 245	86 018	61	100
2014	139 223	85 493	61	100
2015	147 134	93 177	63	100
2016	148,898	93,907	64	100

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

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

All the mercury in the amalgam is assumed to become volatilized 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 have been shown to lead to a significant reduction in mercury emissions. Measurements that were taken, when in compliance with the NeR, resulted in concentrations of between 0.001 and 0.004 mgHg/m^3 (Elzenga, 1996). Based on this result, an emission factor of 0.1 gHg/cremation (0.05 mgHg/m^3 fume) was assumed when in compliance with the NeR.

Emission factor for TSP, PM_{10} and $PM_{2.5}$
When no emission reduction measures were in place, an emission factor of 100 g TSP/cremation was 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.
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.

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

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

7.5 Waste-water handling (5D)

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

7.6 Other waste (5E)

7.6.1 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. The emissions from this source, in line with the guidebook, are reported under “Sewage sludge applied to soils (3Da2b)”.
The remainder of the sewage sludge is recycled or incinerated. To minimize the costs 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. The 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 possibilities for 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 happens mainly at individual 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 and sent to specialized recycling companies. During the recycling process, a small amount of NMVOCs is emitted from the fridges’ and freezers’ insulating layer.

Accidental building and car fires

Due to accidents or sometimes on purpose, cars and houses are lost in a fire. The smoke caused by the fire is the source of the emissions. When a house or car burns, the amount of material lost in the fire is determined by the response time of (professional) fire fighters.

Accidental building and car fires produce, amongst others, emissions of particulate matter and dioxins.

7.6.2 *Overview of shares and trends in emissions*

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

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

Waste preparation for recycling

Data on the 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 implied emission factors and production data or those 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) will emit 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 were 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. The monitoring reports are published online at www.wecycle.eu. In the past, these data were supplied by the NVMP (Dutch Foundation Disposal Metalelectro Products). 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 van $PM_{2.5}$ and dioxin coming from accidental building and car fires are relatively small.

Emission factors used

The emission factors of house fires in the guidebook (5.E. Tables 3.3 to 3.5) seem inappropriate for the Dutch situation. The emission factor in the guidebook is based on a Norwegian study. However, the houses built in Norway contain more wood and Norway is more rural.
To get an estimate for the Dutch situation, a study on the Dutch house stock by TNO was used to obtain an amount of combustible materials, leaving out the 95% non-combustible materials like concrete and bricks. Without the interior of the house, this results in about 10.3 tonnes. Based on the judgement of experts, the interior is estimated to be three tonnes, making a total of 13.3 tonnes. According to statistics of fire fighters in the Netherlands (brandweerstatistiek 2013), about 90% of the fires are regarded as small and 10% as big. To come to a correct estimate for the amount of materials destroyed in a fire, for small fires it's assumed 25% of the materials are combusted and for big fires 100% of the materials is combusted. So, on average, 32.5% of the house is lost in a fire, resulting in about 4.3 tonnes of materials burned. An

emission factor of 2.5 g PM_{10}/kg was applied (based on open wood burning), resulting in 10.8 kg PM_{10}/fire.
The PM_{10} emission factor was converted to a $PM_{2.5}$ and EC emission factor based on the judgement of experts.
The PCDD/F emission factor is based on the relation of PCDD/F and PM_{10} emission factors presented in the guidebook.
The emission factors of heavy metals presented for house fires in the guidebook are considered irrelevant for the Dutch situation, since the amounts released are very low (<<0.1%).

For car fires, an article was found that provides the numbers of car fires for 2015 and 2016. This article refers to ‘www.alarmeringen.nl’ and seems to be legitimate. The year 2014 was interpolated from 2013 and 2015.

Activity data used
The number of houses and cars exposed to fire was reported annually by CBS Statline until 2013. Those numbers are used for the time series of 1990-2013.
For the house fires occurring in 2014 and the years since, an assumption was made that 0.2% of the houses were exposed to a fire.

The number of car fires (6,034 in 2016) in the Netherlands is derived from the emergency service networks register (https://alarmeringen.nl).

8 Other

8.1 Overview of the sector

The Other sources sector emissions (Table 8.1) include those from sources that cannot be placed under a specific NFR. The Other sources sector (NFR 6) 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 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). The emissions from horses and ponies in an agricultural setting are reported under the Agricultural sector (3B), while the emissions of NH_3, NO_x and PM resulting from the Manure management from horses and ponies in a non-agricultural setting are reported in this sector and calculated using NEMA (see Chapter 6.2).

From 2016, privately owned sheep and mules and asses are also considered 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 sewer system, the ammonia 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 amount of cattle is used for nature management (grazing in nature areas). From this non-agricultural source, emissions of NH_3 and NO_x come from the storage and application of the manure and from grazing.

Domestic animals (Pets)

Emissions from Domestic animals (Pets) originate mainly from 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 Mineral products (2A)

	Category / Subcategory	Pollutant	Contribution to total of 2016 (%)
6A	Other sources	NH_3	7.8

8.2.3 *Methodological issues*

The methodology used for calculating the emissions from the sources `*Human transpiration and respiration*' and `*Pet animals*' are described in WESP, 2018. The methodology for calculating the emissions coming from the sources `*Privately owned livestock*' and `*Manure sold and applied to private properties or nature areas*' can be found in Vonk et al.(2018).

There are no specific methodological issues.

8.2.4 *Uncertainties and time series consistency*

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

8.2.5 *Source-specific QA/QC and verification*

Verification for the source Domestic animals (Pets) is done using a survey conducted by order of the branch organization DIBEVO (entrepreneurs in the pet supplies branch). The numbers of cats and dogs from this survey combined with the emission factors for cats and dogs from Sutton et al.(2000) represent 70% of the total emissions (Booij, 1995).
There are no further source-specific QA/QC procedures in place in this sector. The remainder of sources in this sector are covered by the general QA/QC procedures, as discussed in Chapter 1.

8.2.6 *Source-specific recalculations*

The emissions from human transpiration and respiration have been recalculated. This refers to an error correction in the calculation of the NH_3 emissions. Former time series were erroneously calculated with NH_3-N as a physical unit for the emission factors. The methodology has now been corrected with a correction factor of 17/14 to correct for this. As a result of this recalculation, the emissions of NH_3 from this source increased for the complete time series by approximately 0.3 Gg.

8.2.7 *Source-specific planned improvements*

There are no source-specific planned improvements.

8.2.8 *Overview of shares and trends in emissions*

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

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

	Main Pollutants		Particulate Matter		
	NO_x	NH_3	TSP	$PM_{2.5}$	PM_{10}
Year	Gg	Gg	Gg	Gg	Gg
1990	**1.7**	**12.1**	**0.042**	**0.066**	**0.066**
1995	1.9	9.6	0.042	0.066	0.066
2000	1.7	8.3	0.042	0.066	0.066
2005	2.0	9.8	0.042	0.066	0.066
2010	1.8	8.8	0.042	0.066	0.066
2015	1.9	9.6	0.042	0.066	0.066
2016	**2.0**	**10.0**	**0.045**	**0.071**	**0.071**
1990-2016 period [1)]	0.295	-2.1	0.003	0.005	0.005
1990-2016 period [2)]	18%	-17%	8%	8%	8%

[1)] Absolute difference
[2)] Relative difference to 1990 in %

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

Privately owned livestock

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

Starting in 2016, a number of sheep and mules and asses previously considered within the Agriculture sector are now considered under 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 coming from this source gradually increased over the time series in line with the increase in human population, from 1.5 Gg in 1990 to 1.7 Gg in 2016.
The population numbers in the Netherlands are derived from CBS Statline (http://statline.cbs.nl/) and increased from 14,893,000 in 1990 to 16,979,000 people in 2016.
To avoid underestimation, the high-end emission factor of 0.0826 kg NH_3 per person per year (Sutton et al., 2000) is used to calculate the emission coming from this source.

Manure sold and applied to private properties or nature areas

The NH_3 emissions from this source decreased over the time series from 5.8 Gg in 1990 to 3.4 Gg in 2016, while the NOx emissions from this source increased from 1.6 Gg in 1990 to 1.9 Gg in 2016.

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

Domestic animals (Pets)
The NH_3-emissions from this source gradually increased over the time series from 1.2 Gg in 1990 to 1.5 Gg in 2016.
Emissions are calculated using an emission factor per house. The number of houses is derived from Statistics Netherlands. The emission factor used is based on Booij (1995), who calculated a total emission of 1,220 tonnes NH_3 from all domestic animals (cats, dogs, rabbits and birds) for the year 1990. With the total emission in 1990 and the number of houses in 1990, an emission factor of 0.2 kg NH_3 per household was calculated.

9 Response to the reviews

9.1 Combined CLRTAP and NEC review 2015

At the twenty-fifth session of the Executive Body for the Convention on Long-range Transboundary Air Pollution (2007), the Executive Body 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 submitted data (see http://www.ceip.at/).
The review also seeks to achieve a common approach to prioritizing and monitoring inventory improvements under the Convention with other organizations 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 of the Netherlands was last reviewed in 2015. In the review report, several recommendations were given to improve the inventory and inventory reporting. These recommendations are part of the annual plan for improvement.

Table A2.1 provides an overview of the status of the recommendations' implementation.

9.2 NEC review 2017

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 2017 submission of 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 as extras to the work plan in order to ensure a follow-up to the majority of recommendations before the next review in 2018.

Table A2.2 shows the status of the implementation of these recommendations from this NEC-review.

10 Recalculations and other changes

10.1 Recalculations of certain elements of the IIR2017

Compared with the IIR2017 (Jimmink *et al.*, 2017), only a few methodological changes were implemented in the Pollutant Release and Transfer (PRTR) system:

- Inclusion of two new emissions sources (Accidental building and car fires) in the inventory;
- Inclusion of the NOx emissions (formerly reported under category 11C) in the national total
- Inclusion of two new emissions sources for NO_x (crop residues applied to soils and agriculture other, cultivation of organic soils).

10.2 Improvements

10.2.1 *Included improvements*

During the compilation of the IIR2017, minor errors were detected, which have been repaired in the IIR2018. The following significant improvements were carried out during the improvement process of the Dutch PRTR:

- Revision of the fuel use of diesel and biogas based on a revision of the energy statistics;
- Detailing of the energy statistics for the years 1991-1994. They now fully align with the other years, which were revised in previous years;
- Due to the update of parameters in the N flow model, NH_3 emissions from agriculture changed compared with the latest submission.

10.2.2 *Planned improvements*

In 2015, the IIR and NFR-tables were subjected to a stage 3 review. This resulted in several findings by the review team. These issues were, to some extent, dealt with in the IIR 2017.
In 2017, the IIR was reviewed in relation to the NEC emissions. The recommendations were implemented according to Table A2.2.

The remaining actions with respect to content will be prioritized and are planned for implementation in the inventories of 2018 and 2019. Appendix 2 gives a quick view of the planning regarding the actions from the reviews.

10.3 Effects of recalculations and improvements

Table 10.1 to Table 10.2 show the changes in total national emission levels for the various compounds, compared with the inventory report of 2017.

Table 10.1 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010 and 2015 (NO_x, NMVOC, SO_x, NH_3 and particulate matter).

National total		**NO_x (as NO_2) Gg NO_2**	**NMVOC Gg**	**SO_x (as SO_x) Gg SO_x**	**NH_3 Gg**	**$PM_{2.5}$ Gg**	**PM_{10} Gg**	**TSP Gg**	**BC Gg**	**CO Gg**
1990	IIR 2017	**603.9**	**489.8**	**193.3**	**368.8**	**50.8**	**74.0**	**97.4**	**13.1**	**1143.2**
	IIR 2018	**655.6**	**498.0**	**197.4**	**350.1**	**51.6**	**74.9**	**98.3**	**13.3**	**1141.8**
Difference	absolute	**51.7**	**8.2**	**4.1**	**-18.7**	**0.8**	**0.9**	**0.9**	**0.2**	**-1.4**
	%	*8.6%*	*1.7%*	*2.1%*	*-5.1%*	*1.7%*	*1.2%*	*0.9%*	*1.9%*	*-0.1%*
2000	IIR 2017	**420.5**	**243.5**	**73.4**	**177.9**	**27.9**	**42.5**	**51.0**	**9.6**	**751.6**
	IIR 2018	**463.7**	**252.2**	**77.9**	**175.1**	**28.9**	**43.5**	**52.0**	**9.9**	**749.5**
Difference	absolute	**43.2**	**8.6**	**4.5**	**-2.8**	**0.9**	**1.0**	**1.0**	**0.2**	**-2.1**
	%	*10.3%*	*3.5%*	*6.2%*	*-1.6%*	*3.3%*	*2.3%*	*1.9%*	*2.5%*	*-0.3%*
2010	IIR 2017	**299.7**	**165.2**	**33.9**	**134.9**	**16.5**	**30.0**	**36.8**	**5.3**	**675.4**
	IIR 2018	**333.8**	**174.7**	**35.2**	**132.7**	**17.0**	**30.5**	**37.3**	**5.4**	**674.5**
Difference	absolute	**34.1**	**9.5**	**1.4**	**-2.2**	**0.5**	**0.5**	**0.5**	**0.2**	**-0.9**
	%	*11.4%*	*5.7%*	*4.1%*	*-1.6%*	*3.1%*	*1.7%*	*1.4%*	*3.3%*	*-0.1%*
2015	IIR 2017	**228.2**	**139.0**	**30.3**	**127.6**	**12.8**	**26.4**	**33.9**	**3.2**	**570.0**
	IIR 2018	**267.8**	**149.3**	**30.6**	**125.8**	**13.2**	**26.8**	**34.2**	**3.4**	**568.9**
Difference	absolute	**39.7**	**10.3**	**0.3**	**-1.8**	**0.3**	**0.3**	**0.3**	**0.2**	**-1.0**
	%	*17.4%*	*7.4%*	*1.2%*	*-1.4%*	*2.6%*	*1.2%*	*1.0%*	*6.6%*	*-0.2%*

The increase in NOx emissions is mainly caused by the inclusion of new emission sources in the national total (agricultural emissions). These NOx sources (inorganic N-fertilizers, animal manure applied to soils and urine and dung deposited by grazing animals) were reported under “Memo Items” (11C) in previous IIRs.
The increase in the emissions of NMVOC was caused by the recalculation of the use of windscreen washer fluid (transport) and the new emissions source of scented candles/incense sticks/fragrance oils (consumers), both reported in category 2.
The increase in SO_x in earlier years was caused by the revision of the fuel use. The changes occurred mostly in the category National fisheries.

