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

Emissions of transboundary air pollutants *in the Netherlands* *1990-2014*

Informative Inventory Report 2016

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Synopsis

Informative Inventory Report 2016

Ammonia emissions increased

In 2014 total Dutch ammonia emissions increased. Despite the decrease during the period 1990-2013, the ammonia emission still exceeds the maximum set to this by the European Union since 2010. Two important contributors to the increase are the growth in dairy cattle and the altered cattle feed composition. Emissions of nitrogen oxides, sulphur dioxides and non-methane volatile organic compounds continue to decrease slightly. For this end the Netherlands are complying to the ceilings set.

This is concluded by the Informative Inventory Report 2016. In this, the RIVM and partner institutes collect, analyse and report emission data. Apart from substances as mentioned above, this also includes emissions of carbon monoxide, particulate matter, heavy metals and persistent organic pollutants. The emissions of most of these substances have decreased during the 1990 – 2014 period. The downward trend may in particular be attributed to cleaner fuels, cleaner car engines and to emission reductions in industry.

Adjustments for agriculture
In 2014 ammonia emissions increased by 3.4 Gg compared to 2013 to a national total of 133.8 Gg. Partly this increase was a result of the altered cattle feed composition. As a result of the good quality of processed grass, fed to dairy cattle in 2014, digestibility and therefore ammonia emission per animal increased. In combination with the growth in animal number, the total ammonia emission increased. New insights on manure application techniques lowered the ammonia emission series retroactively from 2008 by about 3.0 Gg. On the other hand ammonia is increased by about 0.5 Gg per year during grazing, by adjusting the emission factor upward.

Adjustments transport
When nitrogen oxides emissions by transport are concerned, some issues raise attention. The emissions by light-duty vehicles have now been measured and appear to be higher than until previously calculated. Diesel sales and on such based road transport emissions have in 2014 relatively decreased steeper (8 percent compared to 2013) than emissions based on fuel use (1.6 percent). Nitrogen dioxide emissions from mobile machinery in harbours were added as a new source. The contribution to the national is 1.2 percent.

Keywords: emissions, transboundary air pollution, emission inventory

Publiekssamenvatting

Informatieve Inventory Report 2016

Toename ammoniakemissies

In 2014 steeg de ammoniakemissie. Ondanks de daling in de voorgaande jaren blijft de ammoniak emissie nog steeds boven het plafond dat de Europese Unie hieraan sinds 2010 stelt. De twee belangrijkste oorzaken voor de stijging zijn de groei van de melkveestapel en de veranderde voedselsamenstelling voor het vee. De emissies van stikstofoxiden, zwaveldioxiden en niet-methaan vluchtige organische stoffen blijven licht dalen. Voor deze stoffen voldoet Nederland aan de gestelde plafonds.

Dit blijkt uit het Informative Inventory Report (IIR) 2016. Hierin verzamelt, analyseert en rapporteert het RIVM de emissiecijfers met partnerinstituten. Behalve bovengenoemde stoffen gaat het om de uitstoot van koolmonoxide, fijn stof, zware metalen en persistente organische stoffen. De uitstoot van de meeste van deze stoffen is tussen 1990 en 2014 gedaald. Dit komt vooral door schonere auto's en brandstoffen en door emissiebeperkende maatregelen in de industrie.

Bijstellingen landbouw
De ammoniakemissie steeg in 2014 met 3,4 kiloton ten opzichte van 2013 tot een nationaal totaal van 133,8 kiloton. Deze stijging is gedeeltelijk veroorzaakt door de veranderde voedselsamenstelling voor het vee. Het kuilgras dat in 2014 is gevoerd zorgde voor een hogere ammoniakproductie per dier. In combinatie met een stijging van het aantal koeien steeg de totale ammoniak uitstoot. Door nieuwe wetenschappelijke inzichten over mestaanwendingstechnieken is de ammoniak emissiereeks met terugwerkende kracht vanaf 2008 ongeveer 3 kiloton omlaag bijgesteld. Daartegenover staat dat de emissiefactor bij beweiding is verhoogd, waardoor er circa 0,5 kiloton meer ammoniak per jaar vrijkomt.

Bijstellingen verkeer
Bij de uitstoot van stikstofoxiden door verkeer vallen een aantal zaken op. De emissie van bestelauto's is nu gemeten en blijkt hoger dan voorheen berekend. De emissie van wegverkeer die op basis van de brandstofverkoop voor dieselauto's wordt bepaald, is in 2014 relatief harder gedaald (8 procent ten opzichte 2013) dan die op basis van verbruikte brandstof (1,6 procent). Deze cijfers zijn toegevoegd om een internationale vergelijking mogelijk te maken. De bijdrage van mobiele werktuigen in havens aan het nationale totaal stikstofoxiden, die als nieuwe emissiebron is toegevoegd, is 1,2 procent.

Kernwoorden: emissies, grootschalige luchtverontreiniging, emissieregistratie

Contents

1 Introduction

The United Nations Economic Commission for Europe's' Geneva 1979 Convention on Long-Range Transboundary Air Pollution (CLRTAP) was accepted by the Netherlands in 1982. Under the Convention parties are obligated to report emission data to the Conventions' Executive Body in compliance with the implementation of the Protocols to the Convention (also accepted by the Netherlands). The annual Informative Inventory Report (IIR) on national emissions of SO_2, NO_X, NMVOC, CO, NH_3 and various heavy metals and POP is prepared using the Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution 2014 (UNECE, 2014).
The Netherlands' IIR 2016 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 2014, 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 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 the process of data collection, processing and registration, and reporting on emission data for some 350 compounds. Emission data (for the most important pollutants) and documentation can be found at www.prtr.nl.
Instead of using the defaults from the EMEP/EEA air pollutant emission inventory guidebook 2013 (EEA, 2013), the Netherlands often applies country-specific methods with associated activity data and emission factors. The emission estimates are based on official statistics of the Netherlands (e.g. on energy, industry and agriculture) and environmental reports 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 Environment (IenM) has the overall responsibility for the emission inventory and submissions to CLRTAP. A Pollutant Release and Transfer Register (PRTR) system has been in operation in the Netherlands since 1974. Since 2010, the Ministry of IenM 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 an annual set of unequivocal emission data that is up to date, complete, transparent, comparable, consistent and accurate. Emission data are produced in

annual (project) cycles (RIVM, 2014; 2015). Various external agencies contribute to the PRTR by performing calculations or submitting activity data (see next section). In addition to the RIVM, the following institutes contribute to the PRTR:

- 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;
- Alterra WUR;
- Wageningen UR Livestock Research;
- Agricultural Economics Research Institute (LEI);
- Fugro-Ecoplan, which co-ordinates 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

Data collection

For the collection and processing of data (according to pre-determined methods), the PRTR is organised according to task forces. The task forces consist of sector experts of 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 recalculation of historical emissions. The following task forces are recognised (see Figure 1.1):

- Task Force on Agriculture and Land Use;
- 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 collection of the emission data, several quality control checks are performed by the task forces during a yearly 'trend analysis' workshop. After approval 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. 5x5 km grid, municipality scale, provincial scale and water authority scale).

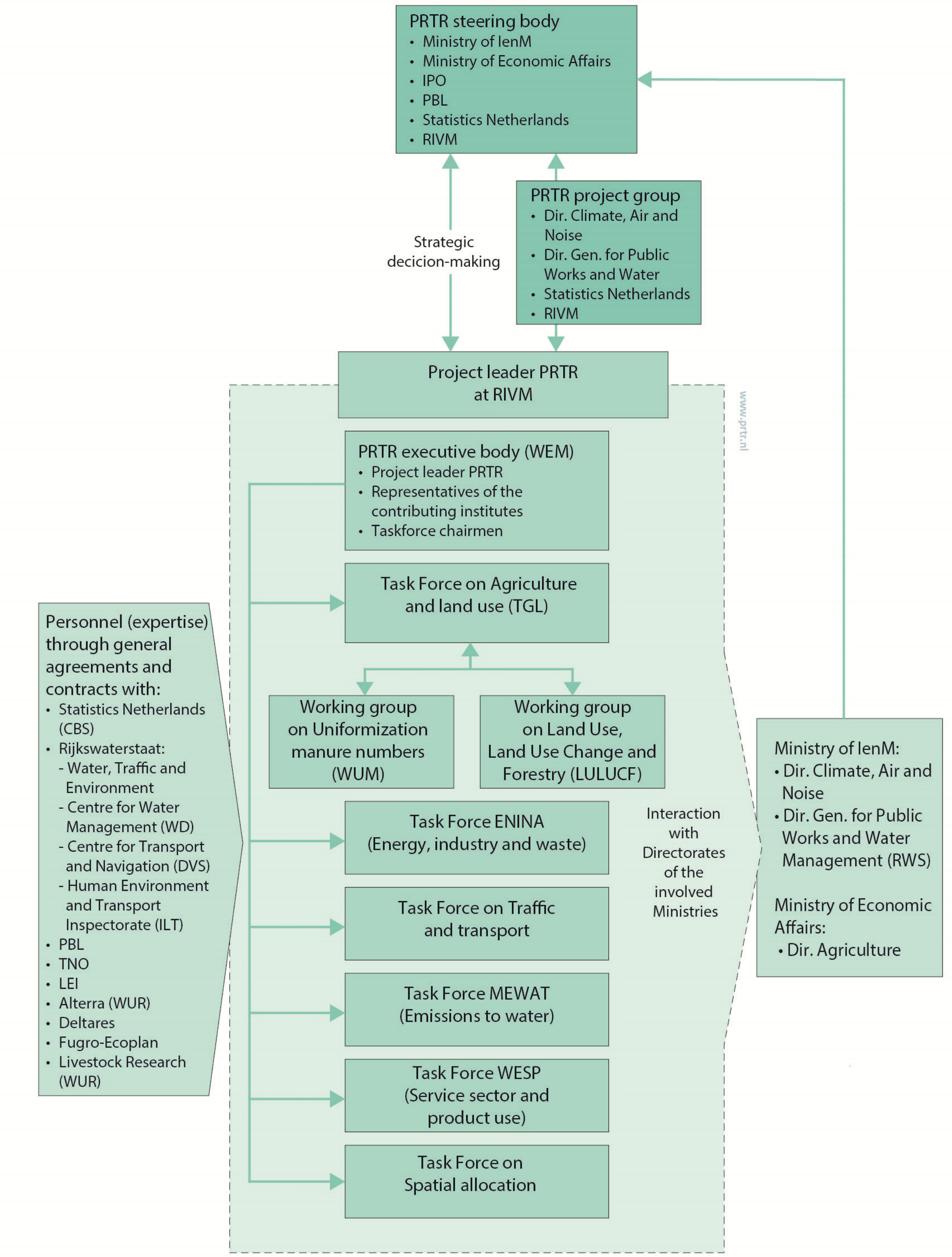

Figure 1.1 The organisational arrangement of the Netherlands Pollutant Release and Transfer Register (PRTR)

1.3.1 *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 1000 facilities are 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 reported amount of the main pollutants for each subsector approximately meets 80% of the subsector total. This criterion has been set as 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 part of an Annual Environmental Report (AER), electronically. All these companies have emission monitoring and registration systems with specifications in agreement with 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 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 (Dröge and Ten Broeke, 2012). 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, for instance (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 1.2). The PRTR database, consisting of a large number of geographically distributed emission sources (about 700), contains complete annual records of emissions in the Netherlands. Each emission source includes information on the NACE-code (Nomenclature statistique des Activités économiques dans la Communauté Européenne) and industrial subsector, separate information on process and combustion emissions, and the relevant environmental compartment and location. These emission sources can be selectively aggregated, per NFR category.