The changes in NH_3 emissions originate from the recalculations of the digestibility of animal feed, resulting in lower emission factors in the

agricultural sector, and from updated emission factors for NH_3 from poultry housing.
The changes in particulate emissions resulted from the changes in fuel use in transport (fisheries, MNRM), updated PM_{10} and $PM_{2.5}$ fractions in industry and a new emissions source; Accidental building and car fires.

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

National total		Pb Mg	Cd Mg	Hg Mg	As Mg	Cr Mg	Cu Mg	Ni Mg	Se Mg	Zn Mg
1990	IIR 2017	**331.6**	**2.1**	**3.6**	**1.3**	**11.8**	**36.8**	**72.9**	**0.4**	**224.1**
	IIR 2018	**331.6**	**2.1**	**3.6**	**1.3**	**11.8**	**36.8**	**72.9**	**0.4**	**224.1**
Difference	absolute	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	%	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2000	IIR 2017	**27.3**	**1.0**	**1.1**	**0.9**	**5.0**	**39.2**	**18.6**	**0.5**	**95.4**
	IIR 2018	**27.3**	**1.0**	**1.1**	**0.9**	**5.0**	**39.2**	**18.6**	**0.5**	**95.4**
Difference	absolute	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	%	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2010	IIR 2017	**37.5**	**2.6**	**0.6**	**0.6**	**3.8**	**45.2**	**2.1**	**1.5**	**102.4**
	IIR 2018	**37.5**	**2.6**	**0.6**	**0.6**	**3.8**	**45.2**	**2.1**	**1.5**	**102.4**
Difference	absolute	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	%	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*-0.1%*	*0.0%*	*0.0%*
2015	IIR 2017	**8.6**	**0.6**	**0.6**	**0.7**	**3.4**	**40.6**	**2.0**	**1.0**	**101.1**
	IIR 2018	**8.6**	**0.6**	**0.6**	**0.6**	**3.4**	**45.4**	**2.0**	**1.0**	**103.1**
Difference	absolute	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**4.8**	**0.0**	**0.0**	**2.0**
	%	*-0.1%*	*0.3%*	*-0.8%*	*-0.3%*	*0.7%*	*11.8%*	*0.9%*	*0.0%*	*2.0%*

Table 10.2shows only significant changes compared with the previous submission for the year 2015. Changes in the 2015 figures are the result of using improved activity data for that year.

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

National total		**PCDD/ PCDF (dioxines/ furanes)**	**PAHs**				
			benzo(a) pyrene	**benzo(b) fluoranthene**	**benzo(k) fluoranthene**	**Indeno (1.2.3 -cd) pyrene**	**Total 1-4**
		g I-Teq	**Mg**	**Mg**	**Mg**	**Mg**	**Mg**
1990	IIR 2017	**742.5**	**5.2**	**7.8**	**4.0**	**2.8**	**19.8**
	IIR 2018	**744.0**	**5.2**	**7.8**	**4.0**	**2.8**	**19.8**
Difference	absolute	**1.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	%	*0.2%*	*-0.1%*	*0.0%*	*0.0%*	*0.0%*	*-0.1%*
2000	IIR 2017	**31.1**	**1.8**	**1.7**	**0.9**	**0.8**	**5.1**
	IIR 2018	**32.8**	**1.8**	**1.7**	**0.9**	**0.8**	**5.1**
Difference	absolute	**1.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	%	*5.5%*	*-0.2%*	*-0.2%*	*-0.2%*	*0.0%*	*-0.2%*
2010	IIR 2017	**31.4**	**1.6**	**1.6**	**0.8**	**0.8**	**4.9**
	IIR 2018	**33.2**	**1.6**	**1.6**	**0.8**	**0.8**	**4.8**
Difference	absolute	**1.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	%	*5.9%*	*-0.1%*	*-0.1%*	*0.0%*	*0.0%*	*-0.1%*
2015	IIR 2017	**21.5**	**1.6**	**1.5**	**0.8**	**0.8**	**4.7**
	IIR 2018	**23.4**	**1.6**	**1.5**	**0.8**	**0.8**	**4.7**
Difference	absolute	**1.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	%	*8.9%*	*0.1%*	*0.1%*	*0.1%*	*0.1%*	*0.1%*

All changes shown in Table 10.3 for PCDD/F are due to the inclusion of house and car fires in the inventory. PAH emissions changed as a result of the changes in fuel use in National fishing.

Changes in the 2015 figures are also the result of using improved activity data for that year.

11 Projections

The emission projections in the IIR report 2018 consist of an update of air pollutant projections as presented in the IIR report 2017 (Jimmink et al., 2017). Emission projections are recalculated every year by the PBL Netherlands Environmental Assessment Agency (Smeets et al., 2018). An overview of the historical and projected total emissions for the Netherlands is given in Table 11.2. The explanatory notes in this chapter focus on the scenario with additional measures (WAM) and summarizes the relevant changes compared with the emissions projections in the IIR report 2017.

Transport emission projections
Emission projections for transport have been adjusted for several substances. This can partially be attributed to the recalculations that were described in Chapter 4:

- PM_{10} and $PM_{2.5}$ exhaust emission factors for Euro-3, -4, -5 and -6 petrol-driven passenger cars were adjusted downwards by 50% based on recent measurements (Kadijk et al., in prep.), resulting in lower emission projections for 2020 and 2030.
- NO_x emission factors for current Euro-6 diesel light-duty trucks were adjusted downwards by 14-73% based on recent measurements (Kadijk et al. 2017). The share of Euro-6 in the light-duty truck fleet has also been adjusted downwards, though based on vehicle registration data, as described in Section 4.3.8. This results in lower NO_x emission projections for light-duty trucks in 2020 and 2030.
- NO_x and CO emission factors for Euro-V and Euro-VI heavy-duty trucks have been re-estimated using a new study on driving behaviour (Heijne & Ligterink, 2018), as described in Section 4.3.8. As a result, NO_x emission projections have increased somewhat for 2020 and 2030.
- Emissions from fisheries were recalculated in this year's inventory using an AIS-based approach to estimate Implied Emissions Factors and using fuel sales data from the national Energy Balance. This is described in Section 4.7.8. These methodological changes have also been applied to the emission projections from fisheries. Since fuel sales data for fisheries are significantly higher than estimated, fuel consumption in the Dutch territorial waters, activity data and resulting emissions from fisheries have increased significantly in this year's inventory, both historically and in the emission projections.

Apart from these changes, the NO_x emission projections for light-duty vehicles have also been affected by an adjustment of the NO_x emission factors for RDE-approved diesel passenger cars and light-duty trucks. TNO establishes national road vehicle emission factors annually based on real-world measurements, as described in Section 4.3.4. For projection purposes, emission factors are also required for new vehicle types that are not yet commercially available or have not yet been measured under real-world circumstances, such as RDE-approved Euro-6 diesel passenger cars and light-duty trucks. These emission factors are

established based on the judgement of experts, taking into account the knowledge about and previous experiences with the technologies that are likely to be used to comply with future emission standards, as well as the legislation and underlying testing regime. For this year's inventory, the NO_x emission factors for RDE-approved Euro-6 passenger cars and light-duty trucks were decreased by 50% based on the current (January 2018) progress on RDE negotiations. This results in a significant reduction of the projected NO_x emissions of passenger cars and light-duty trucks in 2030.
Emission projections for heavy-duty trucks were adjusted downwards by 2% for 2025 and by 6% for 2030 based on the planned introduction (included in WAM) of a heavy-duty vehicle road pricing scheme starting in 2022. Emission changes of 2% and 6% also incorporate some minor changes in HDV traffic volumes due to the adjustments in historical HDC traffic volume (see Section 4.3.8). The impact of these changes on transport emission projections are shown in Table 10.1 for NO_x, PM_{10} and NMVOC. The NO_x and PM_{10} emission projections for road transport have decreased for 2020 and 2030, but this is compensated by the higher projections for fisheries resulting from the use of fuel sales activity data.

Table 11.1 Changes in transport emission projections (Gg), IIR-2018-WAM compared to IIR-2017-WAM.

	2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Road transport	-5.0	-6.1	-0.13	-0.14	-0.12	-0.16	+0.03	-0.01	-	-
Fisheries	+3.6	+4.8	+0.19	+0.22	+0.20	+0.24	+0.14	+0.21	+0.15	+0.15
Total	**-1.3**	**-1.3**	**+0.06**	**+0.08**	**+0.08**	**+0.08**	**+0.17**	**+0.19**	**+0.15**	**+0.15**

Agriculture emission projections

Emission projections for agriculture have been adjusted for NH_3. These changes can be attributed to the recalculations that were described in Chapter 6:

- For dairy cattle, a new approach has been developed to better estimate the faecal nitrogen digestibility (Bannink et al., 2016). These changes have been incorporated into the emission inventory and NH_3 projections have been adjusted accordingly. The new approach is in line with the Tier 3 approach used to estimate enteric CH_4 emissions (Bannink et al., 2011). Previously, the faecal N digestibility was systematically overestimated. This over-estimation for dairy cattle has also been used to estimate the other cattle categories. A lower digestibility leads to lower TAN values, thus leading to substantially lower emissions during manure application. The improved approach for digestibility has led to lower emission projections. Due to this change, NH_3 emissions have been reduced by 2.4 Gg for 2020 and 1.8 Gg for 2030 compared with the projections for these years in the IIR-report 2017.
- The emissions from crop residues have been recalculated, resulting in a slightly lower NH_3 emission by 0.1 Gg for 2020 and 2030.

The definition of agricultural sources that are included in the national total for nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOC) in Table 10.2 is in line with Article 4.3 of EU Directive 2016/2284 (EU, 2016). Article 4.3 states that agricultural emissions of NO_x and NMVOC from categories 3B (manure management) and 3D (agricultural soils) have not been verified for compliance with national emission reduction commitments. The effect of this article is that 3B and 3D sources are excluded from the national (compliance) totals. The implementation of this article implies a change for the national (compliance) total, compared with the IIR-report 2017 (Table 11.1). The national total in the IIR report 2017 included some 3B/3D categories, i.e. all categories under 3B (manure management), 3Da2c (other organic fertilizers applied to soils including compost) and 3Da2b (sewage sludge applied to soils). With the IIR-report 2018, these categories have been excluded from the national compliance total. Due to this change, the NO_x-emission total for 2005 has decreased by 3 Gg for 2005 and 2030. The NMVOC-total has also decreased by 0.2 Gg for 2005 and 2030 due to this change.

Table 11.2 Historical and projected national emissions (Gg) for the Netherlands for the purpose of compliance, calculated based on fuel sold (Smeets et al., 2018 in prep.).

Pollutant	**Historical**				**Projected (WM with Measures)**		**Projected (WaM with additional Measures)**	
Gg	**2005**	**2010**	**2015**	**2016**	**2020**	**2030**	**2020**	**2030**
SO_x	67	35	31	28	30	31	30	31
NO_x	372	303	235	221	173	127	173	125
NH_3	153	133	126	127	115	107	115	107
NMVOC	190	174	149	141	144	146	143	145
PM_{10}	36.1	30.5	26.8	26.3	24.8	23.8	24.7	23.6
$PM_{2.5}$	22.1	17.0	13.2	12.5	10.9	9.9	10.9	9.8

a. The national emission total for NOx and NMVOC excludes agricultural sources 3B (manure management) and 3D (agricultural soils).

12 Spatial distributions

12.1 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 are disaggregated to the standard EMEP grid with a resolution of 7km x 7km. Reporting is 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 UNECE (2009). 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 (UNECE, 2009). These aggregations can be achieved through the aggregation of the spatially resolved (mapped), detailed NFR sectors.

The gridded emission data of the 2017 reporting is available at the Central Data Repository (CDR) on the EIONET website.

12.2 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: http://www.prtr.nl.
Such a 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 institutes concerned. Furthermore, an Excel sheet is available 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 concerns all companies that are required by Dutch law to report their air and water emissions by means of Annual Environmental Reports (AER), combined with data concerning waste-water treatment plants (RWZIs). Altogether, this category encompasses almost three thousand 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, 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 (roads, shipping routes and railways), land cover and the number of employees per facility.

12.3 Maps with geographically distributed emission data

Examples of combinations of the three methods can be seen in the maps below, based on the latest reporting data (2015) from the Netherlands Pollutants Release and Transfer Register http://www.prtr.nl . The selected air pollutants are ammonia (NH_3), sulphur dioxide (SO_x), nitrogen dioxide (NOx) and fine particulates ($PM_{2.5}$). Figure 12.1-Figure 12.4 show the geographically distributed emissions for these air pollutants. Even from the spatial allocation at a national level, specific patterns from the major sectors are recognizable.