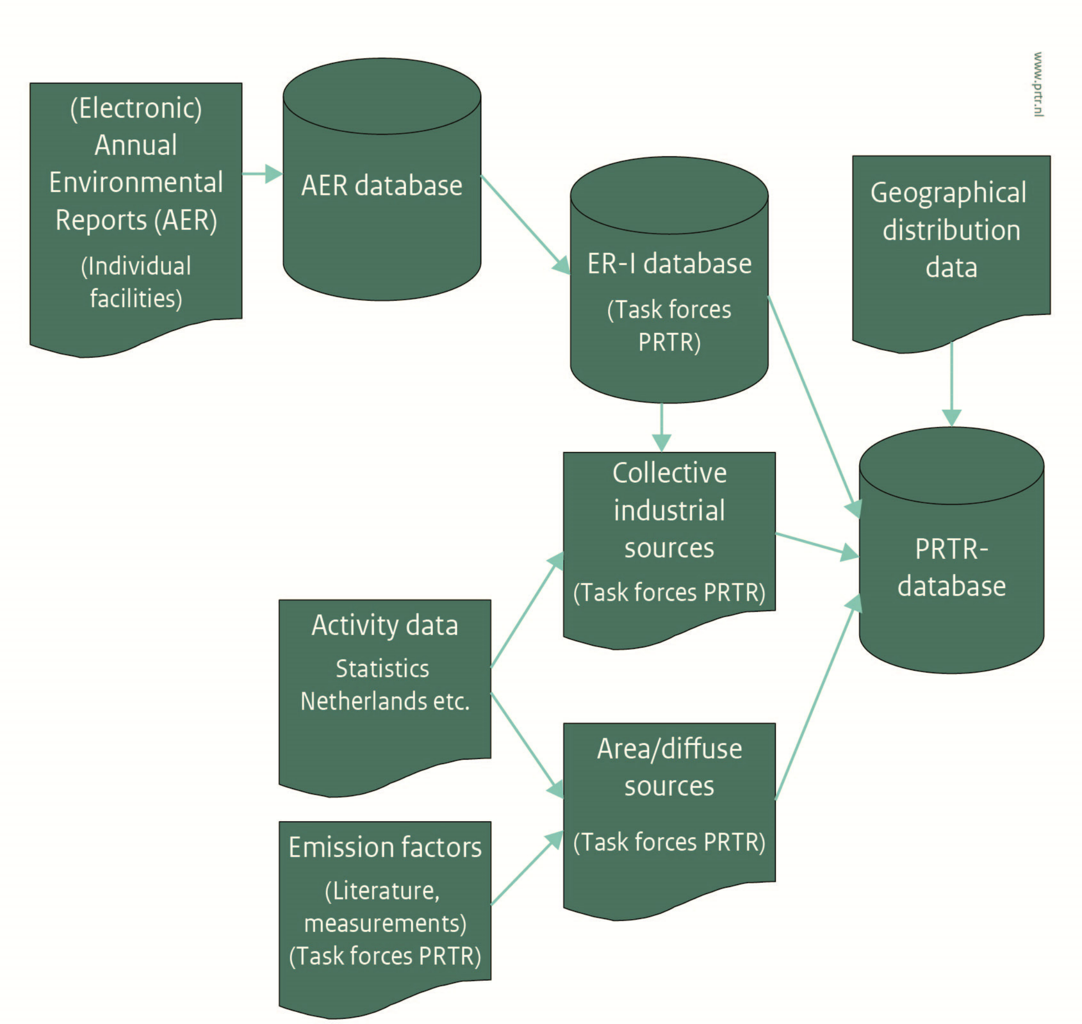

Figure 1.2 The data flow in the Netherlands Pollutant Release and Transfer Register

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 in 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 'Co-operation 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, 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 (EEA, 2013). The level assessments were performed for both the latest inventory year 2014, 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

Reporting

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

QA/QC

The RIVM has an ISO 9001:2008 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 annual project plans (RIVM, 2014; 2015). The general QA/QC activities meet the international inventory QA/QC requirements described in part A, chapter 6 of the EMEP inventory guidebook (EEA, 2013).

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

Quality Assurance (QA)

QA activities can be summarised as follows:
- For the energy, industry and waste sectors, emission calculation in the PRTR is based mainly on AERs 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 Emissions and air quality of the RIVM Centre for Environmental Quality;
- Furthermore, there are annual external QA checks 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 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 2014 inventory the PRTR task forces filled in a standard-format database with emission data from 1990 to 2013. 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 trend (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 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 organised by the RIVM (see Text box 1.1). 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 2015 and NFR/IIR 2016

QC Item/action	Date	Who	Result	Documentation *
Automated initial check on internal and external data consistency	During each upload	Data Exchange Module (DEX)	Acceptation or rejection of uploaded sector data	Upload event and result logging in the PRTR-database
Input of hanging issues for this inventory	07-07-2015	RIVM-PRTR	List of remaining issues/actions from last inventory	Actiepunten voorlopige cijfers 2014 v 07 juli 2015.xls
Input for checking allocations from the PRTR-database to the NFR tables	30-04-2015	RIVM-NIC	List of allocations	NFR-ER-Koppellijst-2015-04-30-DTT48_bj.xlsx
Input for error checks	24-11-2015	RIVM-PRTR	Comparison sheets 2013-2014 data	Verschiltabel_LuchtActueel_24-11-2015.xlsx
Input for trend analysis	30-11-2015	RIVM-PRTR	Updated list of required actions	Actiepunten definitive cijfers 1990-2014 v 30 nov 2015.xls

Trend analysis workshops	03-12-2015	Sector specialists, RIVM-PRTR	Explanations for observed trends and actions to resolve before finalising the PRTR dataset	– Emissies uit de landbouw 1990-2014.ppt – Presentatie ENINA TrendAnalyse dag 3 dec 2015.pptx – Trendanalyse verkeer 2015.pptx Trendanalyse WESP 2015.pptx
Input for resolving the final actions before finalising the PRTR dataset	9-12-2015	RIVM-PRTR	Updated Action list	Actiepunten definitive cijfers 1990-2014 v 9 dec 2015.xls
Request to the contributing institutes to endorse the PRTR database	16-12-2015 till 19-12-2015	PRTR project secretary, Representatives of the contributing institutes	Reactions of the contributing institutes to the PRTR-project leader	– Email with the request – Actiepunten definitive cijfers 1990-2014 v 15 dec 2015.xls Emails with consent from PBL, Deltares and CBS
Input for compiling the NEC report (in NFR-format)	01-12-2015	RIVM-NIC	List of allocations for compiling from the PRTR-database to the NFR-tables	NFR-ER-Koppellijst-2015-12-01-dtt50_bj.xlsx
Final PRTR dataset	19-12-2015	PRTR project leader	Updated Action list	Email with approval on the data for reporting
List of allocations for compiling from the PRTR-database to the NFR-tables	10-02-2016	RIVM	Input for compiling the EMEP/LRTAP report (NFR format)	NFR-ER-Koppellijst-2016-02-10-dtt50-v2_bj.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 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 more 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 per 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 2013 from the new time series were compared with the time series of last years' inventory and 2) the data for 2014 were compared with the trend development per 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 2 weeks or be 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 relating 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, updating of monitoring protocols for substances under the CLRTAP is one of the priorities within the PRTR system. Emphasis is placed on 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 such emission reports as the National Inventory Report (UNFCCC) and the Informative Inventory Report (CLRTAP), are made available on the website of the PRTR: www.prtr.nl.

1.7 Uncertainties

Uncertainty assessments constitute a means to either provide the inventory users with a quantitative assessment of the inventory quality or to direct the inventory preparation team to priority areas, where improvements are warranted and can be made cost-effective. For these purposes, quantitative uncertainty assessments have been carried out since 1999. However, awareness of uncertainties in emission figures was expressed earlier in the PRTR in so-called quality indices and in several studies on industrial emissions and generic emission factors for industrial processes and diffuse sources. To date, the Dutch PRTR is restricted to one value per type of emission (calculation result, rounded off to three significant digits).

The information on the uncertainty about emission figures presented here is based on the TNO report 'Uncertainty assessment of NO_x, SO_2 and NH_3 emissions in the Netherlands' (Van Gijlswijk *et al.*, 2004), which presents the results of a Tier 2 'Monte Carlo' uncertainty assessment. This uncertainty assessment is based on emissions in the year 2000. Since then, several improvements in activity data and methods (e.g. total N to TAN; see Chapter 6) have been implemented. Therefore, it is necessary to update the uncertainty assessment. This is foreseen within the next years and results will be presented in the IIR in question. Then also a more detailed uncertainty analysis will be provided.

1.7.1 *Quantitative uncertainty*

Uncertainty estimates on national total emissions have been reported in the Dutch Environmental Balances since 2000 (PBL, 2012). These estimates were based on uncertainties per source category, using simple error propagation calculations (Tier 1). Most uncertainty estimates were based on the judgement of RIVM/PBL emission experts. A preliminary analysis on NMVOC emissions showed an uncertainty range of about 25%. Van Gijlswijk *et al.* 2004) assessed the uncertainty in the contribution from the various emission sources to total acidification (in acidification equivalents) according to the Tier 2 methodology (estimation of uncertainties per source category using Monte Carlo analysis). See Table 1.2 for results. A comparison was also made between the Tier 1 and Tier 2 methodologies. This was not straightforward, as the two studies used a different knowledge collection. The 2000 Tier 1 analysis used CLRTAP default uncertainties for several NO_x processes, which explains the difference with the 1999 Tier 1 results. For NH_3, the difference between the 2000 Tier 1 and Tier 2 can be explained by taking non-normal distributions and dependencies between individual emission sources per animal type into account (both are violations of the Tier 1 assumptions: effects encapsulated in the 1999 Tier 1 analysis). The differences for SO_2 and total acidifying equivalents are small. The conclusion drawn from this comparison is that focusing on the order of magnitude of the individual uncertainty estimates, as in the RIVM (2001) study, provides a reasonable first assessment of the uncertainty of source categories.

Table 1.2 Uncertainty (95% confidence ranges) in acidifying compounds and for total acidifying equivalents for 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%
Total acid equivalents	± 9%	± 8%	± 10%

The RIVM (2001) study draws on the results from an earlier study on the quality of nitrogen oxide (NO_x) and sulphur dioxide (SO_2) emissions, as reported by individual companies for point sources under their national reporting requirements. In addition to providing quantitative uncertainty estimates, the study yielded important conclusions. For example, it was concluded that a limited number of facilities showed high uncertainties (e.g. 50% or more for NO_x), which could be reduced with little extra effort, and that companies generally have a lack of knowledge on the uncertainty about the emissions they report.

In the study by Van Gijlswijk *et al.* (2004), emission experts were systematically interviewed on quantitative uncertainties, which provided simultaneous information on the reliability and quality of the underlying knowledge base. For processes not covered by interviews, standard default uncertainties, derived from the Good Practice Guidance for CLRTAP emission inventories, were used (Pulles and Van Aardenne, 2001). The qualitative knowledge (on data validation, methodological aspects, empirical basis and proximity of data used) was combined into a score for data strength, based on the so-called NUSAP approach (Van der Sluijs *et al.*, 2003; Van der Sluijs *et al.*, 2005). The qualitative and quantitative uncertainties were combined in so-called diagnostic diagrams that may be used to identify areas for improvement, since the diagrams indicate strong and weak parts of the available knowledge (see Figure 1.3). Sources with a relatively high quantitative uncertainty and weak data strength are thus candidates for improvement. To effectively reduce uncertainties, their nature must be known (e.g. random, systematic or knowledge uncertainty). A general classification scheme on uncertainty typology is provided by Van Asselt (2000).

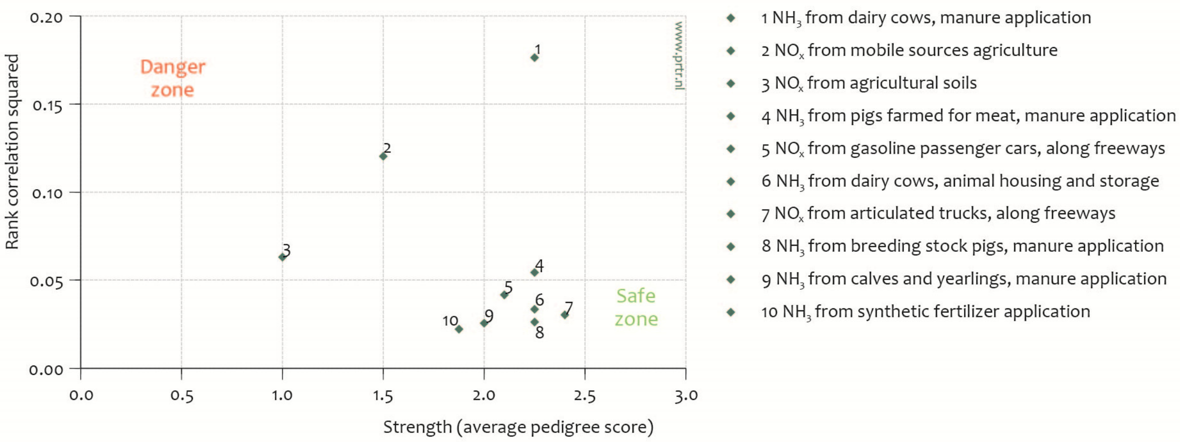

Figure 1.3 NUSAP diagnostic diagram indicating strong and weak elements in the available knowledge on acidifying substances

1.8 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 subsectors in detail. This is the reason why notation keys are used in the emission tables (NFR). These notation keys will be explained in tables

1.3 to 1.5. Most of the time the NE notation key has been used, the respective source is assumed to be negligible and/or there is no method available for estimation of the respective source. IE notation keys have been included in the category listed under Notes in NFR-tables, see column D.

Table 1.3 The Not Estimated (NE) notation key explained

NFR13 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; no method available
1A1c	All, except SO_2 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; no method available
1A2f	All	respective source is assumed negligible
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
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
1B2av	NMVOC	respective source is 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_2	respective source is assumed negligible
3Df	NO_x, NMVOC, SO_2, 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 1.4 The Included Elsewhere (IE) notation key explained

NFR13 code	Substance(s)	Included in NFR code
1A3aii(i)	All	1A3ai(i)
1A3e	All	1A2f, 1A4cii, 1B2b
1B1a	TSP, PM_{10}, $PM_{2.5}$	2H3
1B2c	NMVOC, TSP, PM_{10}, $PM_{2.5}$, CO	1B2b, 1B2aiv
2A2	NO_x, NMVOC, SO_2	2A6
2A5a	NMVOC	2H3
2A5b	NO_x, NMVOC, SO_2	2A6
2A5c	NO_x, NMVOC, SO_2	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
3B4giii	NO_x, NH_3, PM_{10}, $PM_{2.5}$	3B4gii
3B4giv	NO_x, NH_3, PM_{10}, $PM_{2.5}$	3B4gii
3Da1	NO_x	11C
3Da3	NO_x	11C
5A	NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A1a
5B2	NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A4ai
5D1	NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A4ai
5D2	NO_x, SO_2, TSP, PM_{10}, $PM_{2.5}$, BC, CO	1A4ai

Table 1.5 Sub-sources accounted for in reporting 'other' codes

NFR13 code	Substance(s) reported	Sub-source description
1A2gviii		Combustion in not elsewhere reported industries, machineries, services, product making activities
1A5a		Combustion gas from landfills
1A5b		Recreational navigation, ground machinery at airports
2A6		Processes, excl. combustion, in building activities, 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, use of pesticides; cosmetics, fireworks, preservation and cleaning of wood and other materials
2H3		Making products of wood, plastics, rubber, metal, textiles, paper. Storage and handling
3B4h	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	Pts, rabbits and furbearing animals
3Da2c	NO_x, NH_3	Use of compost
5E		Preparation for recycling, scrapping of white goods, decontamination
6A		Transpiration; breathing; manure application to private domains and nature; horses and ponies from private owners
11C	NO_x	Volatilatization of nitrogen oxides from agricultural and non-agricultural land

2 Trends in emissions

2.1 Trends in national emissions

Following the implementation of new insights in the emission calculation, the Dutch NH_3 emission series are now superseding the national emission ceiling set for the year 2010 (NEC2010). For NO_x, SO_2 and NMVOC the Netherlands is in compliance with the respective ceilings in 2014. The emissions of all substances showed a downward trend in the 1990-2014 period (see Table 2.1). The major overall drivers for this trend are:

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

Road transport emissions have decreased 87% since 1990 for NMVOC, 75% for PM, 67% for NO_x and 99% for SO_2, despite a growth in road transport of 20%. 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 emission stocks of heating installations (BEES). In meeting these requirements, Dutch industrial plants have realised a reduction of 93% in PM emissions and 62% in NO_x emissions, since 1990. Sections 2.2-2.8 elaborate in more detail on the drivers for the downward emission trend for specific substances.

Table 2.1 Total national emissions, 1990-2014

	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	**603**	**489**	**193**	**372**	**50**	**74**	**97**	**17**	**1144**
1995	505	349	131	231	37	55	73	13	920
2000	419	243	73	182	28	42	51	10	752
2005	367	180	64	160	21	35	43	8	724
2010	300	165	34	140	16	30	37	5	681
2013	260	148	30	130	13	27	35	4	597
2014	**235**	**143**	**29**	**134**	**13**	**26**	**34**	**4**	**571**
1990-2014 period [1)]	-368	-346	-164	-238	-37	-47	-63	-13	-573
1990-2014 period [2)]	-61%	-71%	-85%	-64%	-75%	-64%	-64%	-79%	-50%

[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	**334**	**2.1**	**3.6**	**742**	**20**	**1.3**	**12**	**46**	**73**	**0.4**	**224**
1995	156	1.1	1.5	66	10	0.9	8.5	49	85	0.3	146
2000	29	1.0	1.1	31	5.1	0.9	5.0	51	19	0.5	95
2005	31	1.8	1.0	29	5.1	1.3	4.3	53	10	2.6	88
2010	39	2.6	0.6	31	4.8	0.6	3.8	58	2	1.5	110
2013	15	0.7	0.6	25	4.6	0.7	3.6	55	2	0.5	99
2014	**10**	**0.6**	**0.5**	**22**	**4.7**	**0.7**	**3.5**	**55**	**2**	**0.8**	**127**
1990-2014 period [1)]	-323	-1.5	-3.0	-721	-15	-0.6	-8.3	8.6	-71	0.4	-97
1990-2014 period [2)]	-97%	-70%	-85%	-97%	-77%	-48%	-70%	19%	-98%	96%	-43%

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

2.2 Trends in sulphur dioxide (SO_2)

The Dutch SO_x emissions (reported as SO_2) decreased by 164 Gg in the 1990-2014 period, corresponding to 85% of the national total in 1990 (Figure 2.1). Main contributions to this decrease came from the energy, industry and transport sectors. The use of coal declined and major coal-fired electricity producers installed flue-gas desulphurisation plants. The sulphur content in fuels for the (chemical) industry and traffic was also reduced. At present the industry, energy and refining sector (IER) is responsible for 98% of the national SO_2 emissions.

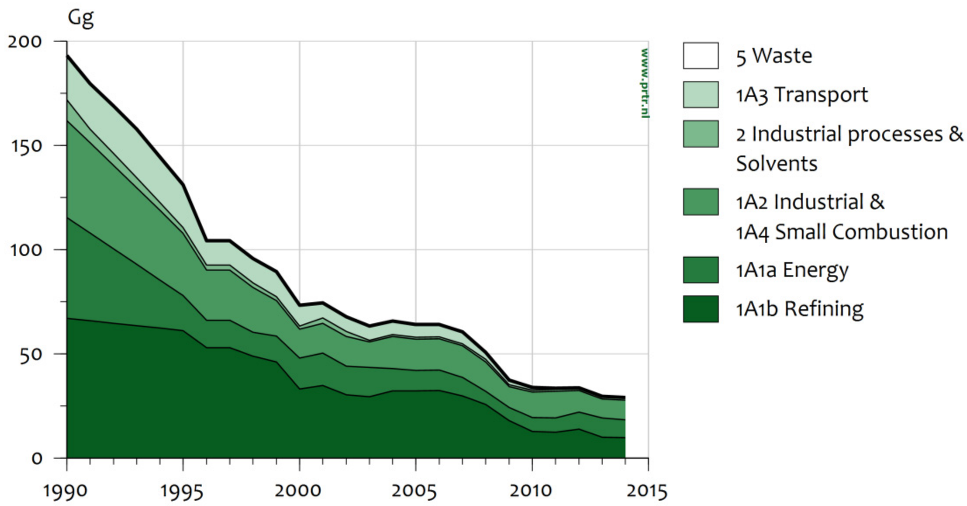

Figure 2.1 SO_2, emission trend 1990-2014

2.3 Trends in nitrogen oxides (NO_x)

The Dutch NO_x emissions (NO and NO_2, expressed as NO_2) decreased by 368 Gg in the 1990-2014 period, corresponding to 61% of the national total in 1990 (Figure 2.2). Main contributors to this decrease are road transport and the energy sector. Although emissions per vehicle decreased significantly in this period, an increase in number and mileages of 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.

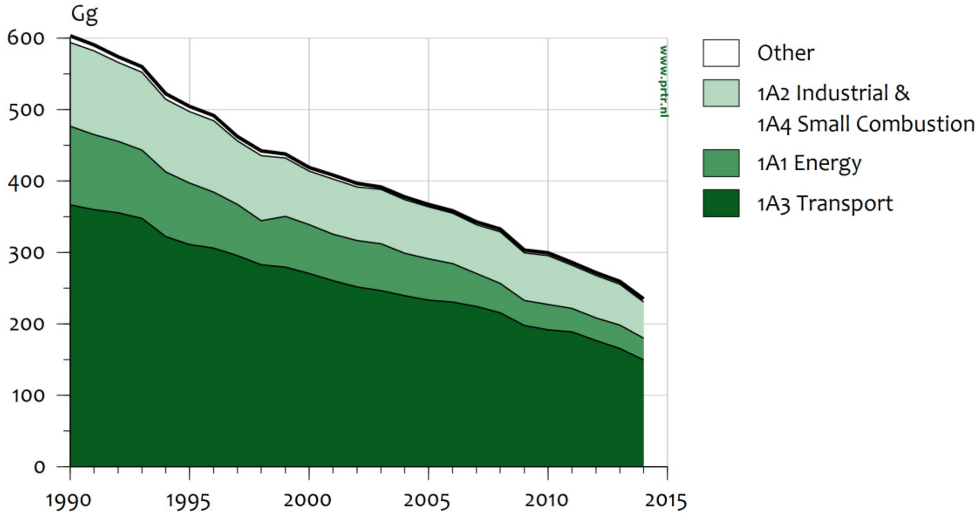

Figure 2.2 NO_x, emission trend 1990-2014

2.4 Trends in ammonia (NH_3)

Most of the NH_3 emissions (at present, 89%) come from agricultural sources. From 1990-2013, the decreasing trend in NH_3 due to emission reductions from agriculture also shows in the decreasing trend of the national total. In 2014, however, NH_3 emissions increased by 3.5 Gg to a national total just above 134 Gg and continued to exceed the maximum set to this by the European Union since 2010. As a result of the good quality of grass, fed to dairy cattle, digestibility and therefore NH_3 emission per animal increased. In combination with the growth in animal number, total NH_3 emissions increased.

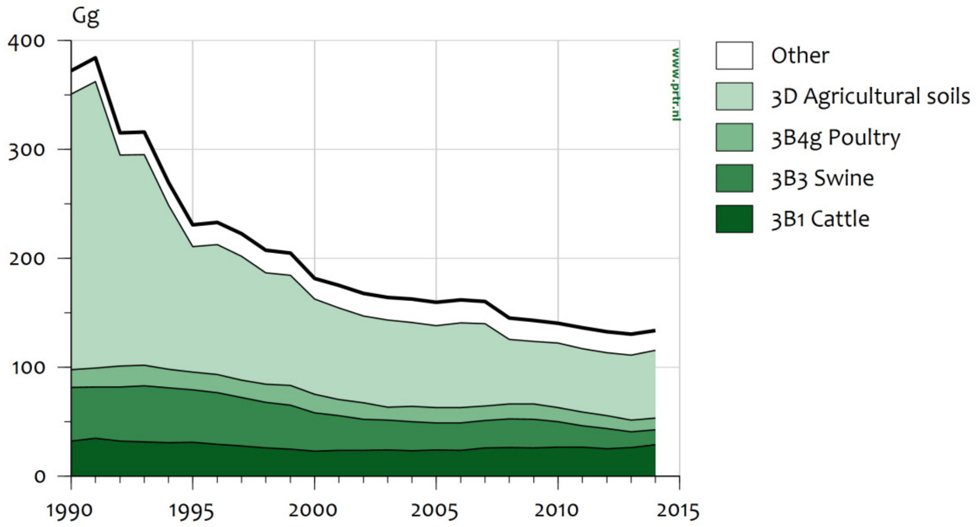

Figure 2.3 NH_3, emission trend 1990-2014

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

The Dutch NMVOC emissions decreased by 346 Gg in the 1990-2014 period, corresponding with 71% 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 specific for NMVOC).

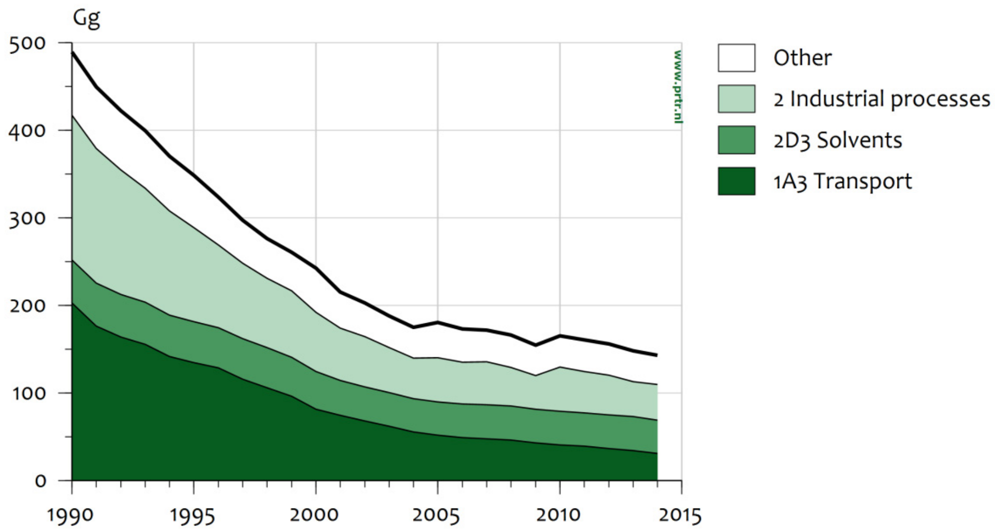

Figure 2.4 NMVOC, emission trend 1990-2014

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.*, 1998) and decreased by 37 Gg in the 1990-2014 period, corresponding with 75% of the national total in 1990 (Figure 2.5). The two major source categories contributing to this decrease were the industrial sector (combustion and process emissions), due to cleaner fuels in refineries and the side effect of emission abatement for SO_2 and NO_x and the transport sector.