On a national scale, the agricultural sector is the major contributor to NH_3 emissions. Emissions of NH_3 are mainly related to livestock farming and especially to the handling of manure. Emissions of NH_3 are therefore related to the storage and spreading of manure, as well as emissions from stables (Bruggen, van et al., 2017). Some inland shipping routes and fishing grounds are visible because the burning of fossil fuels also releases NH_3 and there are no other large sources on the water. 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 were in inland shipping.

Finally, the map of fine particulate matter shows a pattern in which cities, airports, agriculture, main roads and shipping routes can all be recognized. This is due to the fact that residential heating, agricultural animal housing, traffic and shipping are all main sources of particulate matter.

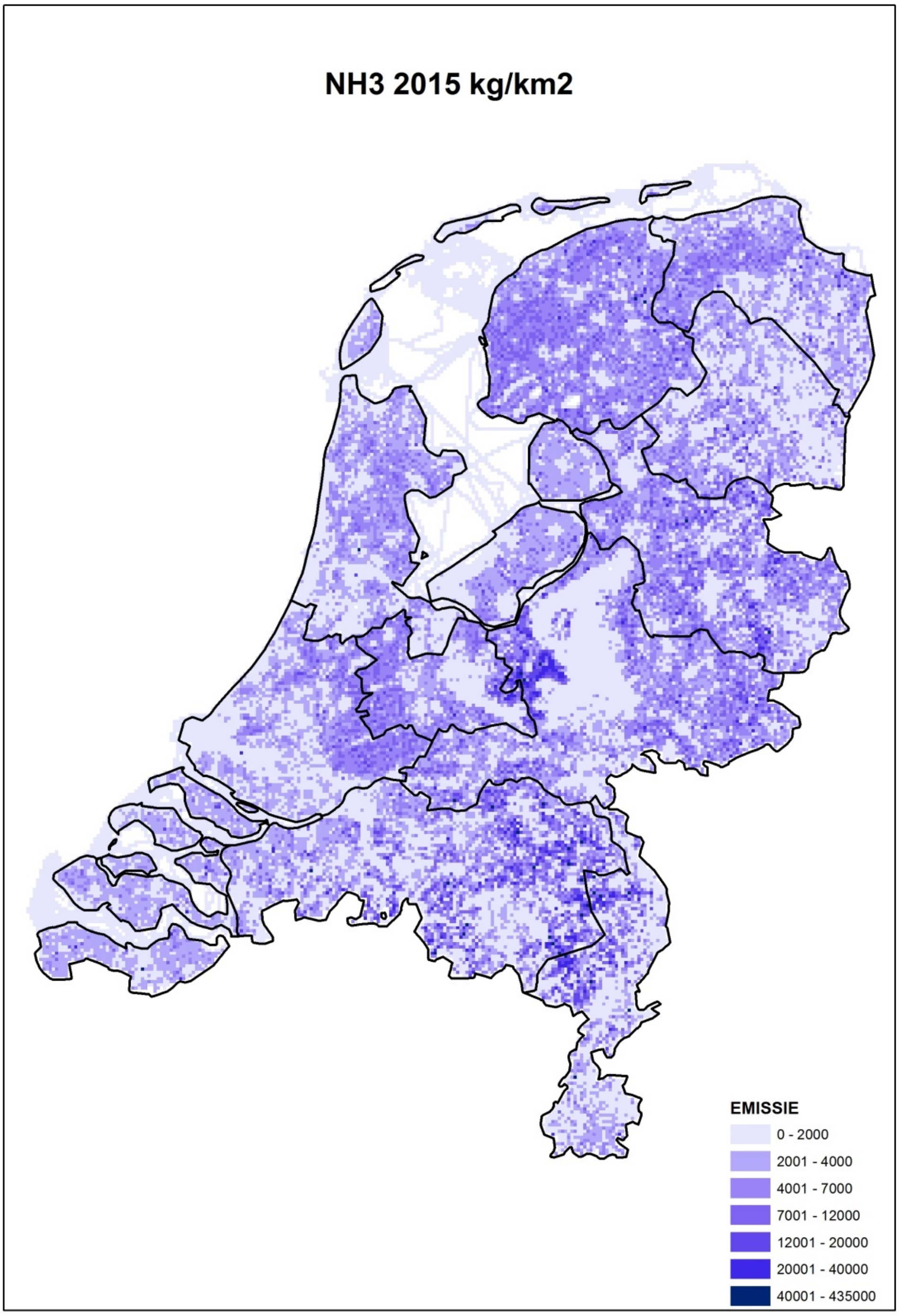

Figure 12.1 Geographical distribution of NH_3 emissions in the Netherlands in 2015

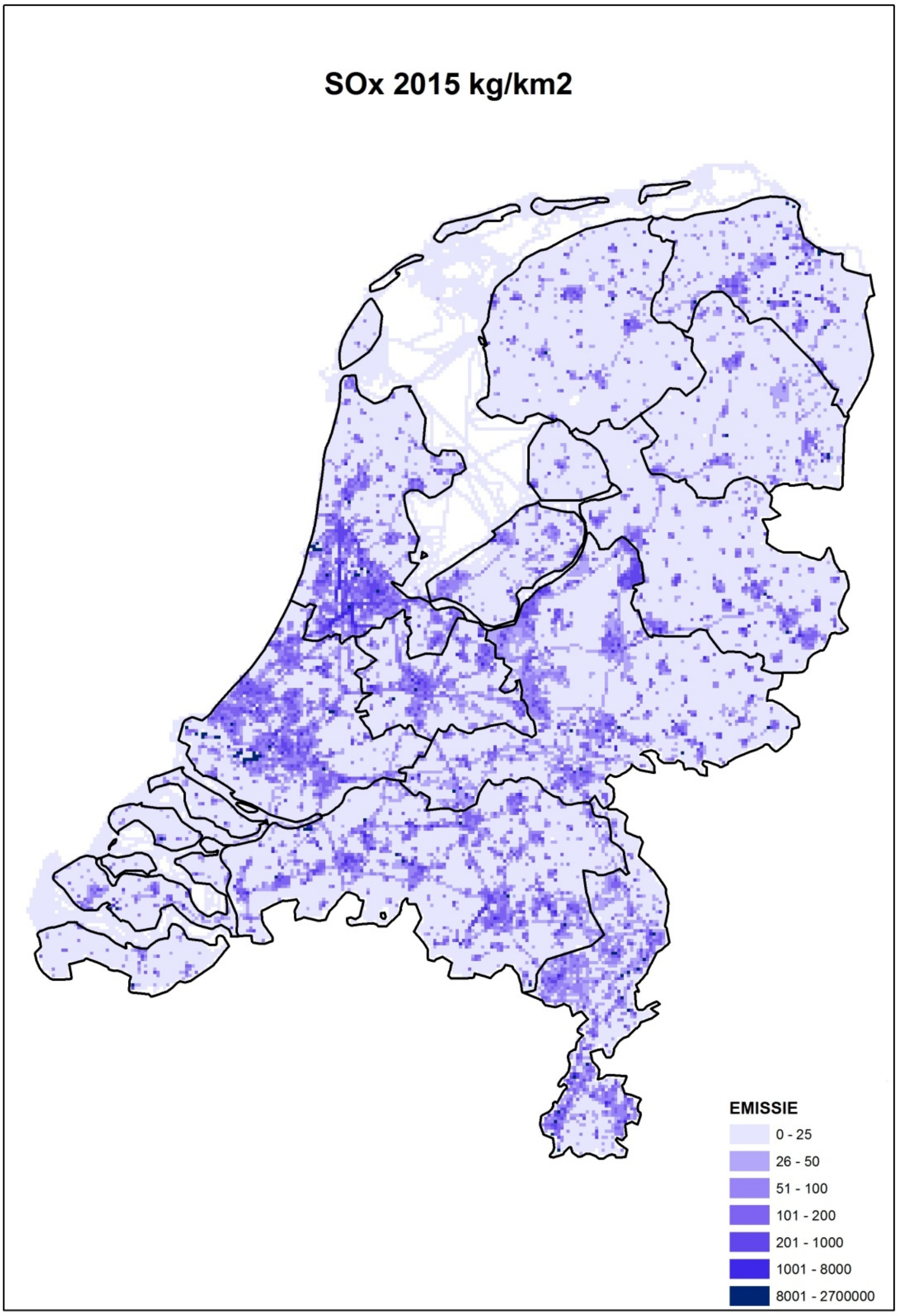

Figure 12.2 Geographical distribution of SO_x emissions in the Netherlands in 2015

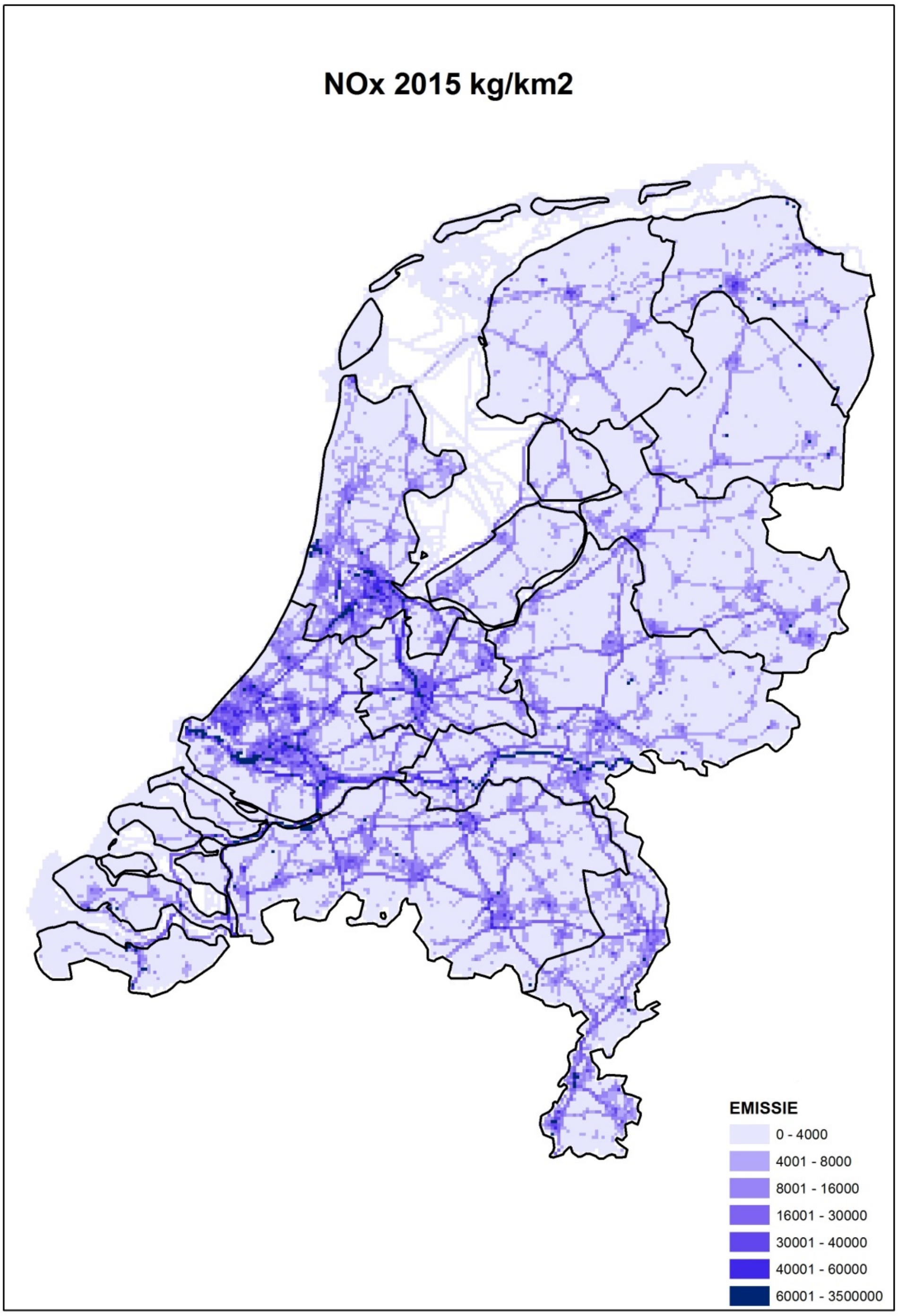

Figure 12.3 Geographical distribution of NO_x emissions in the Netherlands in 2015