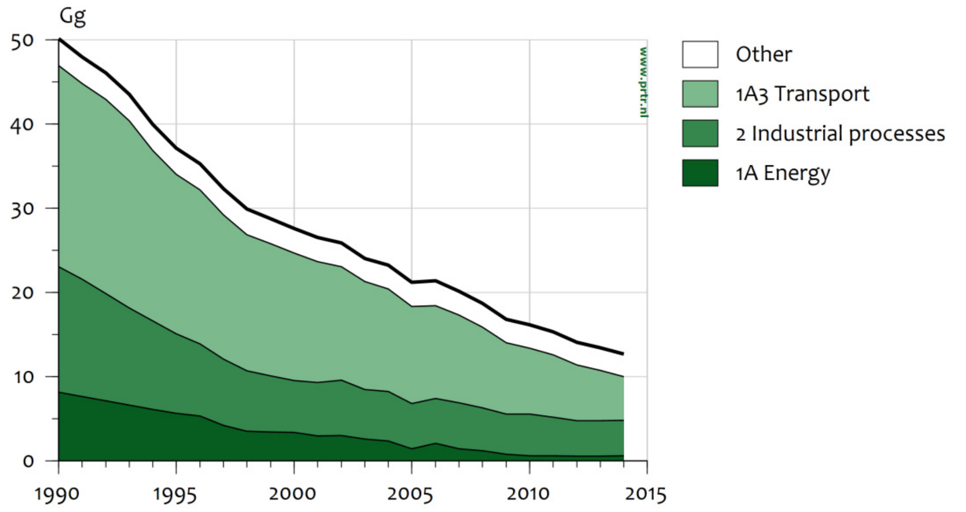

Figure 2.5 $PM_{2.5}$, emission trend 1990-2014

2.7 Trends in PM_{10}

Dutch PM_{10} emissions decreased by 47 Gg in the 1990-2014 period, corresponding with 64% of the national total in 1990 (Figure 2.6). The major source categories contributing to this decrease are:

- industry (combustion and process emissions), due to cleaner fuels in refineries and the side-effect of emission abatement for SO_2 and NO_x;
- traffic and transport.

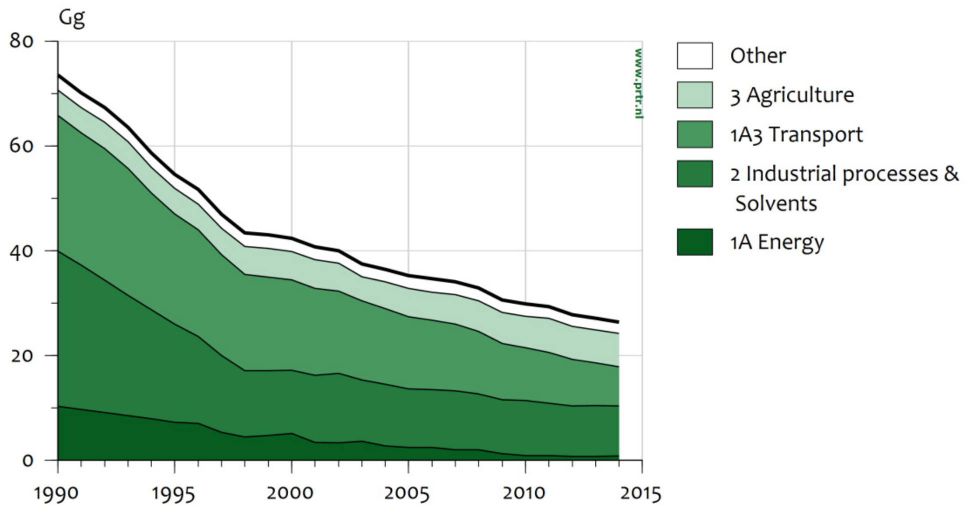

Figure 2.6 PM_{10}, emission trend 1990-2014

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 1990-2014 period, corresponding with 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, in particular from the iron and steel industry.

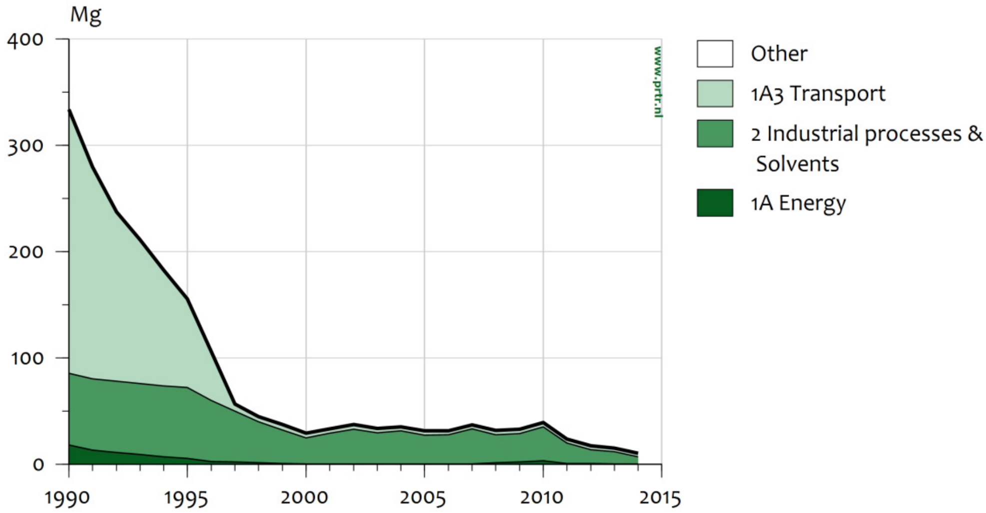

Figure 2.7 Pb, emission trend 1990-2014

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 by large industrial companies. For SO_2, 98% of the emissions is reported based on environmental reports, while for other pollutants this is 97% (NH_3), 78% (NMVOC), 73% (NO_x) and 56% (PM_{10}) in 2014. 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) are calculated with energy statistics and default emission factors.

As for most developed countries, the energy system in the Netherlands is largely driven by the combustion of fossil fuels. In 2014, natural gas supplied about 40% of the total primary fuels used in the Netherlands, followed by liquid fuels (39%) and solid fossil fuels (12%). The contribution of non-fossil fuels, including renewables and waste streams, is rather limited (6%). Figure 3.1 shows 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 2014. Using the button "Change selection" on the website, it is possible to select the data of another year.

Energy statistics of 2014:
http://statline.cbs.nl/Statweb/publication/?VW=T&DM=SLEN&PA=83140ENG&D1=a&D2=3-4,6-10,13-16,18-34,43-45,47-48&D3=l&HD=160128-1200&LA=EN&HDR=G2,G1&STB=T

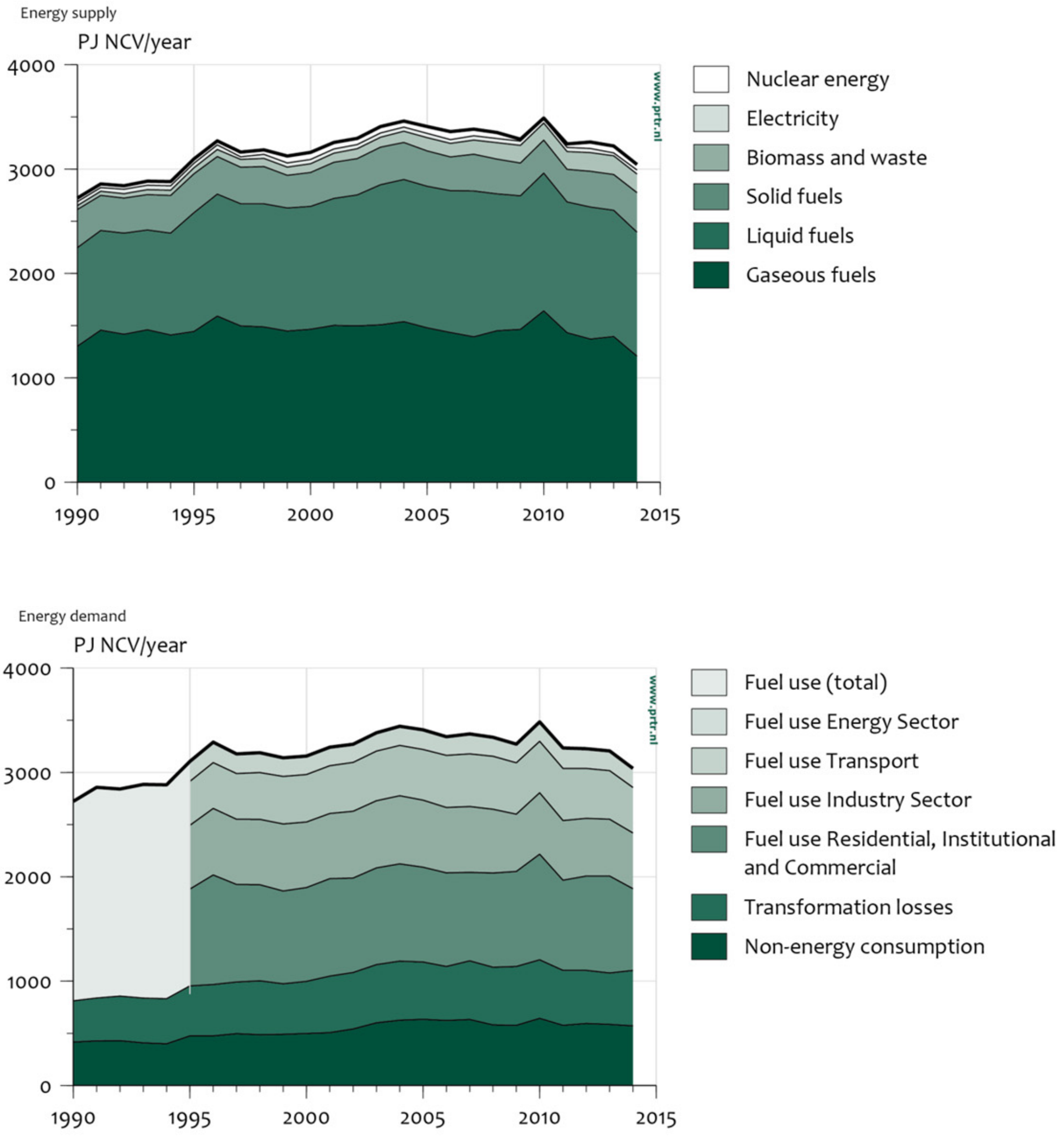

Figure 3.1 Energy supply and demand in the Netherlands. For the years 1990 – 1994, only the total fuel use is shown

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. Compared 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 2014 (%)
1A1a Public electricity and heat production	SO_x	29.6
	NO_x	8.2
	Hg	42.2

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 2014, while fuel consumption increased over the same period.
The NO_x and SO_x emissions decreased by 77% and 82%. Other pollutant emissions decreased by 46% to 99%. The decrease in emissions was partly caused by a shift from coal to gas consumption. Furthermore, the decrease in emissions was caused by technological improvements. The only pollutants for which the emissions have increased are NMVOC, NH_3 and Se due to an increase in activity rate.

Table 3.2 Overview of trends in emissions

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**83**	**0.7**	**48**	**0**	**1.9**	**2.2**	**2.5**	**0**	**8.2**
1995	62	1.1	17	0.039	0.4	0.6	1.0	0	7.4
2000	52	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	0.8	0	8.2
2010	26	0.3	7	0.074	0.2	0.3	0.7	0	5.0
2013	22	1.5	9	0.083	0.2	0.3	0.7	0	5.8
2014	**19**	**1.4**	**9**	**0.081**	**0.3**	**0.4**	**0.8**	**0**	**4.4**
1990-2014 period [1)]	-63	0.7	-40	0.081	-1.6	-1.9	-1.7	0	-3.7
1990-2014 period [2)]	-77%	102%	-82%		-86%	-84%	-67%		-46%

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	0.4
2010	0.3	0.18	0.2	1.2	0.01	0.11	0.14	0.15	0.16	1.33	11.3
2013	0.4	0.04	0.2	0.9	0.02	0.10	0.20	0.23	0.15	0.43	15.0
2014	**0.2**	**0.03**	**0.2**	**1.0**	**0.02**	**0.07**	**0.18**	**0.18**	**0.08**	**0.70**	**15.1**
1990-2014 period [1]	-16	-0.9	-1.7	-567	-0.15	-0.43	-0.4	-1.9	-2.4	0.7	-25.5
1990-2014 period [2]	-98%	-97%	-88%	-100%	-88%	-87%	-71%	-91%	-97%	3439%	-63%

[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, 90% to 100% of the emissions are based on AERs. For estimation of 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 (Tier-3 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.

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

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 3.3).

ER-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 emission 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	Dieselo oil	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	12437	30	10	10	50	10	70
Particulate matter	0.15	2	6	4.5	2	1.8	60	22.5	1
Coarse particulates			4	0.5		0.2	40	2.5	

3.2.6 Uncertainties and timeseries 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
Emissions of the following sources have been recalculated:

- Error correction of the NMVOC emission of one company
- Correction of the PM2.5 emissions

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 2014 (%)
1A1b Petroleum refining	SO_x	33.5
1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	SO_x CO	11.0 11.0
1A2c Stationary combustion in manufacturing industries and construction: Chemicals	NO_x	4.1
1A2gviii Stationary combustion in manufacturing industries and construction: Other	SO_x Hg	9.5 6.7

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 reduced since 1990 for most pollutants, except for NH_3 and dioxins. Reduction in emissions of main pollutants has been caused by improvement in used abatement techniques. Fluctuation in dioxin emissions have been caused by differences in fuels used and/or incidental emissions. Emission reduction of SO_2 and PM_{10} is mainly caused by a shift in fuel use by refineries 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**	**6.5**	**110**	**0.58**	**6.3**	**8.1**	**8.9**	**0.37**	**266**
1995	78	7.0	90	0.33	5.2	6.7	7.0	0.36	215
2000	49	2.2	46	0.05	3.1	4.8	4.8	0.29	161
2005	49	2.6	46	0.06	1.0	1.9	2.1	0.11	154
2010	40	3.9	24	0.43	0.36	0.5	0.8	0.02	124
2013	36	3.2	18	0.39	0.34	0.5	0.6	0.01	91
2014	**36**	**3.4**	**19**	**0.30**	**0.35**	**0.5**	**0.6**	**0.01**	**90**
1990-2014 period [1]	-65	-3.2	-92	-0.27	-5.9	-7.7	-8.3	-0.36	-176
1990-2014 period [2]	-65%	-48%	-83%	-47%	-94%	-94%	-93%	-97%	-66%

	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**	**1.02**	**0.17**	**2.5**	**1.4**	**65**	**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
2013	0.11	0.001	0.07	0.22	0.09	0.007	0.01	0.01	0.16	0.0001	1.1
2014	**0.12**	**0.001**	**0.05**	**0.20**	**0.09**	**0.001**	**0.01**	**0.00**	**0.11**	**0.0001**	**0.9**
1990-2014 period [1]	-1.77	-0.14	-0.13	0.19	-0.92	-0.17	-2.48	-1.39	-64	-0.04	-2.09
1990-2014 period [2]	-94%	-99%	-70%	1904%	-91%	-100%	-100%	-100%	-100%	-100%	-71%

[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, 90% of the CO emissions and 20% of the SO_x emissions are collectively estimated (in 2014).

Non-ferrous metals (1A2b)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 16% of the NMVOC emission, 8% of the NO_x emissions and 25% of the SO_x emissions are collectively estimated (in 2014).

Chemicals (1A2c)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 4% of the NO_x and SO_x emissions and 2% of the PM and NMVOC emissions are collectively estimated (in 2014).

Pulp, paper and print (1A2d)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 50% NMVOC emissions, 12% of NO_x emissions and 7% of the CO emissions are collectively estimated (in 2014).

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.

Other (1A2gviii)
This sector includes all combustion emissions from the industrial sectors not belonging 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 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 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 3.6).

ER-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 emission 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 oil	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	12437	30	10	10	50	10	70
Particulate matter	0.15	2	6	4.5	2	1.8	60	22.5	1
Coarse particulates			4	0.5		0.2	40	2.5	

3.3.6 *Uncertainties and timeseries 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*

Emissions of the following sources have been recalculated:

- The national energy statistics have been revised, resulting in improved emission estimates for the category 1A2gviii. The revision is described in CBS (2015).
- Some corrections in environmental reports from individual companies in 2011-2013.

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 by 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 for 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 sector

Category / Sub-category	Pollutant	Contribution to total of 2014 (%)
1A4ai Commercial/institutional, stationary	NO_x	3.2
1A4bi Residential, stationary	NO_x NMVOC CO PM_{10} $PM_{2.5}$ BC Cd Dioxine PAH	3.6 7.9 13.6 7.9 15.7 19.2 9.1 31.2 87.6
1A4ci Agriculture/forestry/fishing, stationary	NO_x	4.3

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 increased slightly.

Table 3.8 Overview of trends in emissions

	Main Pollutants				Particulate Matter				Other
	NO_x	NMVOC	SO_x	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**43**	**16.3**	**3.0**	**0**	**2.6**	**2.8**	**5.5**	**0.9**	**81**
1995	47	17.0	1.2	0	2.5	2.7	5.2	0.9	86
2000	42	15.6	0.8	0	2.3	2.4	4.8	0.9	83
2005	38	15.2	0.6	0	2.3	2.4	4.7	0.8	85
2010	39	15.3	0.5	0	2.2	2.3	4.5	0.7	85
2013	32	14.4	0.6	0	2.1	2.2	4.4	0.7	83
2014	**26**	**13.8**	**0.6**	**0**	**2.0**	**2.1**	**4.4**	**0.7**	**82**
1990-2014 period 1)	-17	-2.5	-2.4	0	-0.6	-0.6	-1.1	-0.2	1
1990-2014 period 2)	-40%	-15%	-81%		-23%	-23%	-20%	-27%	1%

	Priority Heavy Metals			POPs		Other Heavy Metals					
	Pb	Cd	Hg	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	**0.78**	**0.07**	**0.12**	**108**	**3.8**	**0.05**	**3.5**	**0.72**	**2.8**	**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	0.03	0.0000	0.69
2005	0.08	0.05	0.03	7.0	4.1	0.00	0.01	0.35	0.2	0.0001	0.75
2010	0.08	0.05	0.03	6.8	4.1	0.00	0.00	0.37	0.02	0.0000	0.79
2013	0.08	0.06	0.03	6.9	4.1	0.00	0.00	0.39	0.01	0.0000	0.82
2014	**0.09**	**0.06**	**0.03**	**6.9**	**4.2**	**0.00**	**0.00**	**0.39**	**0.01**	**0.0000**	**0.84**
1990-2014 period 1)	-0.69	-0.01	-0.08	-101	0.4	-0.05	-3.5	-0.33	-2.8	-0.0036	-1.2
1990-2014 period 2)	-89%	-15%	-70%	-94%	10%	-99%	-100%	-45%	-100%	-100%	-58%

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 sector 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 oil	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
Fijn stof	0.15	2	4.5	2	1.8	60	22.5	1
Coarse particulates			0.5		0.2	40	2.5	

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 mostly 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 and Dröge, 2011).

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

Substance name	Natural gas	DieselOil	LPG	Petroleum	Coal
Hydrocarbons	6.3	15	2	10	60
Natural gas	50				
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	1500
Particulate matter	0.3	4.5	2	1.8	120
Coarse particulates		0.5		0.2	80

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

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

Table 3.11 Emission factors for stationary combustion emissions from the Agriculture/forestry/fishing sector (g/GJ)

Substance name	Natural gas	DieselOil	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
Particulate matter	0.15	4.5	2	1.8	20	45
Coarse particulates		0.5	8	0.2	80	5

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

3.4.5 *Methodological issues*
A Tier 2 methodology was used for calculating 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 timeseries 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*
Emissions of the following sources have been recalculated:
- Emissions of all pollutants have been recalculated for the residential combustion of wood in 2013, due to updated activity data.
- The national energy statistics have been revised, resulting in improved emission estimates for the categories 1A4ai and 1A4ci. The revision is described in CBS (2015).

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:
- 1B2ai Fugitive emissions oil: Exploration, production, transport

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

3.5.2 *Key sources*

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

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

Category / Sub-category	Pollutant	Contribution to total of 2014 (%)
1B2ai Oil and gas production	NMVOC	3.4
1B2aiv Refining	NMVOC	8.1

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 2013.

Table 3.13 Overview of trends in emissions

	POPs	
	DIOX	PAH
Year	g I-Teq	Mg
1990	0	0.006
1995	0	0.025
2000	0	0
2005	0	0.039
2010	0	0
2013	0	0
2014	0	0
1990-2014 period [1]	0	-0.006
1990-2014 period [1]		-100%

[1] Absolute difference

[2] Relative difference to 1990 in %

3.5.4 *Activity data and (implied) emission factors*

Emissions from category 1B2ai 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 1B2ai comprise process emissions from oil and gas production and were completely derived from the companies' environmental reports (Tier 3 methodology).

The fugitive NMVOC emissions from category 1B2aiv comprise dissipation losses from gasoline service stations, leakage losses during vehicle and airplane refueling and refinery processes. Emissions were calculated based on annual fuel consumption (Tier 2 methodology).

The fugitive NMVOC emissions from category 1B2b comprise emissions from gas transport (compressor stations) and gas distribution networks (pipelines for local transport). The NMVOC emissions from gas transport were completely derived from the companies' environmental reports (Tier 3 methodology). The NMVOC emissions from gas distribution were calculated on the basis of a NMVOC profile with the CH_4 emission from annual reports of the sector as input (Tier 2 methodology).

3.5.6 Uncertainties and timeseries consistency

Uncertainties are explained in Section 1.7

3.5.7 Source-specific QA/QC and verification

General QA/QC is explained in Section 1.6

3.5.8 Source-specific recalculations

Emissions of the following sources have been recalculated:

- NMVOC emissions from gas transport (1B2b) have been updated, due to improved data from the companies' environmental reports.

3.5.9 Source-specific planned improvements

There are no source-specific planned improvements.

4 Transport

4.1 Overview of the sector

The transport sector is a major contributor to emissions of NO_x, NMVOC, CO, TSP, PM_{10} and $PM_{2.5}$. 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 water-borne 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 in the current submission emissions of NO_x, PM_{10}, $PM_{2.5}$, EC, NMVOC, CO and NH_3 from road transport are reported on the basis of fuel sold. In last year's submission road transport emissions were reported on a fuel used basis. Total fuel sold emissions from road transport were reported as a memo item. The difference between fuel used and fuel sold emission totals 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, 1A5b), 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 also calculated using a Tier 3 method.

In this chapter, trends and shares in emissions are described for the different source categories within the transport sector. The methodologies used for emission calculations are also described in general. A more detailed description of these methodologies and overviews of transport volumes, energy use and emission factors for the different source categories can be found in Klein *et al.* (2015).

Table 4. Source categories and methods for 1A3 Transport and for other transport related source categories

NFR code	Source category description	Method	AD	EF	Basis
1A3a	Civil Aviation	Tier 3	NS	CS	Fuel used
1A3b	Road Transport	Tier 3	NS	CS	Fuel sold
1A3c	Railways	Tier 2	NS	CS	Fuel

					sold
1A3d	Waterborne navigation	Tier 3	NS	CS	Fuel used
1A2gvii	Mobile combustion in manufacturing industries and construction	Tier 3	NS	CS	Fuel used
1A4aii	Commercial/institutional mobile	Tier 3	NS	CS	Fuel used
1A4bii	Residential: household and gardening (mobile)	Tier 3	NS	CS	Fuel used
1A4cii	Agriculture/forestry/fishing: off-road vehicles and other machinery	Tier 3	NS	CS	Fuel used
1A4ciii	National fishing	Tier 3	NS	CS	Fuel sold
1A5b	Other, Mobile (including military, land based and recreational boats)	Tier 3	NS	CS	Fuel used

NS = National Statistics
CS = Country-Specific

4.1.1 *Key sources*

The source categories within the transport sector are key sources for different pollutants, as is shown in Table 4.2. The percentages in Table 4.2 relate to the 2014 level and the 1990-2014 trend (in italics) assessment. Some source categories are key sources for both the trend and the 2014 level assessment. In those cases, Table 4.2 shows to which of the two these source categories contribute the most. The full results of the trend and level 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_2	NO_x	NMVOC	CO	PM_{10}	$PM_{2.5}$	BC	Pb
1A3ai(i)	International aviation LTO (civil)		*2.4%*						14.9%
1A3aii(i)	Domestic aviation LTO (civil)								
1A3bi	Passenger cars	*6.2%*	*26.0%*	*18.4%*	39.6%	*6.9%*	7.7%	16.9%	*45.7%*
1A3bii	Light-duty vehicles	*2.8%*	*10.8%*	*2.8%*	*7.5%*	4.1%	8.5%	24.4%	
1A3biii	Heavy-duty vehicles and buses	*10.0%*	18.0%	*3.9%*		*10.2%*	*14.5%*	*32.6%*	
1A3biv	Mopeds and motorcycles			6.1%	*13.4%*				
1A3bv	Gasoline evaporation			*9.6%*					
1A3bvi	Automobile tyre and brake wear					5.2%	*2.2%*		
1A3bvii	Automobile road abrasion					4.2%			
1A3c	Railways								8.6%
1A3di(ii)	International inland waterways		*7.4%*				3.8%	*6.0%*	

1A3dii	National navigation (shipping)		*6.6%*				*3.0%*	*5.8%*	
1A2gvii	Mobile Combustion in manufacturing industries and construction		3.5%				3.9%	7.0%	
1A4aii	Commercial/institutional: mobile								
1A4bii	Residential: household and gardening (mobile)				8.1%				
1A4cii	Agriculture/forestry /fishing: off-road vehicles and other machinery		3.4%				3.4%	6.1%	
1A4ciii	Agriculture/forestry /fishing: National fishing								
1A5b	Other, Mobile (including military, land based and recreational boats)				3.7%				

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) from 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 from civil aviation result from the combustion of jet fuel (jet kerosene) and aviation gasoline and from wear of tyres and brakes. Most civil aviation in the Netherlands stems from Amsterdam Airport Schiphol, which is by far the largest airport in the country. Some regional airports have grown rather quickly though since 2005.