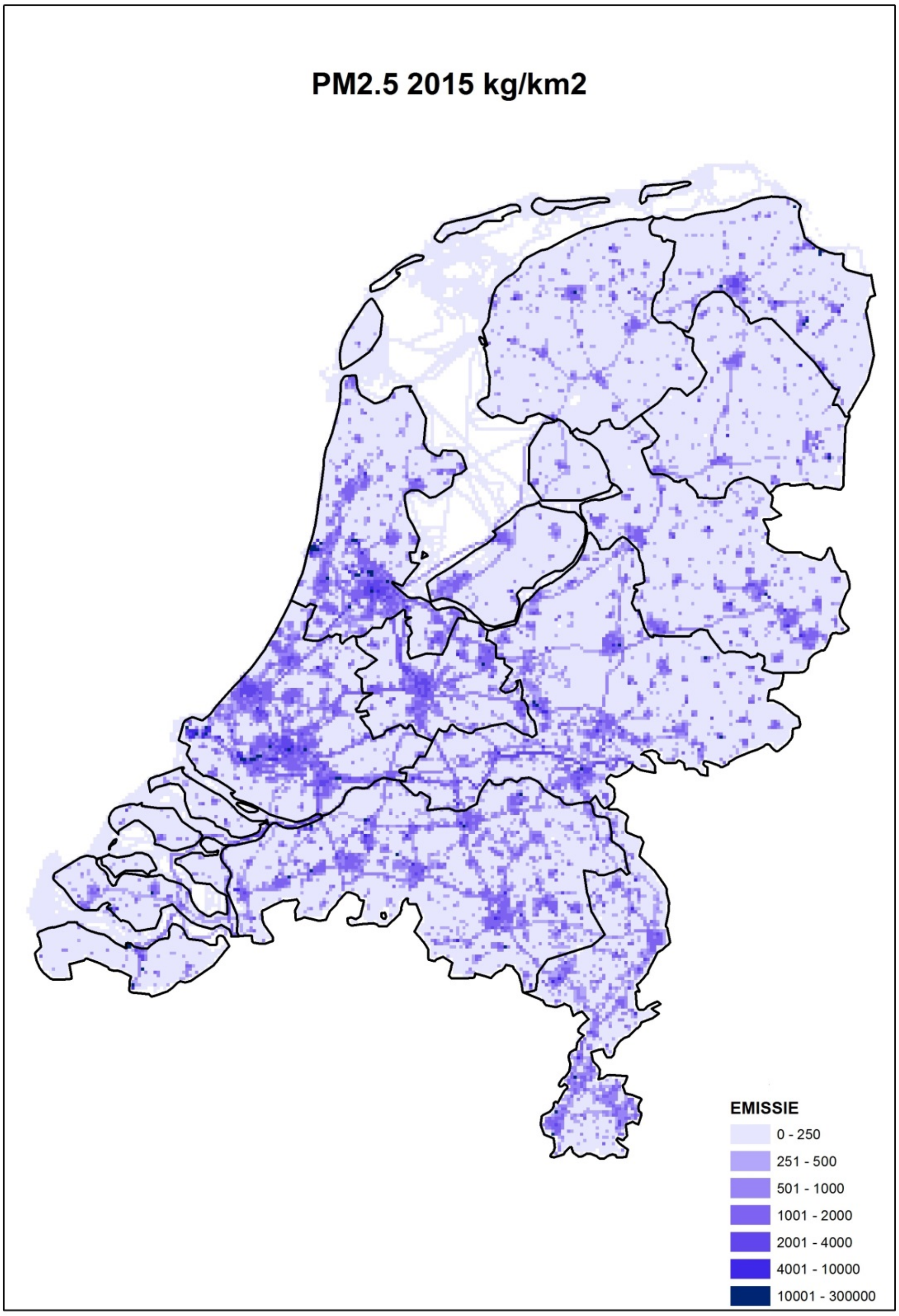

Figure 12.4 Geographical distribution of $PM_{2.5}$ emissions in the Netherlands in 2015

References

AFS (2013). HESSQ jaarverslag 2012. Aircraft Fuel Supply B.V. (In Dutch).

Agrawal, H., A.A. Sawant, K. Jansen, J.W. Miller & D.R. Cocker III (2008). Characterization of chemical and particulate emissions from aircraft engines. Atmospheric Environment 42, p. 4380-4392.

Booij H., (1995), Gezelschapsdieren, RIVM-rapport 772414003, RIZA nota 93.46/C6, DGM (in Dutch).

Bremmer, H.J., L.M. Troost, G. Kuipers, J. de Koning & A.A. Sein (1993). Emissies van dioxinen in Nederland. RIVM/TNO rapportnummer 770501003, National Institute for Public Health and the Environment/TNO, Bilthoven/Apeldoorn (in Dutch).

Broeke, H.M. ten, J.H.J. Hulskotte & H. Denier van der Gon (2008). Emissies door bandenslijtage afkomstig van het wegverkeer. TNO, Utrecht (in Dutch).

Bruggen, C. van, A. Bannink, C.M. Groenestein, J.F.M. Huijsmans, H.H. Luesink, S.M. van der Sluis, G.L. Velthof & J. Vonk, (2015). Emissies naar lucht uit de landbouw, 1990-2013. Berekeningen van ammoniak, stikstofoxide, lachgas, methaan en fijn stof met het model NEMA (in Dutch). WOt-technical report 46. WOT Natuur & Milieu, Wageningen.

Bruggen, C. van, A. Bannink, C.M. Groenestein, J.F.M. Huijsmans, H.H. Luesink, S.V. Oude Voshaar, S.M. van der Sluis, G.L. Velthof e J. Vonk, 2017, Emissies naar lucht uit de landbouw in 2015. Berekeningen met het model NEMA WOt-technical report. WOT Natuur & Milieu, Wageningen.

Bruggen, C. van, A. Bannink, C.M. Groenestein, J.F.M. Huijsmans, H.H. Luesink, S.M. van der Sluis, G.L. Velthof & J. Vonk, 2018, in prep. Emissies naar lucht uit de landbouw in 2016. Berekeningen met het model NEMA. WOt-technical report. WOT Natuur & Milieu, Wageningen.

CBS (2012). Uncertainty analysis of mineral excretion and manure production. Statistics Netherlands, The Hague/Heerlen.

CBS (2012a). Standardised calculation methods for animal manure and nutrients. Standard data 1990-2008. Statistics Netherlands, The Hague/Heerlen.

CBS (2017). Landbouw; gewassen, dieren, grondgebruik en arbeid op nationaal niveau. Statistics Netherlands, Den Haag/Heerlen/Bonaire. Available: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=81302ned&D1=387-427,470-502&D2=0,5,10,13-16&HDR=G1&STB=T&VW=T (in Dutch).

Coenen, P.W.H.G. (1997). Onderzoek naar de kwikemissies van crematoria en beschikbare reinigingstechnieken, Tauw Milieu Rapport R3517616.W02/BWH, Deventer (in Dutch).

Coenen, P.W.H.G. & J.H.J. Hulskotte (1998). Onderzoek naar de emissies naar oppervlaktewater van railverkeer in de provincie Zuid-Holland. TNO, Apeldoorn (in Dutch).

Coops, O., L. Luning, H. Oonk, J. Boom, (1995). Emissies van stortplaatsen *(Emissions from landfill sites)*. VROM Hoofdinspectie Milieuhygiene, Publicatie Emissieregistratie 28, Den Haag, 1995. In Dutch.

Dellaert, S.N.C. (2016). Emissions of mobile machinery at Dutch container terminals. TNO report, TNO 2016 R10160, TNO, Utrecht.

Dellaert, S.N.C. & R. Dröge (2017). Uncertainty of the NO_x, SO_x, NH_3, PM_{10}, $PM_{2.5}$, $EC_{2.5}$ and NMVOC emissions from transport. In preparation.

Dellaert, S.N.C. & J.H.J. Hulskotte (2017). Emissions of air pollutants from civil aviation in the Netherlands. TNO 2017 R10055.

Denier van der Gon, H., H.M. ten Broeke & J.H.J. Hulskotte (2008). Emissies door wegdekslijtage ten gevolge van het wegverkeer. TNO, Utrecht (in Dutch).

Denier van der Gon, H. & J.H.J. Hulskotte (2010). Methodologies for estimating shipping emissions in the Netherlands. A documentation of currently used emission factors and related activity data. BOP Report 500099012, PBL Netherlands Environmental Assessment Agency, Bilthoven.

DHV (1999). Eindevaluatierapport meetprogramma GFT-verwerkingsinstallaties SMB, SOW/CAW en Arcadis . Final report by order of ministry VROM, registration number ML-TE981217, DHV (in Dutch).

EMEP/EEA (2016). EMEP/EEA Air pollutant emission inventory guidebook 2016. EEA Technical report No 21/2016, European Environment Agency (EEA), Copenhagen, Denmark. https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

Ellen, H.H., C.M. Groenestein & N.W.M. Ogink, 2017. Actualisering ammoniak emissiefactoren pluimvee. Advies voor aanpassing van ammoniak emissiefactoren van pluimvee in de Regeling ammoniak en veehouderij (Rav) (in Dutch). Report 1015. Wageningen Livestock Research, Wageningen (in Dutch).

Elzenga, J.G. (1996). Crematoria. RIVM report nr. 772414009, National Institute for Public Health and the Environment, Bilthoven (in Dutch).

EPA (1985). Compilation of air pollutant emission factors. Volume II: Mobile sources. 4th edition, US Environmental Protection Agency, Research Triangle Park, North Carolina, USA.

EU, (2016), DIRECTIVE (EU) 2016/2284 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC.

Geilenkirchen, G., M. 't Hoen & M. Traa (2017) Verkeer en vervoer in de Nationale Energieverkenning 2016, The Hague: PBL Netherlands Environmental Assessment Agency (in Dutch).

Gijlswijk, R. van, P.W.H.G. Coenen, T. Pulles & J.P. van der Sluijs (2004). Uncertainty assessment of NO_x, SO_x and NH_3 emissions in the Netherlands. TNO report R 2004/100, TNO, Apeldoorn. Available: http://www.rivm.nl/bibliotheek/digitaaldepot/TNOreportRa2004.pdf.

Goudappel Coffeng (2010). Onderzoek naar de wegtype-verdeling en samenstelling van het wegverkeer. Final report, Goudappel Coffeng, Deventer (in Dutch).
Harvey, C.A., P. Carey & J. Warila (2003). EPA's Newest Draft Non-road Emission Inventory Model (NONROAD). 12th International Emission Inventory Conference, San Diego, California, USA.
Hasselrot, A. (2001). Hurdy-Gurdy 1.0 with Database of 25 Turboprop Aircraft, a File Maker Solution. (Software on CD), FOI/FFA.
Heijne, V.A.M. & N.E. Ligterink (2018), Driving behaviour parameters for emission factors of heavy-duty vehicles, TNO, Delft.
Helms, H., U. Lambrecht, & W. Knörr (2010), Aktualisierung des Modells TREMOD - Mobile Machinery (TREMOD-MM). UBA TEXTE 28/2010, Dessau-Rosslau, Germany (in German).
Hoek, K.W. van der (2002). Uitgangspunten voor de mest- en ammoniakberekeningen 1999 tot en met 2001 zoals gebruikt in de Milieubalans 2001 en 2002, inclusief dataset landbouwemissies 1980-2001. RIVM report 773004013, National Institute for Public Health and the Environment, Bilthoven (in Dutch).
Hulskotte, J.H.J. & W.W.R. Koch, (2000). Emissiefactoren zeeschepen. TNO-report TNO-MEP-R2000/221, TNO, Apeldoorn (in Dutch).
Hulskotte, J., E. Bolt & D. Broekhuizen (2003). EMS-protocol emissies door verbrandingsmotoren van zeeschepen op het Nederlands Continentaal Plat, Adviesdienst Verkeer en Vervoer, Rotterdam (in Dutch).
Hulskotte, J.H.J., J. Oonk & J.C. van den Roovaart (2005). Waterverontreininging door motoremissies uit de recreatievaart. TNO-MEP, TNO, Apeldoorn (in Dutch).
Hulskotte, J.H.J. & R.P. Verbeek (2009). Emissiemodel Mobiele Machines gebaseerd op machineverkopen in combinatie met brandstof Afzet (EMMA). TNO-report TNO-034-UT-2009-01782_RPT-ML, TNO, Utrecht (in Dutch).
Hulskotte, J.H.J. & E. Bolt (2013). EMS-protocol emissies door binnenvaart: verbrandingsmotoren. TNO-report, TNO, Utrecht (in Dutch).
Hulskotte, J.H.J, Brake ter M.C., (2017), Revised calculation of emissions of fisheries on the Netherlands territory, TNO report TNO 2017 R10784, 29 June 2017.
Jager, D. de & K. Blok, 1993. Onderzoek naar het gehalte aan organische stof in de verschillende afvalcomponenten *(Research into volatile solids content in the various waste components)*, Utrecht, 1993. In Dutch.Jansen, B.I., J.A.J. Meesters and M.M. Nijkamp, 2018, Methodology on the calculation of emissions from Product usage by consumers, construction and services, RIVM 2018-0011, RIVM, Bilthoven.
Jansen, B.I. & R. Dröge (2011). Emissiemodel houtkachels. TNO report TNO-060-UT-2011-00314, TNO, Utrecht (in Dutch).

Jimmink, B.A., H.M. ten Broeke, P.W.H.G. Coenen, R. Dröge, G.P Geilenkirchen, A.J. Leekstra, C.W.M van der Maas, R.A.B. te Molder, C.J. Peek, J. Vonk & D. Wever (2014). Emissions of transboundary air pollutants in the Netherlands 1990-2012. Informative Inventory Report 2014. RIVM report 680355015/2014, National Institute for Public Health and the Environment, Bilthoven.

Jimmink, B.A., P.W.H.G. Coenen, R. Dröge, G.P. Geilenkirchen, A.J. Leekstra, C.W.M. van der Maas, R.A.B. te Molder, C.J. Peek, J. Vonk & D. Wever (2017). Emissions of transboundary air pollutants in the Netherlands 1990-2015. Informative Inventory Report 2017. RIVM Report 2017-0002, National Institute for Public Health and the Environment, Bilthoven.

Kadijk, G., N. Ligterink, & J. Spreen (2015) On-road NO_x and CO_2 investigations of Euro 5 Light Commercial Vehicles. TNO report TNO R10192, TNO, Delft.

Kadijk, G., Ligterink, N., Mensch, P. van, Spreen, J., Vermeulen, R. & Vonk, W. (2015), Emissions of nitrogen oxides and particulates of diesel vehicles, TNO 2015 R10838, Delft: TNO.

Kadijk, G., M. Elstgeest, N.E. Ligterink (2018), Emissions of six petrol vehicles with high mileage, (in prep), TNO, Delft.

Kadijk, G., R. Vermeulen, E. Buskermolen, M. Elstgeest, D. van Heesen, Veerle Heijne, N. Ligterink, P. van der Mark (2017), NO_x emissions of eighteen diesel Light Commercial Vehicles: Results of the Dutch Light-Duty road vehicle emission testing programme 2017, TNO 2017 R11473, TNO, Delft.

Klein, J., H. Molnár-in ‘t Veld, G. Geilenkirchen, J. Hulskotte, N. Ligterink, S. Dellaert and R. de Boer, (2018), Methods for calculating the emissions of transport in the Netherlands, CBS, Den Haag.

Klein J., H. Molnár-in ‘t Veld, G. Geilenkirchen, J. Hulskotte, N. Ligterink, S. Dellaert and R. de Boer, Methods for calculating the emissions of transport in the Netherlands Tables, (2018), CBS.

Klein Goldewijk, K; Olivier, J. G.J.; Peters, J.A.H.W; Coenen, P.W.H.G; Vreuls, H.H.J., (2004. Greenhouse gas emissions in the Netherlands 1990-2002. National Inventory Report 2004. RIVM report 773201008/2004.

KLM (2016). APU emission factors. KLM, Amsterdam.

Kok, H.J.G. (2014). Update NO_x-emissiefactoren kleine vuurhaarden – glastuinbouw en huishoudens. TNO report 2014 R10584, TNO, Utrecht (in Dutch).

Kraan, T.C., N.E. Ligterink & A. Hensema (2014). Uncertainties in emissions of road traffic: Euro-4 diesel NO_x emissions as case study, TNO report TNO R11316, TNO, Delft.

Kuiper, E. & N.E. Ligterink (2013), Voertuigcategorieën en gewichten van voertuigcombinaties op de Nederlandse snelweg op basis van assen-combinaties en as-lasten, TNO report TNO R12138, TNO, Delft (in Dutch).

Kugele, A., F. Jelinek & R. Gaffal (2005). Aircraft particulate matter estimation through all phases of flight, Eurocontrol Experimenal Centre, Brétigny sur Orge, France.

Lambrecht, U., H. Helms, K. Kullmer & W. Knörr (2004). Entwicklung eines Modells zur Berechnung der Luftschadstoffemissionen und des Krafstoffverbrauchs von Verbrennungsmotoren in mobilen Geräten und Machinen. IFEU, Heidelberg, Germany (in German).
Ligterink, N.E. & R. de Lange (2009). Refined vehicle and driving behaviour dependencies in the VERSIT+ emission model. TNO Science & Industry, Delft.
Ligterink, N.E., L.A. Tavasszy, and R. de Lange (2012). A velocity and payload-dependent emission model for heavy-duty road freight transportation. Transportation Research Part D 17, p. 487-491.
Ligterink, N.E., P.S. van Zyl & V.A.M. Heijn (2016). SRM emission factors for CO_2. TNO, Delft.
Ligterink, N.E. (2016) Dutch market fuel composition for GHG emissions. TNO, Delft.
Ligterink (2017), The fleet composition on the Dutch roads relevant for vehicle emissions, TNO, Delft.
Ligterink (2017) Elemental carbon emission factors of vehicles for Dutch air-quality assessments. TNO, Delft.
LVC (2017). http://www.lvc-online.nl/viewer/file.aspx?FileInfoID=172
MARIN (2011). MARIN's emission inventory for North Sea Shipping 2009: validation against ENTEC's inventory and extension with port emissions. MARIN, Wageningen.
MARIN (2014). Sea shipping emissions 2012: Netherlands Continental Shelf, port areas and OSPAR Region II. MARIN, Wageningen.
MARIN (2018). Sea shipping emissions 2016: Netherlands Continental Shelf, port areas and OSPAR Region II. MARIN, Wageningen.
Molnár-in 't Veld, H. & A. Dohmen-Kampert (2010). Methoderapport verkeersprestaties autobussen. Statistics Netherlands, Heerlen (in Dutch).
Morris, K.M. (2007). Emissions from aircraft, airframe sources: tyre and brake wear, British Airways, 12 April 2007, http://www.cate.mmu.ac.uk/saaq/presentations/Morris.pdf
Netcen (2004). Revision to the Method of Estimating Emissions from Aircraft in the UK Greenhouse Gas Inventory. Abingdon.
Nollet, J. (1993). Taxitijden t.b.v. PMMS-werkgroep 4 (herziene versie), NV Luchthaven Schiphol, Amsterdam (in Dutch).
NS-CTO (1992). Project koperemissies spoorwegverkeer, NS-CTO, Utrecht (in Dutch).
Ntziachristos, L. & Z. Samaras (2000). COPERT III, Computer Programme to calculate emissions from road transport, methodology and emission factors (version 2.1). European Environmental Agency, Copenhagen, Denmark.
Oenema, O., G.L. Velthof, N. Verdoes, P.W.G. Groot Koerkamp, G.J. Monteny, A. Bannink, H.G. van der Meer & K.W. van der Hoek (2000). Forfaitaire waarden voor gasvormige stikstofverliezen uit stallen en mestopslagen, Alterra rapport 107, gewijzigde druk, ISSN 1566-7197, Wageningen (in Dutch).
Oonk, H., A. Weenk, , O. CoopsL.Luning, 1994. Validation of landfill gas formation models, 1994. TNO report 94-315, Apeldoorn, 1994

Oonk, H., 2016. Correction factor F for adsorption CO2 in leachate, Oonkay, Apeldoorn, 2016
Peek C.V.J., J.A. Montfoort, R. Dröge, B. Guis, C. Baas, B. van Huet, O.R. van Hunnik and A.C.W.M. van den Berghe, 2018, Methodology on the calculation of emissions from the sectors Energy, Industry and Waste (Update 2017), RIVM 2018-0007, National Institute for Public Health and the Environment, Bilthoven.
Rail Cargo, 2007: Spoor in Cijfers 2007. Statistisch overzicht railgoederenvervoer. Rail Cargo, Hoogvliet (in Dutch).
Rail Cargo, 2013: Spoor in Cijfers 2013. Rail Cargo, Hoogvliet (in Dutch).
Riemersma, I.J. & R. Smokers (2004) Ontwikkeling van het Versit+ HD emissiemodel. TNO, Delft (in Dutch).
Rindlisbacher, T. (2007). Aircraft piston engine emissions, Report 0/3/33/33-05-003, FOCA, Bern. http://www.hjelmco.com/upl/files/2425.pdf
Rindlisbacher, T. (2009). Guidance on the Determination of Helicopter Emissions, Report 0 / 3/33/33-05-020, Edition 1, FOCA, Bern.
RIVM (2001). Environmental Balance 2000. RIVM report 251701051, Bilthoven (in Dutch).
RIVM (2017). Werkplan Emissieregistratie 2017. National Institute for Public Health and the Environment, Bilthoven (in Dutch).
Ruijter, F.J. de, J.F.M. Huijsmans, M.C. van Zanten, W.A.H. Asman & W.A.J. van Pul (2013). Ammonia emission from standing crops and crop residues: contribution to total ammonia emission in the Netherlands, Plant Research International Report 535, Wageningen.
RWS (2008). Remslijtage. Waterdienst, Centre for Water Management, Lelystad (in Dutch).
Smeets et al. (2018), Emissieramingen luchtverontreinigende stoffen – rapportage 2018, Den Haag: PBL manuscript in preparation.
Soest-Vercammen, E.L.J. van, J.H.J. Hulskotte & D.C. Heslinga (2002). Monitoringsprotocol Bijschatting Stationaire NO_x-bronnen kleiner dan 20 MWth. TNO report R2002/042, TNO Milieu, Energie en Procesinnovatie, Apeldoorn (in Dutch).
Spakman, J., M.M.J Van Loon, R.J.K Van der Auweraert, D.J. Gielen, J.G.J. Olivier, E.A. Zonneveld, (1997). Methode voor de berekening van broeikasgasemissies *(Method of calculating greenhouse gas emissions)*, VROM, Emissions registration 37. In Dutch.
Spreen, J.S., G. Kadijk, R.J. Vermeulen, V.A.M. Heijne, N.E. Ligterink, U. Stelwagen, R.T.M. Smokers, P.J. van der Mark & G. Geilenkirchen (2016) Assessment of road vehicle emissions: methodology of the Dutch in-service testing programmes, TNO, Delft.
Stelwagen, U., & N.E. Ligterink (2015). HD Euro-V Truck PM_{10} and EC emission factors. TNO, Delft.
Stelwagen, U., N.E. Ligterink & S. van Zyl (2015). NH_3 emission factors for road transport. TNO, Delft.
Sutton, M.A., U. Dragosits, Y.S. Tang & D. Fowler (2000). Ammonia emissions from non-agricultural sources in the UK, Atmospheric Environment 34 (2000) 855-869.

Swertz, O., S. Brummelkamp, J. Klein & N. Ligterink (2017), Adjustment of heating values and CO_2 emission factors of petrol and diesel, Statistics Netherlands, The Hague.
UNECE (2009). Guidelines for Estimating and Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution. http://www.ceip.at/fileadmin/inhalte/emep/reporting_2009/Rep_%20Guidelines_ECE_EB_AIR_97_e.pdf.
UNECE (2014). Guidelines for Estimating and Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution. https://www.unece.org/fileadmin/DAM/env/documents/2015/AIR/EB/English.pdf 125_ADVANCE_VERSION_reporting_guidelines_2013.pdf
Visschedijk, A., W, Appelman, J.H.J. Hulskotte & P. Coenen (2007). Onderhoud van methodieken Emissieregistratie 2006-2007. TNO report nr. A-R0865/B, Apeldoorn (in Dutch).
Vonk, J., S.M. van der Sluis, A. Bannink, C. van Bruggen, C.M. Groenestein, J.F.M. Huijsmans, J.W.H. van der Kolk, L.A. Lagerwerf, H.H. Luesink, S.V. Oude Voshaar & G.L. Velthof (2018). Methodology for estimating emissions from agriculture in the Netherlands – update 2018. Calculations of CH_4, NH3, N_2O, NO_x, PM_{10}, $PM_{2.5}$ and CO_2 with the National Emission Model for Agriculture (NEMA). Wageningen, The Statutory Research Tasks Unit for Nature and the Environment (WOT Natuur & Milieu). WOt-technical report 115, Wageningen.
VROM (2002). MilieuEffectRapport Landelijk afvalbeheerplan (Environmental Impact Report National Waste Management Plan) 2002-2012. Ministry of Housing, Spatial Planning and the Environment (VROM), VROM 02.0115/04-03 21770/206, Den Haag.
VROM (2008). Milieuverslaglegging en PRTR: veranderingen vanaf het verslagjaar 2009. Ministerie van Infrastructuur en Milieu, Den Haag. Available: https://www.rijksoverheid.nl/documenten/brochures/2009/10/01/milieuverslaglegging-en-prtr-veranderingen-vanaf-het-verslagjaar-2009 (in Dutch).

Appendix 1 Key category analysis results

Results from the key (source) category analysis have been calculated and sorted for every component. In addition to a 2016 and 1990 level assessment, a trend assessment was also performed. In both approaches, key source categories are identified using a cumulative threshold of 80%.

SO_x key sources

Table 1.1.a SO_x key source categories identified by 2016 level assessment (emissions in Gg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1A1b	Petroleum refining	11.2	40%	40%
1A1a	Public electricity and heat production	6.8	25%	65%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	2.8	10.1%	75%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	2.6	9.2%	84.0%

Table 1.1.b SO_x key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A1b	Petroleum refining	67	34%	34%
1A1a	Public electricity and heat production	48	25%	59%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	20	10%	69%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	9.1	4.6%	73%
1A3biii	Road transport: Heavy duty vehicles and buses	7.8	3.9%	77%
2A6	Other mineral products (please specify in the IIR)	5.5	2.8%	80.1%

Table 1.1.c SO_x key source categories identified by 1990-2016 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	2.6	16%	16%

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1b	Petroleum refining	11.2	15.2%	31%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	2.8	13%	45%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	1.5	12%	57%
1A3biii	Road transport: Heavy-duty vehicles and buses	0.04	9.2%	66%
1A3bi	Road transport: Passenger cars	0.1	5.6%	71%
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.14	5.15%	77%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.4	2.7%	79%
1A3bii	Road transport: Light-duty vehicles	0.03	2.6%	82%

NO_x key sources

Table 1.2.a NOx key source categories identified by 2016 level assessment (emissions in Gg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy-duty vehicles and buses	33	13%	13%
1A3bi	Road transport: Passenger cars	25	10%	23%
1A3bii	Road transport: Light-duty vehicles	19	7.6%	31%
1A1a	Public electricity and heat production	18	7.1%	38%
1A3di(ii)	International inland waterways	17	6.7%	44%
3Da2a	Animal manure applied to soils	12	4.7%	49%
1A4ci	Agriculture/Forestry/Fishing: Stationary	10.6	4.2%	53%
3Da1	Inorganic N-fertilizers (also includes urea application)	10.0	3.9%	57%
1A3dii	National navigation (shipping)	9.8	3.9%	61%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	9.5	3.8%	65%

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	9.2	3.6%	68%
1A4ciii	Agriculture/Forestry/Fishing: National fishing	8.5	3.3%	72%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	8.1	3.2%	75%
1A4bi	Residential: Stationary	7.9	3.1%	78%
1A4ai	Commercial/institutional: Stationary	7.0	2.8%	80.8%