The Civil aviation source category does not include emissions from vehicles operating at airports (platform traffic). These vehicles are classified as mobile machinery, and the resulting emissions were reported under source category *Other, Mobile* (1A5b). Emissions from the storage and transfer of kerosene were reported under source category *Fugitive emissions oil: Refining/storage* (1B2aiv). Cruise emissions from domestic and international aviation (i.e. emissions occurring above 3000 feet) are 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. Due to the small size of the country, there is hardly any domestic aviation in the Netherlands though with the exception of general aviation. Therefore, all fuel consumption and resulting emissions from civil aviation were reported under *International aviation* (1A3i) in the NFR.

4.2.2 Key sources

Civil aviation is a key source for NO_x (1990-2014 trend) and for lead (2014 level and 1990-2014 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, has more than doubled between 1990 and 2014, increasing from 4.9 to 10.3 PJ. Amsterdam Airport Schiphol is responsible for over 90% of total fuel consumption by civil aviation in the Netherlands. Fuel consumption (LTO) at Amsterdam Airport Schiphol has more than doubled between 1990 and 2008. After an 8% 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 2014, total fuel consumption by civil aviation at Schiphol Airport increased by 3.6% compared to 2013.

Fuel consumption by civil aviation at regional airports in the Netherlands was fairly constant at 0.4-0.5 PJ between 1990 and 2003. After 2003 fuel consumption increased steadily to 0.7 PJ in 2014. This can be attributed to an increase in air traffic at regional airports, particularly at the two largest regional airports in The Netherlands: Rotterdam Airport and Eindhoven Airport. The number of passengers at Rotterdam Airport has increased by 163% since 2003 to 1.6 million in 2014, whereas the number of passengers at Eindhoven Airport increased from 0.4 million to 4 million in this time span.

Table 4.3 Trends in emissions from 1A3a Civil Aviation

	Main Pollutants				Particulate Matter				Other	Priority Heavy Metls
	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	**1.4**	**0.4**	**0.1**	**0.001**	**0.03**	**0.03**	**0.03**	**0.02**	**4.00**	**3.31**
1995	1.8	0.4	0.1	0.001	0.04	0.04	0.04	0.03	4.42	3.53
2000	2.4	0.3	0.2	0.002	0.04	0.05	0.05	0.03	4.07	2.75
2005	2.8	0.3	0.2	0.002	0.04	0.05	0.05	0.03	3.65	1.96
2010	2.8	0.3	0.2	0.002	0.04	0.05	0.05	0.03	3.94	2.26
2013	3.0	0.3	0.2	0.002	0.04	0.06	0.06	0.03	3.40	1.51
2014	**3.1**	**0.3**	**0.2**	**0.002**	**0.05**	**0.06**	**0.06**	**0.03**	**3.51**	**1.52**
1990-2014 period 1)	1.8	-0.1	0.1	0.001	0.02	0.03	0.03	0.01	-0.49	-1.79
1990-2014 period 2)	132%	-32%	82%	119%	58%	75%	75%	56%	-12%	-54%

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 in the past 24 years has led to an increase in emissions of NO_x, SO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$ and BC. Fleet average NO_x emission factors have not changed significantly throughout the time series, therefore NO_x emissions have more than doubled between 1990 and 2014, following the trend in fuel consumption. Fleet average PM_{10} exhaust emission factors (per unit of fuel) have decreased by 27% since 1990, but since total fuel consumption more than doubled between 1990 and 2014, PM_{10} (and $PM_{2.5}$) exhaust emissions increased significantly throughout the time series as well. PM_{10} emissions due to tyre and brake wear increased by 172% between 1990 and 2014, in line with the increase in the maximum permissible take-off weight (MTOW) of the airplanes. As a result, the share of tyre and brake wear in PM_{10} emissions from civil aviation increased from 16% to 25% between 1990 and 2014.

Aviation gasoline still contains lead, whereas gasoline for other transport purposes has been unleaded for quite some time. With lead emissions from other source categories decreasing substantially, the share of civil aviation in lead emissions in the Netherlands increased to 15% in 2014, thereby becoming a key source in the 2014 level assessment. The share of civil aviation in total emissions of NO_x (2.4%), SO_x (1.6%), BC (1.4%) 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_2 and heavy metals from civil aviation in the Netherlands were calculated using a flight-based Tier-3 method. Specific data was used on the number of aircraft movements per aircraft type and per airport, derived from the airports and from Statistics Netherlands. These data have been used in the EMASA model to calculate LTO fuel consumption and resulting emissions (see also Klein *et al.*, 2015). The EMASA model was derived from the method for calculating aircraft emissions of 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 for calculating 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 EMASA were taken from the ICAO Engine Emissions DataBank. The EMASA database also contains a number of emission factors for smaller engines determined by the EPA and published in the AP42 (EPA, 1985). Emission factors for aircraft with turboprop engines are also included in the EMASA 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). In 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 emission factors of PM the results obtained by the formula of Kugele *et al*. 2005 are multiplied by a factor of two. The $PM_{2.5}/PM_{10}$ ratio for engine exhaust emissions is 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 equal to those for road transportation. Emissions of different VOC and PAH species were calculated using species profiles as reported in Klein *et al*. (2015).
The duration of the different flight modes (except the Idle mode) 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. The quantity of fuel that is used per arriving and departing passenger was estimated at 500 g. NMVOC emissions from storage and transfer of kerosene were derived from the total volume of kerosene that was delivered annually. Because the kerosene at Schiphol airport is transferred multiple times, the volume of vapour is multiplied by a turnover factor. At Schiphol airport, the average turnover factor is approximately 3. One cubic metre of kerosene vapour contains approximately 12 grams of hydrocarbons. This amount has been experimentally measured by TNO.

4.2.5 Methodological issues

Due to a lack of data, the split of LTO fuel consumption and resulting emissions between domestic and international aviation could not be made. 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 (LTO) emissions from civil 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. It should be noted though that the EEA Emission Inventory Guidebook does not provide a methodology yet for estimating emissions from APUs.

4.2.6 Uncertainties and time series consistency

There was no accurate information available for assessing the uncertainties of the emissions from civil aviation. Consistent methodologies have been used throughout the time series.

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 Subsection 4.2.3. Agreement between both trends is good.

4.2.8 Source-specific recalculations

The time series for consumption of aviation gasoline by civil aviation has been recalculated in this year’s inventory, as is shown in Figure 4.1. Two errors have been corrected in the current inventory:

1. The time-in-mode for regional airports has been corrected. In last year’s inventory the TIM had not been properly assigned to the different regional airports.
2. The number of flights at regional airports has been underestimated in last year’s inventory for the 1990-1999 period because the flights that could not be assigned to the ICAO engine

database were mistakenly not taken into account when estimating total energy use and resulting emissions.

It should be noted that the use of aviation gasoline in civil aviation is small compared to the use of kerosene, so emission totals by civil aviation have changed only slightly in the current inventory due to these error corrections, with the exception of NMVOC (+5-7% in the 1990-1999 period) and Pb (+25-30% in the 1990-1999 period).

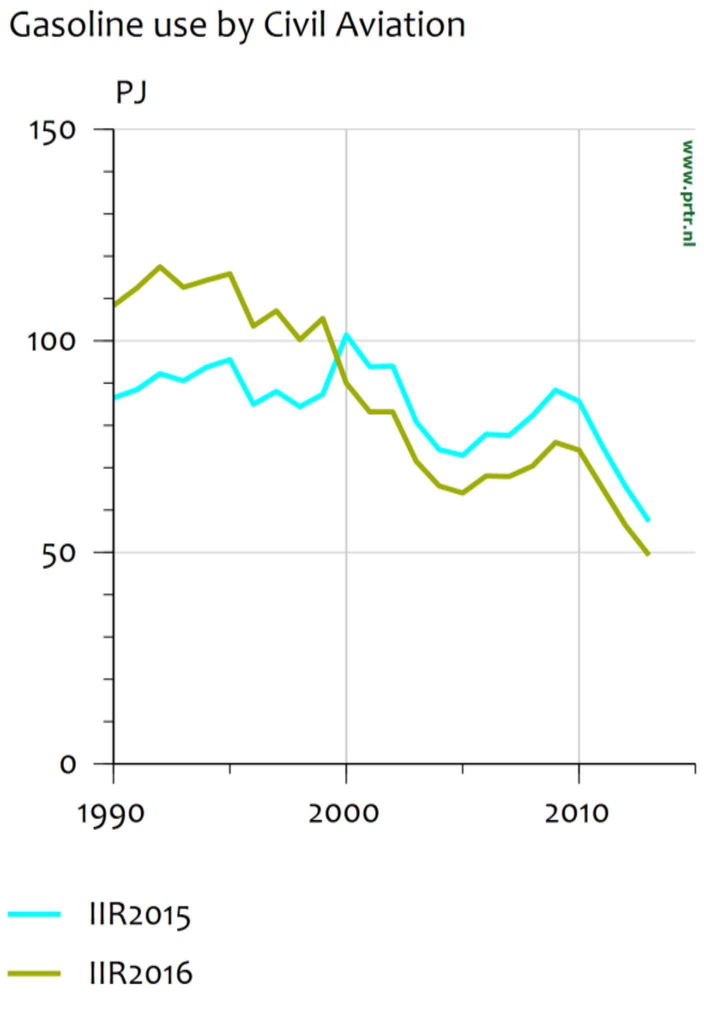

Figure 4.1 Aviation gasoline use in this year's and last year's inventory

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 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. The UNECE guidelines on reporting emission data under the LRTAP convention state that emissions from transport should be consistent with national energy balances as reported to Eurostat and the International Energy Agency. As such, emissions from road transport should be estimated based on *fuel sold* (FS) on national territory. In addition, emissions from road transport may also be reported based on FU or kilometres driven on national territory (UNECE, 2009). In previous inventories, the FS emission totals for road transport were reported as a memo item in the NFR-tables. In the current inventory however, reported emissions from road transport are based on fuel sold. The FU emissions from road transport are reported as a memo item. The methodologies used to estimate both FU and FS emissions are described in detail below.

4.3.2 *Key sources*

The different source categories within Road Transport are key sources for many substances in both the 1990-2014 trend assessment and the 1990 and 2014 level assessments, as is shown in Table 4.4.

Table 4.4 Key source analysis for road transport subcategories

Source category		1990 level	2014 level	1990-2014 trend
1A3b i	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
1A3b ii	Light-duty vehicles	NO_x, CO, PM_{10}, $PM_{2.5}$, BC	NO_x, PM_{10}, $PM_{2.5}$, BC	SO_x, NO_x, NMVOC, CO, PM_{10}
1A3b iii	Heavy-duty vehicles and buses	SO_x, NO_x, NMVOC, PM_{10}, $PM_{2.5}$, BC	NO_x, $PM_{2.5}$, BC	SO_x, NMVOC, PM_{10}, $PM_{2.5}$, BC
1A3b iv	Mopeds and motorcycles	NMVOC, CO	NMVOC, CO	CO
1A3b v	Gasoline evaporation	NMVOC		NMVOC
1A3b vi	Tyre and brake wear		PM_{10}	$PM_{10,}$, $PM_{2.5}$
1A3b vii	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. Combined, the different source categories within road transport accounted for 39% of NO_x emissions (national totals), 20% of PM_{10}, 24% of $PM_{2.5}$, 51% of BC, 17% of NMVOC and 53% of CO in The Netherlands in 2014. The trends in emissions from road transport are shown in Table 4.5. The emissions of the main pollutants and particulate matter have 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 of road transport in the national emission totals for NO_x, PM_{10} and $PM_{2.5}$ decreased only slightly between 1990 and 2014 as emissions in other sectors decreased as well. Road transport therefore is still a major source of pollutant emissions in the Netherlands.