Table 1.2.b NO_x key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	145	22%	22%
1A3biii	Road transport: Heavy-duty vehicles and buses	113	17%	39%
1A1a	Public electricity and heat production	83	13%	52%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	36	5.5%	57%
1A3bii	Road transport: Light-duty vehicles	24	3.6%	61%
1A3di(ii)	International inland waterways	22	3.4%	64%
1A4bi	Residential: Stationary	22	3.3%	68%
1A4ciii	Agriculture/Forestry/Fishing : National fishing	21	3.1%	71%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	21	3.1%	74%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	20	3.0%	77.0%
1A1b	Petroleum refining	19	2.9%	79.9%
3Da1	Inorganic N-fertilizers (also includes urea application)	16	2.4%	82.29%

Table 1.2.c NO_x key source categories identified by 1990-2016 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	4.7%	23%	23%
1A1a	Public electricity and heat production	2.2%	10%	33%
1A3biii	Road transport: Heavy-duty vehicles and buses	1.6%	7.8%	41%
1A3bii	Road transport: Light-duty vehicles	1.5%	7.5%	48%
1A3di(ii)	International inland waterways	1.3%	6.1%	55%
1A3dii	National navigation (shipping)	1.1%	5.4%	60%
1A4ci	Agriculture/Forestry/Fish-ing: Stationary	1.1%	5.4%	65%
3Da2a	Animal manure applied to soils	0.90%	4.36%	70%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.67%	3.2%	73%
3Da1	Inorganic N-fertilizers (also includes urea application)	0.61%	2.94%	76%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.46%	2.2%	78%
1A3ai(i)	International aviation LTO (civil)	0.43%	2.1%	80.1%

NH_3 key sources

Table 1.3.a NH_3 key source categories identified by 2016 level assessment (emissions in Gg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	37	29%	29%
3B1a	Manure management - Dairy cattle	20	16%	45%
3B3	Manure management - Swine	13	9.9%	55%
3Da1	Inorganic N-fertilizers (also includes urea application)	12	9.5%	65%
3B1b	Manure management - Non-dairy cattle	10.9	8.5%	73%
6A	Other (included in national total for entire territory) (please specify in IIR)	10.0	7.8%	81.0%

Table 1.3.a NH_3 key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	196	56%	56%
3B3	Manure management - Swine	49	14%	70%
3B1a	Manure management - Dairy cattle	22	6.3%	77%
3Da3	Urine and dung deposited by grazing animals	15	4.3%	80.8%

Table 1.3.c NH_3 key source categories identified by 1990-2016 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
3Da2a	Animal manure applied to soils	10%	38%	38%
3B1a	Manure management - Dairy cattle	3.5%	14%	52%
3Da1	Inorganic N-fertilizers (also includes urea application)	2.0%	7.7%	59%
3B1b	Manure management - Non-dairy cattle	1.9%	7.5%	67%
6A	Other (included in national total for entire territory) (please specify in IIR)	1.6%	6.2%	73.0%
3B3	Manure management - Swine	1.5%	5.8%	78.8%
3B4gi	Manure management - Laying hens	1.3%	4.9%	83.7%

NMVOC key sources

Table 1.4.a NMVOC key source categories identified by 2016 level assessment (emissions in Gg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
2D3a	Domestic solvent use including fungicides	26	18%	18%
2D3i	Other solvent use (please specify in the IIR)	15	10%	28%
2D3d	Coating applications	14	10%	38%
1A3bi	Road transport: Passenger cars	12	8.7%	47%
1A4bi	Residential: Stationary	11	8.1%	55%
2H3	Other industrial processes (please specify in the IIR)	10.3	7.3%	62%
1A3biv	Road transport: Mopeds & motorcycles	8.2	5.8%	68%

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1B2aiv	Fugitive emissions oil: Refining / storage	7.5	5.3%	74%
2B10a	Chemical industry: Other (please specify in the IIR)	4.8	3.4%	77%
1B2ai	Fugitive emissions oil: Exploration, production, transport	4.3	3.0%	79.9%
2D3h	Printing	3.4	2.4%	82.3%

Table 1.4.b NMVOC key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	100	20%	20%
2D3d	Coating applications	93	19%	39%
1A3bv	Road transport: Gasoline evaporation	36	7.2%	46%
2B10a	Chemical industry: Other (please specify in the IIR)	33	6.7%	53%
1B2aiv	Fugitive emissions oil: Refining / storage	32	6.4%	59%
2H3	Other industrial processes (please specify in the IIR)	25	5.1%	64%
1A3biv	Road transport: Mopeds & motorcycles	25	5.0%	69%
2D3i	Other solvent use (please specify in the IIR)	18	3.7%	73%
2D3a	Domestic solvent use including fungicides	16.27	3.27%	76.19%
1A3biii	Road transport: Heavy-duty vehicles and buses	16	3.2%	79.4%
1B2ai	Fugitive emissions oil: Exploration, production, transport	14	2.9%	82.3%

Table 1.4.c NMVOC key source categories identified by 1990-2016 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2D3a	Domestic solvent use including fungicides	4.2%	21%	21%
1A3bi	Road transport: Passenger cars	3.3%	16%	36%
2D3d	Coating applications	2.5%	12.1%	48%
2D3i	Other solvent use (please specify in the IIR)	1.9%	9.2%	58%
1A3bv	Road transport: Petrol evaporation	1.7%	8.3%	66%

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A4bi	Residential: Stationary	1.5%	7.4%	73%
2B10a	Chemical industry: Other (please specify in the IIR)	0.94%	4.6%	78%
1A3biii	Road transport: Heavy-duty vehicles and buses	0.70%	3.4%	81%

CO key sources

Table 1.5.a CO key source categories identified by 2016 level assessment (emissions in Gg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	222	40%	40%
1A4bi	Residential: Stationary	79	14%	54%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	65	12%	65%
1A3biv	Road transport: Mopeds & motorcycles	58	10%	76%
1A4bii	Residential: Household and gardening (mobile)	28	5.1%	80.9%

Table 1.5.b CO key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	588	52%	52%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	187	16%	68%
1A4bi	Residential: Stationary	76	6.7%	75%
1A3bii	Road transport: Light-duty vehicles	48	4.2%	79%
1A3biv	Road transport: Mopeds & motorcycles	45	3.9%	82.7%

Table 1.5.c CO key source categories identified by 1990-2016 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	5.8%	25%	25%
1A4bi	Residential: Stationary	3.6%	16%	41%
1A3biv	Road transport: Mopeds & motorcycles	3.1%	14%	54%

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	2.3%	10%	64%
1A4bii	Residential: Household and gardening (mobile)	1.9%	8.0%	72%
1A3bii	Road transport: Light duty vehicles	1.8%	7.8%	80.2%

PM_{10} key sources

Table 1.6.a PM_{10} key source categories identified by 2016 level assessment (emissions in Gg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
3B4gi	Manure management - Laying hens	2.9	11%	11%
2H3	Other industrial processes (please specify in the IIR)	2.6	9.9%	21%
1A4bi	Residential: Stationary	2.1	7.9%	29%
2H2	Food and beverages industry	1.9	7.1%	36%
1A3bvi	Road transport: Automobile tyre and brake wear	1.5	5.5%	41%
3B4gii	Manure management - Broilers	1.3	4.9%	46%
2C1	Iron and steel production	1.3	4.9%	51%
2B10a	Chemical industry: Other (please specify in the IIR)	1.2	4.7%	56%
1A3bvii	Road transport: Automobile road abrasion	1.2	4.5%	61%
2A6	Other mineral products (please specify in the IIR)	1.1	4.1%	65%
1A3bii	Road transport: Light-duty vehicles	1.0	3.6%	68%
2D3i	Other solvent use (please specify in the IIR)	0.9	3.6%	72%
3B3	Manure management - Swine	0.9	3.5%	75%
1A3bi	Road transport: Passenger cars	0.7	2.5%	78%
3Dc	Farm-level agricultural operations, including storage, handling and transport of agricultural products	0.6	2.2%	80.01%

Table 1.6.b PM_{10} key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
2C1	Iron and steel production	9.1	12%	12%
1A3biii	Road transport: Heavy-duty vehicles and buses	7.0	9.4%	22%
1A3bi	Road transport: Passenger cars	6.6	8.8%	30%
1A1b	Petroleum refining	6.4	8.5%	39%
2H3	Other industrial processes (please specify in the IIR)	5.4	7.3%	46%
1A3bii	Road transport: Light-duty vehicles	4.6	6.1%	52%
2H2	Food and beverages industry	4.3	5.8%	58%
2B10a	Chemical industry: Other (please specify in the IIR)	4.1	5.5%	64%
1A4bi	Residential: Stationary	2.5	3.4%	67%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	2.2	2.9%	70%
1A1a	Public electricity and heat production	2.2	2.9%	73%
2A6	Other mineral products (please specify in the IIR)	2.0	2.7%	75%
2D3i	Other solvent use (please specify in the IIR)	1.9	2.5%	78%
3B3	Manure management - Swine	1.6	2.1%	80.1%

Table 1.6.c PM_{10} key source categories identified by 1990-2016 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
3B4gi	Manure management - Laying hens	3.5%	13%	13%
1A3biii	Road transport: Heavy-duty vehicles and buses	2.7%	9.9%	23%
1A1b	Petroleum refining	2.7%	9.8%	32%
2C1	Iron and steel production	2.6%	9.2%	42%
1A3bi	Road transport: Passenger cars	2.2%	8.0%	50%
1A4bi	Residential: Stationary	1.6%	5.8%	55%
1A3bvi	Road transport: Automobile tyre and brake wear	1.4%	5.0%	60%
3B4gii	Manure management - Broilers	1.2%	4.4%	65%
1A3bvii	Road transport: Automobile road abrasion	1.2%	4.2%	69%

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2H3	Other industrial processes (please specify in the IIR)	0.92%	3.3%	72%
1A3bii	Road transport: Light-duty vehicles	0.88%	3.2%	76%
1A1a	Public electricity and heat production	0.66%	2.4%	77.9%
3B3	Manure management - Swine	0.5%	1.8%	79.7%
3Dc	Farm-level agricultural operations, including storage, handling and transport of agricultural products	0.48%	1.74%	81.45%

$PM_{2.5}$ key sources

Table 1.7.a $PM_{2.5}$ key source categories identified by 2016 level assessment (emissions in Gg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	2.0	16%	16%
1A3bii	Road transport: Light-duty vehicles	1.0	7.7%	24%
2D3i	Other solvent use (please specify in the IIR)	0.9	7.5%	31%
2B10a	Chemical industry: Other (please specify in the IIR)	0.8	6.7%	38%
2C1	Iron and steel production	0.8	6.3%	44%
2H3	Other industrial processes (please specify in the IIR)	0.7	5.6%	50%
1A3bi	Road transport: Passenger cars	0.7	5.2%	55%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	0.6	4.4%	59%
1A3di(ii)	International inland waterways	0.4	3.6%	63%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.4	3.4%	66%
1A3biii	Road transport: Heavy-duty vehicles and buses	0.4	3.3%	70%
2A6	Other mineral products (please specify in the IIR)	0.4	2.9%	73%
1A3dii	National navigation (shipping)	0.3	2.7%	75%
2H2	Food and beverages industry	0.3	2.7%	78.0%

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1A4ciii	Agriculture/Forestry/Fishing: National fishing	0.29	2.31%	80.31%

Table 1.7.b PM2.5 key source categories identified by 1990 level assessment (emissions in Gg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy-duty vehicles and buses	7.0	14%	14%
1A3bi	Road transport: Passenger cars	6.6	13%	26%
2C1	Iron and steel production	5.8	11%	38%
1A1b	Petroleum refining	5.0	10%	47%
1A3bii	Road transport: Light duty vehicles	4.6	8.9%	56%
2B10a	Chemical industry: Other (please specify in the IIR)	2.7	5.1%	61%
1A4bi	Residential: Stationary	2.4	4.7%	66%
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	2.1	4.1%	70%
2D3i	Other solvent use (please specify in the IIR)	1.9	3.6%	74%
1A1a	Public electricity and heat production	1.9	3.6%	77%
2H3	Other industrial processes (please specify in the IIR)	1.6	3.1%	80.5%

Table 1.7.c $PM_{2.5}$ key source categories identified by 1990-2016 trend assessment (emissions in Gg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A4bi	Residential: Stationary	2.7%	15%	15%
1A3biii	Road transport: Heavy-duty vehicles and buses	2.5%	14%	29%
1A1b	Petroleum refining	2.1%	11%	40%
1A3bi	Road transport: Passenger cars	1.8%	9.9%	50%
2C1	Iron and steel production	1.2%	6.7%	57%
2D3i	Other solvent use (please specify in the IIR)	0.9%	5.1%	62%
2H3	Other industrial processes (please specify in the IIR)	0.6%	3.3%	65%

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3dii	National navigation (shipping)	0.51%	2.8%	68%
1A3di(ii)	International inland waterways	0.44%	2.4%	70%
1A1a	Public electricity and heat production	0.43%	2.4%	73%
1A3bvi	Road transport: Automobile tyre and brake wear	0.41%	2.2%	75%
2B10a	Chemical industry: Other (please specify in the IIR)	0.38%	2.1%	76.98%
2C3	Aluminium production	0.33%	1.8%	78.81%
3B4gi	Manure management - Laying hens	0.31%	1.70%	80.5%

Pb key sources

Table 1.8.a Pb key source categories identified by 2016 level assessment (emissions in Mg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
2C1	Iron and steel production	4.5	51%	51%
2C6	Zinc production	1.1	12%	63%
1A3ai(i)	International aviation LTO (civil)	0.8	8.9%	72%
2A3	Glass production	0.8	8.5%	80.3%

Table 1.8.b Pb key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	0.46	69%	69%
2C1	Iron and steel production	4.51	17%	86.2%

Table 1.8.c Pb key source categories identified by 1990-2016 trend assessment (emissions in Mg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	1.73%	45%	45%
2C1	Iron and steel production	0.91%	24%	69%
2C6	Zinc production	0.33%	9%	77%
1A3ai(i)	International aviation LTO (civil)	0.22%	6%	83%

Hg key sources

Table 1.9.a Hg key source categories identified by 2016 level assessment (emissions in Mg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	0.22	36%	36%
2C1	Iron and steel production	0.10	17%	53%
2C5	Lead production	0.09	14%	67%
1A3bi	Road transport: Passenger cars	0.06	11%	78%
1A4bi	Residential: Stationary	0.04	6.0%	84%

Table 1.9.b Hg key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	1.9	54%	54%
2B10a	Chemical industry: Other (please specify in the IIR)	0.7	20%	73%
2C1	Iron and steel production	0.4	11%	84.3%

Table 1.9.c Hg key source categories identified by 1990-2016 trend assessment (emissions in Mg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
2B10a	Chemical industry: Other (please specify in the IIR)	3.3%	26%	26%
1A1a	Public electricity and heat production	3.0%	24%	50%
1A3bi	Road transport: Passenger cars	1.6%	12%	62%
2C1	Iron and steel production	1.0%	7.6%	69.87%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	0.9%	7.2%	77%
1A4bi	Residential: Stationary	0.90%	7.1%	84%

Cd key sources

Table 1.10.a Cd key source categories identified by 2016 level assessment (emissions in Mg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
2C1	Iron and steel production	0.18	28%	28%
2C6	Zinc production	0.15	23%	51%

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	0.10	15%	65%
2B10a	Chemical industry: Other (please specify in the IIR)	0.09	14%	79.5%
1A4bi	Residential: Stationary	0.06	9.3%	88.8%

Table 1.10.b Cd key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	0.9	44%	44%
2C1	Iron and steel production	0.7	32%	76%
1A1b	Petroleum refining	0.11	5.1%	81.4%

Table 1.10.c Cd key source categories identified by 1990-2016 trend assessment (emissions in Mg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	12%	39%	39%
2C6	Zinc production	5.5%	18%	57%
2B10a	Chemical industry: Other (please specify in the IIR)	4.3%	14%	71%
1A3bi	Road transport: Passenger cars	3.4%	11%	82.8%

Dioxine key sources

Table 1.11.a Dioxine key source categories identified by 2016 level assessment (emissions in g I-Teq)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
2D3i	Other solvent use	12	52%	52%
1A4bi	Residential: Stationary	6.9	30%	81.69%

Table 1.11.b Dioxine key source categories identified by 1990 level assessment (emissions in g I-Teq)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	568	76%	76%
1A4ai	Commercial/institutional: Stationary	100	13%	89.79%

Table 1.11.c Dioxine key source categories identified by 1990-2016 trend assessment (emissions in g I-Teq)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	2.2%	41%	41%
2D3i	Other solvent use	1.5%	28%	69%
1A4bi	Residential: Stationary	0.9%	16%	85.0%

PAH key sources

Table 1.12.a PAH key source categories identified by 2016 level assessment (emissions in Mg)

NFR14 Code	Long name	2016	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	4.17	87%	87.3%

Table 1.12.b PAH key source categories identified by 1990 level assessment (emissions in Mg)

NFR14 Code	Long name	1990	Contribution	Cumulative contribution
2C3	Aluminium production	6.9	35%	35%
1A4bi	Residential: Stationary	3.8	19%	54%
2D3d	Coating applications	2.4	12%	66%
2C1	Iron and steel production	1.6	8.3%	74.3%
2H3	Other industrial processes (please specify in the IIR)	1.4	6.9%	81%

Table 1.12.c PAH key source categories identified by 1990-2016 trend assessment (emissions in Mg)

NFR14 Code	Long name	Trend	Trend contribution	Cumulative trend contribution
1A4bi	Residential: Stationary	16%	56%	56%
2C3	Aluminium production	8.3%	28%	84.3%

Appendix 2 Implementing status of review recommendations

As a result of the stage 3 review on the informative inventory report 2015 and 2015 NFR tables, a plan has been drafted on the implementation of actions regarding the issues found. Table A2.1 provides a quick view of the plan for the implementation of actions from the stage 3 review.

Table A2.1 Quick view of the implementation of actions as result of the 2015 stage 3 review

Issue in review report	Planned for	Issue in review report	Planned for
1	See from issue 43 onwards	71	No action necessary
2	See from issue 43 onwards	72	No action necessary
3	See from issue 43 onwards	73	No action necessary
4	See from issue 43 onwards	74	No action necessary
5	See from issue 43 onwards	75	In IIR2016
6	See from issue 43 onwards	76	gradually in IIRs 2016 - 2018
7	See from issue 43 onwards	77	In IIR2016
8	See from issue 43 onwards	78	No action necessary
9	See from issue 43 onwards	79	In IIR2016
10	See from issue 43 onwards	80	In IIR2016
11	See from issue 43 onwards	81	gradually in IIRs 2016 - 2018
12	See from issue 43 onwards	82	gradually in IIRs 2016 - 2018
13	See from issue 43 onwards	83	No action necessary
14	See from issue 43 onwards	84	In IIR2016
15	See from issue 43 onwards	85	No action necessary
16	See from issue 43 onwards	86	No action necessary
17	See from issue 43 onwards	87	No action necessary
18	See from issue 43 onwards	88	No action necessary
19	See from issue 43 onwards	89	In IIR2016
20	See from issue 43 onwards	90	In IIR2016
21	See from issue 43 onwards	91	In IIR2016
22	See from issue 43 onwards	92	gradually in IIRs 2016 - 2018
23	See from issue 43 onwards	93	In IIR2016
24	See from issue 43 onwards	94	No action necessary
25	See from issue 43 onwards	95	In IIR2016
26	See from issue 43 onwards	96	In IIR2016
27	See from issue 43 onwards	97	In IIR2016
28	See from issue 43 onwards	98	In IIR2016
29	See from issue 43 onwards	99	In IIR2016
30	See from issue 43 onwards	100	IIR2017
31	See from issue 43 onwards	101	IIR2017
32	See from issue 43 onwards	102	In IIR2016
33	See from issue 43 onwards	103	IIR2017

Issue in review report	Planned for	Issue in review report	Planned for
34	See from issue 43 onwards	104	No action necessary
35	See from issue 43 onwards	105	No action necessary
36	See from issue 43 onwards	106	In IIR2017 / IIR2018
37	See from issue 43 onwards	107	No action necessary
38	See from issue 43 onwards	108	In IIR2017
39	See from issue 43 onwards	109	No action necessary
40	See from issue 43 onwards	110	No action necessary
41	See from issue 43 onwards	111	In IIR2016
42	See from issue 43 onwards	112	In IIR2016
43	Not settled yet	113	In IIR2016
44	Not settled yet	114	IIR2017
45	No action necessary	115	In IIR2016
46	Not settled yet	116	In IIR2016
47	Not settled yet	117	In IIR2016
48	In IIR2016	118	In IIR2017
49	In IIR2016	119	In IIR2016
50	In IIR2016	120	In IIR2016
51	In IIR2016	121	See Issue 127
52	In IIR2017	122	In IIR2017
53	In IIR2018	123	In IIR2017
54	In IIR2018	124	No action necessary
55	In IIR2018	125	No action necessary
56	In IIR2016	126	In IIR2017
57	In IIR2018	127	In IIR2017
58	In IIR2018	128	In IIR2017
59	In IIR2016	129	In IIR2017
60	No action necessary	130	In IIR2017
61	In IIR2016	131	In IIR2017
62	In IIR2017	132	No action necessary
63	In IIR2018	133	In IIR2016
64	No action necessary	134	In IIR2016
65	In IIR2016	135	In IIR2016
66	In IIR2016	136	In IIR2016
67	In IIR2017	137	In IIR2017
68	In IIR2016	138	In IIR2017
69	In IIR2016	139	In IIR2017
70	In IIR2017		

Table A2.2 Quick view of the implementation of actions as result of the 2017 NEC-review

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
NL-1A1-2017-0001	1A1 Energy industries, $PM_{2.5}$, 2000-2015	To ensure transparency in the IIR, the TERT recommends to indicate more clearly in the IIR the definition of these two pollutants and to add in the section energy in the IIR that $PM_{2.5}$ are estimated on the basis of the standard fractions which are presented in Visschedijk, 2007 (Onderhoud van methodieken Emissieregistratie 2006-2007) and to present these shares in the IIR.	To avoid any confusion, the emission factors for coarse particulates are not shown anymore. Instead we included emission factors for PM10 and for TSP in the relevant tables in chapter 3. The PM2.5 fractions have not yet been included in the IIR. This recommendation will be subject for further consideration in 2018.
NL-1A1-2017-0002	1A1 Energy Industries, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000-2015	The TERT recommends that the Netherlands checks the relevance of the country-specific emission factors to have justifiable references for SO_X and NO_X.	This recommendation is subject for further consideration in 2018.
NL-1A1-2017-0004	1A1 Energy Industries, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000-2015	The TERT recommends that the Netherlands conducts a survey among operators to identify, which ones are reporting emissions on the basis of the validated average values and try to derive a methodology to adjust the national emissions over the time series in order to compensate the fact that national emissions are estimated on the basis of data reported by operators using validated average values.	Performing the suggested survey involves the cooperation of the companies and the competent authorities. There was not enough time to organise these parties to perform the recommended survey before this submission. This will be taken up further during 2018.
NL-1A1a-2017-0001	1A1a Public Electricity and Heat Production, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000-2015	The TERT recommends that in the next submission, the Netherlands adds in its IIR in the category 1A1a the methodology used for waste incineration with energy recovery.	In paragraph 3.2.1, we included a sentence that emissions from all waste incineration plants are included in 1A1a. All of the plants report their emissions in an environmental report and therefore the methodology described in 3.2.5 is also valid for waste incineration.
NL-1A1b-2017-0001	1A1 Energy Industries, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000-2015	For several categories within energy industries, the TERT noted that emissions are estimated for some pollutants but fuel consumptions are reported as 'NO'. In response to a question raised during the review, the Netherlands	The activity data is now included in the NFR-table.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
		explained that the activity data in the NFR tables are incomplete, but emissions are correct. The TERT notes that the issue does not relate to an over- or under-estimate. The TERT recommends that the Netherlands corrects for the next submission the NFR tables with the appropriate value for fuel consumption for the different years.	
NL-1A1c-2017-0001	1A1c Manufacture of solid fuels and other energy industries, NH_3, NMVOC, $PM_{2.5}$, 2000-2015	The TERT notes that the issue does not relate to an over- or under-estimate. Firstly, for the next submission, the TERT recommends that the Netherlands use the appropriate notation key. Secondly, the TERT recommends that the Netherlands develop a methodology, which allows to consider an installation in the same category throughout the time series (if the main activity remains the same) in order to ensure consistency.	We were not able to conclude in time on the discussion of the use of the correct notation key. This recommendation is subject for further consideration in 2018.
NL-1A2b-2017-0001	1A2b Stationary combustion in manufacturing industries and construction: Non-ferrous metals, NH_3, 2000-2015	The TERT recommends that the Netherlands investigates this issue. Firstly, the Netherlands could verify the relevance of NH_3 emissions declared by companies since emissions are not declared every year. Secondly, if these data are validated by operators, the Netherlands could estimate for the entire time series NH_3 emissions in using an average EF determined with data declared or in using an emission factor resulting from literature. The TERT further recommends that the Netherlands ensures time-series consistency by estimating these emissions for all years and include them in the reporting.	This recommendation is subject for further consideration in 2018.
NL-1A2f-2017-0001	1A2f Stationary combustion in manufacturing industries and	The TERT recommends that the Netherlands uses the correct notation keys in its NFR tables regarding the methodology used	In the IIR, it is now described that emissions from non-metallic minerals are allocated to 1A2gviii

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
	construction: Non-metallic minerals, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000-2015	and considers reallocating emissions from mineral production in the category 1A2f instead of category 1A2gviii to improve comparability.	
NL-1A2gvii-2017-0001	1A2gvii Mobile Combustion in Manufacturing Industries and Construction, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	The TERT recommends providing these data in the NFR tables and the IIR as well.	In this year's inventory the notation key has been replaced to IE for relevant years. In next year's inventory the activity data for biomass will be included.
NL-1A3ai(i)-2017-0001	1A3ai(i) International aviation LTO (civil), NH_3, 1990-2015	The TERT welcomes this planned correction and recommends the Netherlands to implement it.	Notation key has been revised.
NL-1A3aii(i)-2017-0001	1A3aii(i) Domestic aviation LTO (civil), SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	The TERT acknowledged the answer provided by the Netherlands, understanding that this is not an issue of completeness. However, to improve the inventory's transparency and comparability, the TERT recommends the Netherlands to look into this issue when resources allow.	None. Emissions from domestic flights are very small and are included in the inventory, see Section 4.2.5. The issue is on the long list of improvements.
NL-1A3b-2017-0001	1A3b Road Transport, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that the Netherlands includes the biomass activity data in its next submission.	In this year's inventory the notation key has been replaced to IE for relevant years. In next year's inventory the activity data for biomass will be included.
NL-1A3b-2017-0002	1A3b Road Transport, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that the Netherlands explains clearly in the IIR where the lubricant consumption for different engines are reported and that the Netherlands reports numbers in NFR tables its next submission.	Explanation included in Section 4.3.4 (Lubricant oil)
NL-1A3b-2017-0003	1A3b Road Transport, $PM_{2.5}$, 2000-2015	The TERT recommends that the Netherlands includes emission factors with references in its next submission.	Explanation and reference included in Section 4.3.4 (PM emission factors)
NL-1A3biii-2017-0001	1A3biii Road transport: Heavy duty vehicles and buses, NH_3, 2007-2015	The TERT recommends that the Netherlands includes the explanation in its next submission.	The explanation is included in section 4.3.3.
NL-1A3bvi-2017-0001	1A3bvi Road transport:	The TERT recommends that the Netherlands includes the correct	Correct data is included in NFR