Emissions of SO_2 decreased by 99% between 1990 and 2014 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 of road transport in total SO_x emissions in the Netherlands subsequently decreased from 7% in 1990 to less than 1% in 2014.

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 (TWC) for gasoline passenger cars. Since 2005, NH_3 emissions from road transport have decreased slightly. Notwithstanding the increase in emissions, road transport is still only a minor source of NH_3 emissions in the Netherlands with a share of 3% in national totals in 2014.

Emissions of heavy metals have increased, with the exception of Pb. Cd and Hg emissions from passenger cars have become key sources in the 2014 level assessment and in 1990-2014 trend assessment. Passenger cars were also a key source of Pb in the 1990 level assessment, but Pb emissions have decreased significantly with the introduction of unleaded gasoline so passenger cars are no longer a key source of Pb. Below the trends and shares in emissions of the different source categories within Road Transport are described.

Table 4.5 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**	**21**	**21**	**13**	**713**
1995	223	120	14	2.4	14	16	16	9	0
2000	180	67	4	4.3	11	13	13	7	0
2005	157	40	0	5.3	8	10	10	5	0
2010	129	32	0	4.8	5	7	7	3	0
2013	107	27	0	4.2	4	6	6	2	0
2014	**92**	**24**	**0**	**3.8**	**3**	**5**	**5**	**2**	**305**
1990-2014 period [1)]	-190	-164	-15	2.9	-16	-15	-15	-11	-408
1990-2014 period [2)]	-67%	-87%	-99%	305%	-84%	-75%	-75%	-86%	-57%

	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	**243**	**0.09**	**0**	**2.37**	**1.56**	**0.00**	**2.13**	**20**	**0.60**	**0.01**	**33**
1995	79	0.10	0	1.36	1.04	0.00	2.11	20	0.60	0.01	34
2000	0.8	0.11	0	0.69	0.62	0.00	2.12	19	0.61	0.01	38
2005	0.8	0.12	0	0.50	0.39	0.00	2.27	21	0.66	0.01	40
2010	0.8	0.12	0	0.34	0.28	0.00	2.33	21	0.67	0.01	41
2013	0.8	0.12	0	0.27	0.22	0.00	2.30	21	0.67	0.01	41
2014	**0.8**	**0.12**	**0**	**0.24**	**0.20**	**0.00**	**2.29**	**21**	**0.66**	**0.01**	**40**
1990-2014 period [1)]	-242.4	0.0	0	-2.12	-1.35	0.00	0.2	1	0.1	0.0	8
1990-2014 period [2)]	-100%	31%	29%	-90%	-87%	26%	8%	5%	10%	26%	23%

[1)] Absolute difference in Gg

[2)] Relative difference to 1990 in %

Passenger cars (1A3bi)

The number of kilometres driven by passenger cars in the Netherlands has steadily increased from approximately 82 billion in 1990 to 103 billion in 2014 (Figure 4.2). The kilometres driven by diesel cars has grown the fastest. Since 1995, the share of diesel-powered passenger cars in the Dutch car fleet has grown significantly, leading to an increase in diesel mileages by 95% between 1995 and 2008. Gasoline mileages increased by only 11% between 1995 and 2008. Since 2008 the total diesel mileage has remained constant however. The share of LPG in the passenger car fleet has decreased significantly, leading to a decrease in LPG mileages by 79% between 1990 and 2014. Figure 4.2 shows that even though the number of diesel kilometres has increased significantly, gasoline still dominates the vehicle kilometres driven by passenger cars. Throughout the time series, the share of gasoline in total kilometres driven in the Netherlands has fluctuated between 64% and 69%. The share of diesel has increased from 20% in 1990 to 31% in 2014, mostly at the cost of the market share of LPG which decreased from 16% to 3% in the same time span.

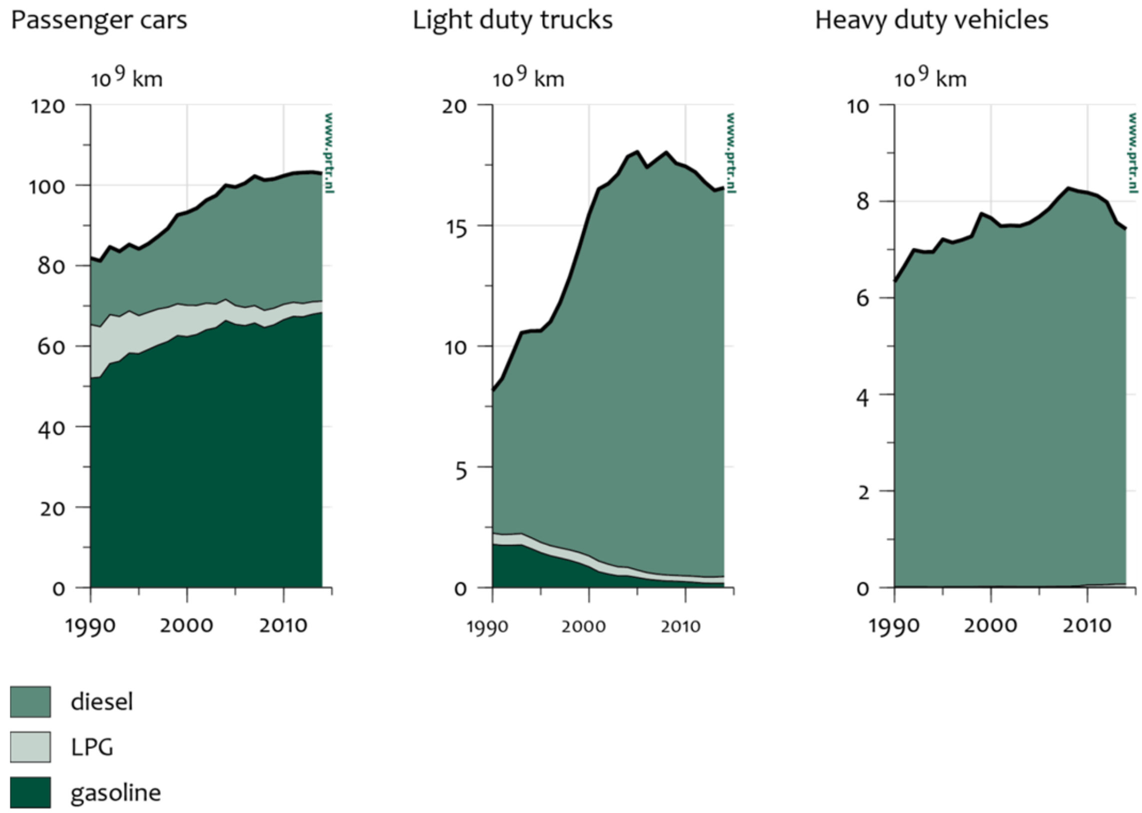

Figure 4.2 Kilometres driven per vehicle and fuel type in the Netherlands

Passenger cars were responsible for 12% of total NO_x emissions in the Netherlands in 2014. NO_x emissions from passenger cars have decreased significantly throughout the time series: from 145 Gg in 1990 (24% of total NO_x) to 28 Gg in 2014. This decrease can mainly be attributed to the introduction of the (closed loop) three way catalyst (TWC), which led to a major decrease in NO_x emissions from gasoline passenger cars. NO_x emissions from gasoline passenger cars decreased by 94% between 1990 and 2014 even though traffic volumes increased by 26%. NO_x emissions from diesel-powered passenger cars increased from 15 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 passenger cars. Since 2007, NO_x emissions from diesel cars have decreased somewhat to 20.5 Gg in 2014. Due to the decrease of NO_x emissions from gasoline passenger cars, NO_x has become mostly a diesel related issue. The share of gasoline in total NO_x emissions from passenger cars has decreased from 76% in 1990 to 25% in 2014, whereas the share of diesel has increased from 11% to 72% between 1990 and 2014.

The introduction of the TWC for gasoline passenger cars also led to a major reduction of NMVOC and CO emissions. NMVOC exhaust emissions from gasoline passenger cars decreased from 83 Gg in 1990 to 11 Gg in 2014, whereas CO emissions decreased from 540 to 218 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 2014, 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 8% of $PM_{2.5}$ emissions and 4% of PM_{10} emissions in The Netherlands in 2014. PM_{10} exhaust emissions from passenger cars have decreased by 85% between 1990 and 2014. Both emissions from gasoline and diesel cars have decreased significantly throughout the time series, resulting from the increasingly stringent EU emission standards for new passenger cars. Exhaust emissions in 2014 were 1 Gg, down 0.3 Gg (22%) from 2013. The continuing decrease of PM_{10} and $PM_{2.5}$ exhaust emissions in recent years is primarily caused by the increasing market penetration of diesel 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 passenger cars was equipped with a DPF. Since 2008, the share of new diesel passenger cars with a DPF has been 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 TWC. Since 2007, emissions have decreased to 3.7 Gg in 2014. 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 0.04 Mg in 2014 due to the phase-out of leaded gasoline.

Light-duty trucks (1A3bii)
The light-duty truck fleet in the Netherlands has grown significantly between 1990 and 2005, leading to a major increase in vehicle kilometres driven (see Figure 4.2). 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 (-2% per year), and subsequently increased slightly in 2014 (+1%). These fluctuations in recent years can probably be attributed to the economic situation combined with the continuing impact of the changes in the fiscal scheme for privately owned light-duty trucks. The share of gasoline-powered trucks in the fleet has decreased steadily throughout the time series. In recent years, diesel engines have dominated the light-duty truck market, with shares of more than 98% of new-vehicles sales. Currently, more than 95% of the fleet is diesel-powered.

NO_x emissions from light-duty trucks have fluctuated between 21 and 25 Gg since 1994. NO_x emissions in 2014 were 11% lower than in 1990 (20.8 Gg vs. 23.5 Gg), even though the number of vehicle kilometres driven has more than doubled in this time span. The tightening of 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. Because of the poor NO_x-emission performance of recent Euro-5 light-duty trucks, the fleet average NO_x emission factor for diesel light-duty trucks has been more or less stable in recent years though. The share of light-duty trucks in total NO_x emissions in The Netherlands was approximately 9% in 2014.

The exhaust emissions of NMVOC and CO from light-duty trucks have decreased significantly throughout the time series. NMVOC emissions decreased from 11 Gg in 1990 to 0.7 Gg in 2014, whereas CO emissions decreased from 48 to 3.4 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 2014. Gasoline-powered trucks emit far more NMVOC and CO than diesel-powered trucks per vehicle kilometre driven; therefore, the decrease in the number of gasoline trucks has also contributed substantially to the decrease in NMVOC and CO emissions. Light-duty trucks currently are a minor source of both CO an NMVOC emissions, accounting for less than 1% of the national totals for both substances in 2014.

The exhaust emissions of PM_{10} (and subsequently also of $PM_{2.5}$) from light-duty trucks decreased throughout the time series as well. The fleet average PM_{10} emission factor has decreased consistently throughout the time series, but in earlier years this decrease was offset by the increase in vehicle kilometres driven. Diesel-powered trucks are 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 stabilisation of the amount of vehicle kilometres driven since 2005, PM_{10} exhaust emissions decreased by 58% between 2005 and 2014. In 2014, light-duty trucks were responsible for 4% of PM_{10} emissions and 8% of $PM_{2.5}$ emissions in The Netherlands.

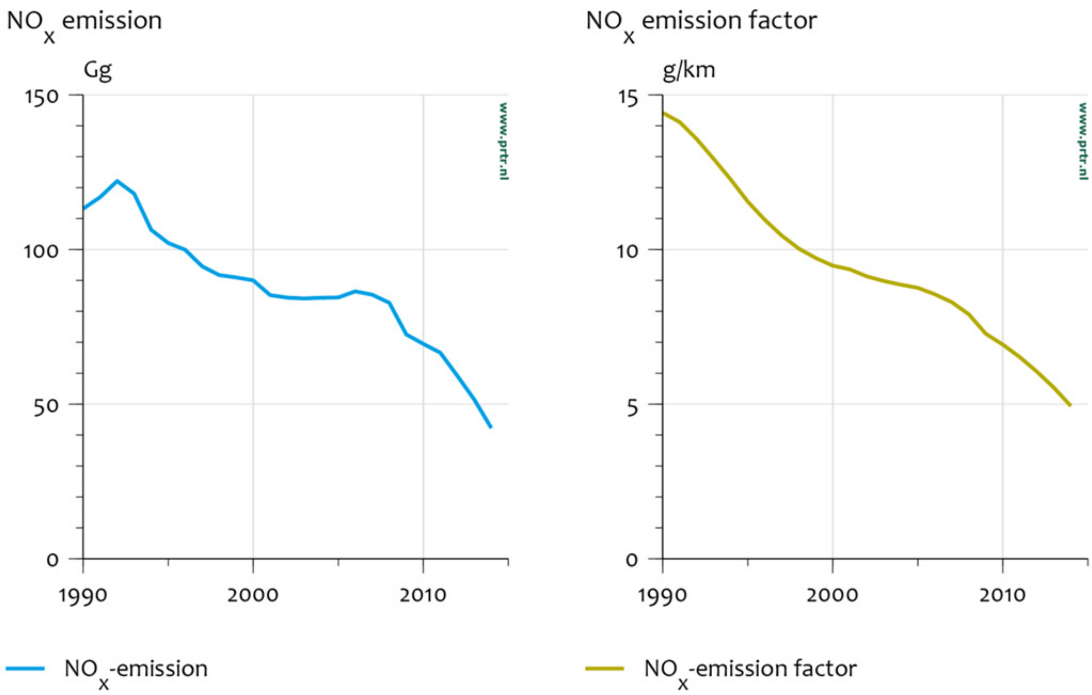

Figure 4.3 NO_x emissions and NO_x emission factors of heavy-duty vehicles in the Netherlands

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 31% between 1990 and 2008 (see Figure 4.2). The economic crisis has since led to a decrease in transport volumes: total vehicle kilometres driven in 2014 was 10% lower than in 2008. Diesel dominates the vehicle fleet with a share of over 99%.