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
	Automobile tyre and brake wear, $PM_{2.5}$, 2000, 2005, 2010	data in its next submission.	
NL-1A3bvii-2017-0001	1A3bvii Road Transport: Automobile Road Abrasion, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that the Netherlands includes the correct data in its next submission.	Correct data is included in NFR
NL-1A3c-2017-0001	1A3c Railways, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2012-2014	The TERT recommends providing sufficient information on trends of both activity data and emissions in the next submission.	The explanation is included in section 4.4.7.
NL-1A3c-2017-0002	1A3c Railways, SO_2, NO_X, NH_3, $PM_{2.5}$, 1990-2015	The TERT agreed with the answer provided by The Netherlands. However, as the Netherlands further stated that separate activity data are available for biofuels and fossil fuels especially from the CRF tables used for GHG reporting, the TERT recommends providing these separate data in the NFR tables and the IIR as well.	In this year's inventory the notation key has been replaced to IE for relevant years. In next year's inventory the activity data for biomass will be included.
NL-1A3di(ii)-2017-0001	1A3di(ii) International Inland Waterways, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	The TERT recommends the Netherlands to check whether there are no biofuels used for navigation at least as part of blended liquid fuels and change notation key accordingly.	Notation key has been changed to IE.
NL-1A3ei-2017-0001	1A3ei Pipeline transport, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	The TERT acknowledged the answer provided by The Netherlands, warmly welcoming the intention to correct the inventory and recommends that this is done for the next submission. However, as the Netherlands also stated that NMVOC emissions were rightfully allocated in category 1B2b, the TERT notes that this allocation would be correct for fugitive NMVOC emissions but not for NMVOC from the fuel combustion in pipeline compressors, recommending the Netherlands to document the nature of NMVOC emissions in the next submission.	This recommendation is subject for further consideration in 2018.
NL-1A4ai-	1A4ai	The TERT recommends that	See paragraph 3.4.4., the

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
2017-0001	Commercial/institutional: Stationary, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2000-2015	Netherlands correct these errors in the next submission.	references are updated and errors corrected.
NL-1A5a-2017-0001	1A5a Other stationary (including military), NH_3, 2000-2015	The TERT recommends the Netherlands to change the allocation of these emissions because it does not follow the 2016 EMEP/EEA Guidebook. Concerning landfill gas, three cases are possible: 1) the gas is not collected or it is collected and not combusted. In this case, emissions should be reported in NFR 5 A Solid waste disposal on land 2) The gas is collected and flared. In this case, emissions should be reported in 5A Solid waste disposal on land 3) The gas is collected and combusted in stationary or mobile equipment. In this case, emissions should be reported in either NFR 1A1a Public Electricity and Heat Production, if there is a local plant for public electricity and heat production or if the biogas is transferred to another plant (domestic, commercial or industrial combustion plant) under the appropriate NFR code. In all cases, these emissions should not be included in category 1A5a unless it is used for military purposes.	This recommendation is subject for further consideration in 2018.
NL-1B1a-2017-0001	1B1a Fugitive Emission from Solid Fuels: Coal Mining and Handling, $PM_{2.5}$, 1990-2015	The TERT accepted the explanation and recommends that the information on IE notation keys in the IIR be modified. As a result of the question, the TERT found out that the implementation of quality controls of the emissions reported was constrained due to the lack of any other data in the inventory besides emissions. The TERT strongly recommends that the Netherlands collects proxy variables, such as production data, which would	An explanation were the emissions from coal storage and handling in plants whose main activity is not the coal storage and handling (e.g. power plants) are reported is included in section 5.6.3. Also the reason why it is not possible to provide activity data and determine/calculate IEF's is included in section 5.6.3

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
		enable to develop internal quality controls.	
NL-1B1b-2017-0001	1B1b Fugitive emission from solid fuels: Solid fuel transformation, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	For category NFR 1B1b Fugitive emission from solid fuels: Solid fuel transformation and for years 1999-2015, the TERT noted that emissions had been reported as not occurring (NO) even though Eurostat energy balances showed coke oven coke production throughout the period. In response to a question raised during the review, the Netherlands pointed out that category 1B1b comprised the emissions from the independent coke oven facility, which closed in 1999, whilst the emissions from coke production at the iron and steel sector had been allocated within NFR 1A2a Stationary combustion in manufacturing industries and construction: Iron and steel. The Netherlands explained it by the fact that it was not possible to distinguish the fraction of emissions from coke oven coke production and stated that notation key would be replaced by 'IE'. The TERT agreed with the explanation provided by the Netherlands and recommends that the Netherlands includes it in the IIR.	See paragraph 3.5.1
NL-1B2av-2017-0001	1B2av Distribution of oil products, NMVOC, 1990-2015	For category 1B2av Distribution of oil products and NMVOC, the TERT noted that the 'NE' notation key had been reported and that emission sources such as dissipation losses from gasoline service stations, leakage losses during vehicle and airplane refuelling had been included within the category 1B2aiv Fugitive emissions oil: Refining / storage. In response to a question raised during the review, the Netherlands stated that the aforementioned emission sources would be reallocated for the next	Emissions are now allocated in 1B2av.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
		submission. The TERT recommends that the Netherlands makes this reallocation in the next submission.	
NL-1B2b-2017-0001	1B2b Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other), SO_2, NMVOC, 1990-2015	For category 1B2b Fugitive emissions from natural gas and NMVOC, the TERT noted that the section in the IIR on this category only contained information on emissions from gas transport (compressor stations) and gas distribution networks (pipelines for local transport). The TERT clarified the issue with the Netherlands that fugitive emissions for all the main activities associated with natural gas (i.e. exploration, production, processing, transmission, storage and distribution) had been estimated. The Netherlands explained that overall NMVOC emissions from the extraction of oil and gas, reported by plants in their annual environmental report, had also been allocated within category 1B2ai Fugitive emissions oil: Exploration, production, transport. The TERT notes that this issue does not relate to an over- or under-estimate. The TERT recommends that the IIR be updated with this information in the next submission, listing all emission sources and including a brief methodological description.	See section 3.5.5
NL-2A-2017-0001	2A Mineral Industry, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	The TERT notes that this issue does not relate to an over- or under-estimate. However, the TERT strongly recommends that the Netherlands collects background information on the activity levels and process characteristics in order to validate the data consistency or repetitiveness, estimate emissions from non-reporting plants or filling gaps in the time series related to one reporting	The reason why it is not possible to provide activity data and determine/calculate IEF's is included in section 5.2.1.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
		plant.	
NL-2B-2017-0001	2B Chemical Industry, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 2005-2015	The TERT notes that this issue does not relate to an over- or under-estimate and recommends that the Netherlands includes these indices in its next IIR to improve transparency.	The indices of the Chemical Production are included in section 5.3.4.
NL-2C-2017-0001	2C Metal Industry, SO_2, 2005-2015	The TERT recommends that the Netherlands investigates the possibility to estimate emissions based on production data, which are reported as confidential in the NFR tables and a default emission factor from the 2016 EMEP/EEA Guidebook.	An explanation why the Netherlands do not report SO2 and PM2.5 emissions for 2005-2015 is included in section 5.4.1.
NL-2C3-2017-0001	2C3 Aluminium production, SO_2, NO_X, 2005-2015	The TERT notes that this issue does not relate to an over- or under-estimate and recommends that the Netherlands includes this in its next submission.	The reason why the Netherlands do not report SO2 and NOx emissions for 2C3 is included in section 5.4.1.
NL-2D-2017-0001	2D Non energy products from fuels and solvent uses, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	The TERT recommends that the Netherlands improve the transparency of the reporting by including descriptions of the methodology, the activity data used including references, the emission factors used including references. The TERT further recommends that the Netherlands, in cases when data are used that stem from plant reporting, provides a thorough description of the data quality (e.g. frequency of measurements) and describes what exact steps are included in the validation performed by the competent authority.	A reference to the WESP report where a lot of information can be found on methodologies, activity data, etc is included in section 5.5.5.
NL-2D3g-2017-0001	2D3g Chemical Products, NMVOC, 1990-2015	The TERT recommends that the Netherlands makes an effort to distinguish between emissions from the use of solvents to be reported in this category and the emissions from other processes to be reported under 2B10.	The reason why disaggregation of the reported emissions under 2B10a is not possible is included in section 5.3.1.
NL-2D3i-2017-0001	2D3i Other Solvent Use, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	The TERT recommends that the Netherlands includes information on the activities covered, the activity data including the data	The activities which belong to 2D3i are included in section 5.5.3, paragraph Other solvent use.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
		sources and the emission factors used including references in its next submission.	
NL-2H2-2017-0001	2H2 Food and beverages industry, NMVOC, 2005, 2010, 2015	The TERT recommends that the Netherlands in the next submission provides information on the activities covered. Furthermore, the TERT recommends that the Netherlands makes the utmost effort to get statistical data for as many of the activities as possible to allow for an estimation of the emissions following the methodology in the 2016 EMEP/EEA Guidebook.	The activities which belong to 2H2 are included in section 5.6.1. The explanation why no activity data or emission factors are available can also be found in section 5.6.1.
NL-3B-2017-0002	3B Manure management, NMVOC, 1990-2015	The TERT recommends the Netherlands to use the 2016 EMEP/EEA Guidebook methodology to include these estimates in the next submission.	Planned improvement for the next submission, see also section 6.2.7.
NL-3B-2017-0003	3B Manure management, NH_3, 1990-2015	For category 3B Manure management and categories related (3Da2a Animal manure applied to soils and 3Da3 Urine and dung deposited by grazing animals) the TERT recommends that the Netherlands enhances the transparency of its next submission by including, apart from the references along the text, the most relevant parameters/factors that affect the estimates: such as consistent livestock numbers, N excretion rates and use of MMS, and a detailed justification of any reduction in emissions (EFs) caused by mitigation measures/national policies. All country specific EFs should also be documented including references and all assumptions should be accompanied by a clear justification of the applicability.	Improved text in chapter 6 Agriculture and the methodology report (Vonk et al., 2018).
NL-3B2-2017-0001	3B2 Manure management - Sheep, $PM_{2.5}$, 1990-2015	The TERT noted that the issue is below the threshold of significance for a technical correction and recommends that emissions or explanation for the	Issue is on the NEMA working group agenda.

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
		current reporting (NE) are included in the next submission.	
NL-3D-2017-0002	3D Crop production and agricultural soils, NO_X, 1990-2015	The TERT recommends that the Netherlands reports the emissions in the correct NFR category in the next submission.	NO_x emissions from category 3D are now allocated to the respective subcategories 3Da1 Inorganic N-fertilizers, 3Da2a Animal manure applied to soils and 3Da3 Urine and dung deposited by grazing animals instead of 11C.
NL-3D-2017-0003	3D Crop production and agricultural soils, $PM_{2.5}$, 1990-2015	The TERT recommends that the Netherlands enhances the transparency of its next submission by including in the IIR the main variables and assumptions made, such as activity data and explanations on how the EF in table 6.8 were derived, information on management practices or other parameters supporting the estimates.	The activity data and the assumptions made are included within the new methodology report (Vonk et al., 2018).
NL-3D-2017-0004	3D Crop production and agricultural soils, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2015	The TERT agrees with this and recommends the Netherlands modifies the text in the IIR, saying that emissions are not estimated because there is currently no methodology available in the 2016 EMEP/EEA Guidebook.	Issue is on the NEMA working group agenda.
NL-3Da1-2017-0001	3Da1 Inorganic N-fertilizers (includes also urea application), NH_3, 2000-2015	The TERT recommends, that the Netherlands includes further information in its next IIR, such as amount of N applied to soils by fertiliser type, EF used for each fertiliser and assumptions accompanied by a clear justification of their applicability.	This has been included within the new methodology report (Vonk et al., 2018).
NL-3F-2017-0001	3F Field burning of agricultural residues, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2005	The TERT recommends that further explanations supporting the lack of estimates (e.g. that sent to the TERT) are included in the next submission.	See section 6.1
NL-5E-2017-0001	5E Other Waste, SO_2, NO_X, NMVOC, $PM_{2.5}$, 2005, 2010, 2015	The TERT recommends that the Netherlands include the revised estimate in its next submission.	The IIR2018 describes the methodology, activity data and emission factors used for calculating the emissions from this source
NL-6A-2017-0002	6A Other Sources, NH_3, 2005-2015	Considering that this is a key category, the TERT recommends that the Netherlands includes a	In the IIR2018 the methodology used for the sources under this sector are described and activity

Observation	NFR, Pollutant(s), Year(s)	Recommendation (shortened text)	Action taken
		methodological description in the IIR and include activity data and emission factors for the different emission sources covered by category 6A.	data and emission factors used are reported.

RIVM

Committed to *health and sustainability* -