Heavy-duty vehicles are a major source of NO_x emissions in The Netherlands with a share of 18% in the national total in 2014. NO_x emissions from heavy-duty vehicles decreased from 113 Gg in 1990 to 42 Gg in 2014 (see Figure 4.3). Emission totals have decreased significantly in recent years due to the combination of a decrease in vehicle mileages, as shown in Figure 4.2, and a decrease in the fleet average NO_x emission factor, as shown in Figure 4.3. The fleet average NO_x emission factor decreased by 58% between 1990 and 2014. This decrease has mainly been caused by 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 emissions levels (Kadijk *et al*., 2015).

NMVOC exhaust emissions decreased by 94%, from 16 Gg in 1990 to 1 Gg in 2014, whereas PM_{10} and $PM_{2.5}$ exhaust emissions decreased by 93%, from 7 Gg to 0.5 Gg. These decreases have also been caused by EU emission legislation. Heavy-duty vehicles were only a minor source of NMVOC (0.7%) and PM_{10} emissions (1.8%) in 2014. Their share in $PM_{2.5}$ emissions was slightly higher at 3.8% of national totals.

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 are a key source though for NMVOC and CO in both the 1990 and 2014 level assessment and in the trend assessment (CO only). Even though the number of vehicle kilometres driven increased by 90% between 1990 and 2014, exhaust emissions of NMVOC decreased significantly due to the increasingly stringent EU emissions standards for two-wheelers. NMVOC exhaust emissions decreased from 25 to 8.7 Gg between 1990 and 2014. Motorcycles and mopeds were responsible for 6% of NMVOC emissions in The Netherlands in 2014. CO emissions from motorcycles and mopeds increased from 45 to 59 Gg between 1990 and 2014. In 2014, motorcycles and mopeds were responsible for 10% of CO emissions in The Netherlands.
NO_x emissions increased from 0.4 to 1.0 Gg between 1990 and 2014, but the share of motorcycles and mopeds in NO_x emissions in the Netherlands was still small (0.4%) in 2014. The share in $PM_{2.5}$ emissions was approximately 1% in 2014, with emissions decreasing from 0.4 to 0.1 Gg in the 1990-2014 timespan.

Gasoline 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. Gasoline passenger cars are by far the major source of evaporative NMVOC emissions from road transport in the Netherlands. Total evaporative NMVOC emissions decreased from 36 Gg in 1990 to 1.6 Gg in 2014 (see Figure 4.4). As a result, evaporative emissions are no longer a key source in the emission inventory, accounting for only 1% of total NMVOC emissions in the Netherlands in 2014 (down from 7% in 1990).

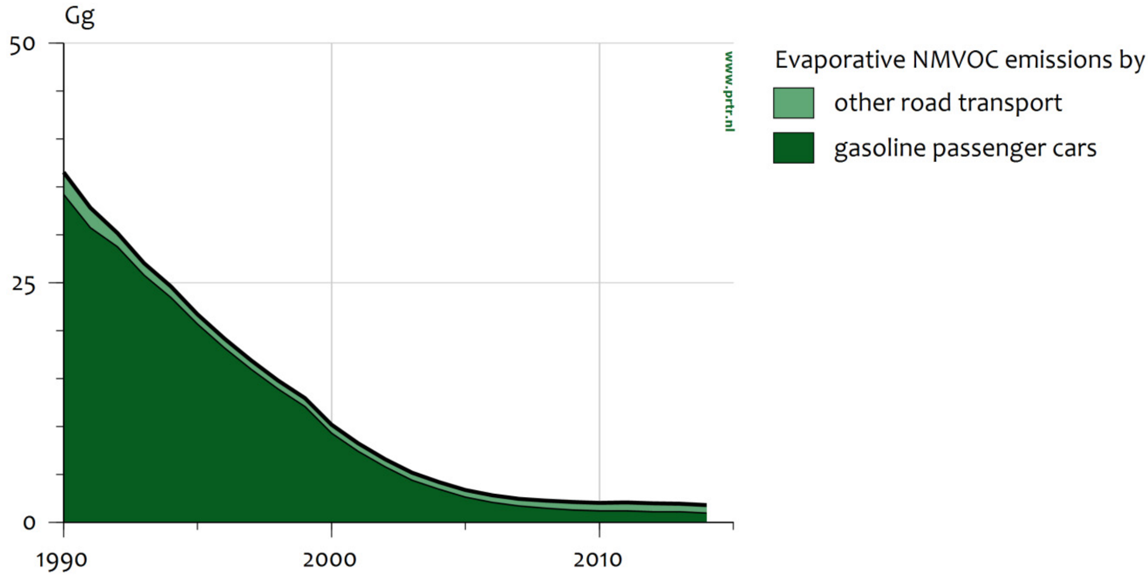

Figure 4.4 Emissions of NMVOC from evaporation by road transport in the Netherlands

PM emissions from tyre and brake wear and road abrasion (1A3bvi and 1A3bvii)

Automobile tyre and brake wear (1A3bvi) and Automobile road abrasion (1A3bvii) were key sources for PM_{10} emissions in the Netherlands in 2014, being responsible for 5% and 4% respectively of PM_{10} emissions in The Netherlands. PM_{10} emissions from brake wear, tyre wear and road abrasion have increased throughout most of the time series, as shown in Figure 4.5, resulting from the increase in vehicle kilometres driven by light and heavy-duty vehicles. PM_{10} emission factors were kept 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 is 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 is smaller though than for PM_{10}.

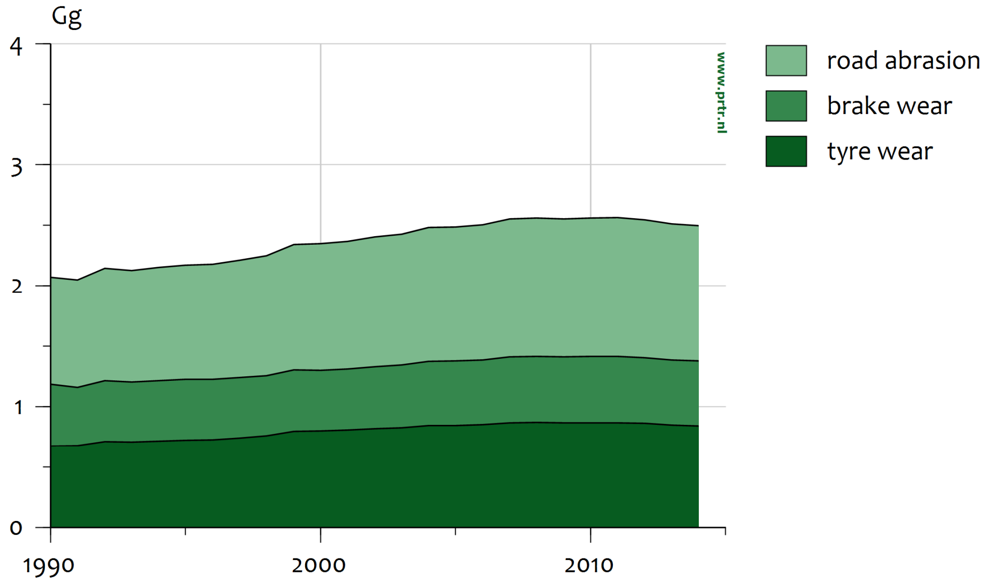

Figure 4.5 Emissions of PM_{10} resulting from brake and tyre wear and road abrasion

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 transportation. Resulting emission totals for CO, NMVOC, NO_x, NH_3 and PM were subsequently corrected for differences between fuel used and 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 by different vehicle types were derived from Statistics Netherlands. Statistics Netherlands calculated total vehicle mileages per vehicle type using data on:

1. The size and composition of the Dutch vehicle fleet;
2. Average annual mileages 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 manufacturing. The annual mileages for different types of road vehicles (2) were calculated from odometer readings from the national car passport corporation (NAP). The NAP database contains odometer readings from all road vehicles that have been to a garage for maintenance or repairs. Every year, Statistics Netherlands acquires the NAP database and uses this data combined with RDW-data on vehicle characteristics to derive average annual mileages for different vehicles types (age classes and fuel types). This methodology was applied to derive average annual mileages for passenger cars, light-duty and heavy-duty trucks and buses. The resulting mileages were corrected for the amount of kilometres driven abroad, using different statistics as described in Klein *et al*. (2016). Average annual mileages for motorcycles and mopeds were derived by Statistics Netherlands in 2013 using a survey among owners, as is described in more 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*. (2016). Vehicle kilometres driven by foreign trucks were derived from statistics on road transportation in the Netherlands and in other EU countries, collected by Eurostat. The vehicle kilometres driven by foreign buses in the Netherlands were estimated by different national and international 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 and 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 share of gasoline passenger cars on urban roads is higher than on motorways. Also, the fleet on motorways on average is younger than on urban roads. These differences can mainly be related to differences in average annual mileages: higher mileages in general result in higher shares of motorway driving in total mileages. The road type distribution for different vehicle categories is reported in detail in Klein *et al.* (2016).
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 by TNO using the VERSIT+ model (Ligterink and 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 analysis fed by different kinds of measuring data. VERSIT+ LD (light-duty) has been developed for light-duty vehicles, i.e. passenger cars and light-duty trucks. The model can be used to estimate emissions under specific transport situations. For the determination of the emission factors, the driving behaviour

dependence and the statistical variation per vehicle has been investigated. Next the results have been used in a model with currently more than 50 light-duty vehicle categories for each of the emission components. The resulting model separates optimal driving behaviour and vehicle category dependencies.

VERSIT+ HD (heavy-duty) (Riemersma & Smokers, 2004) 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 with 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 closer resemble the real-world use of the vehicles. These new data are based on realistic driving behaviour, both from on-road measurements and measurements on test stands, have been used in a model to represent emissions during standard driving behaviour. The emission factors for buses often originate from test stand measurements with realistic driving behaviour for regular service buses.

For the determination of the emission factors for heavy-duty vehicles, the PHEM model was used which has been developed by the Graz University of Technology, using also 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 as the operation of the SCR relies on a sufficient high engine loads. The average payloads of the trucks in the Netherlands were derived from on-road measurements on motorways (Kuiper and 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 and Ligterink, 2015).

Over the years, for most vehicle categories many measurement data have become available, 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 of the great susceptibility of the engine management system, especially on 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 ensure 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 can also be used to predict emission factors on 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 (MON); see also Klein *et al.* (2016). 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*. (2016).

Emissions of SO_2 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_2 and heavy metals were based on the sulphur, carbon and heavy metal contents of the fuels, as described in Klein *et al*. (2016). It is assumed that 75% of the lead is emitted as particles and 95% of the sulphur is transformed to sulphur dioxide. The NH_3 emission factors for passenger cars were derived from a recent study by TNO (Stelwagen *et al*., 2015), as is described in detail in last year's inventory report (Jimmink *et al*., 2015).

NMVOC evaporative emissions are estimated using the methodology from the EEA Emission Inventory Guidebook (EEA, 2007). PM emission factors 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*. (2016) as well.

Deriving fuel sold emissions for road transport
To derive fuel sold (FS) emissions from road transport, the fuel used (FU) emissions per fuel type are adjusted for differences between (estimated) fuel used by road transport in the Netherlands and fuel sold as reported by Statistics Netherlands. Figure 4.6 shows both the bottom-up estimates for fuel used (PJ) by road transport and reported fuel sold to road transport per fuel type for the 1990-2014 time series. For gasoline, the time series show good agreement in both the absolute level and the trend, except for the 2011-2014 period where fuel sold decreased by 10% whereas fuel used decreased by only 1%. Part of this difference might be attributed to the use of preliminary data on vehicle kilometres travelled in the Netherlands to estimate fuel used. Since odometer readings from 2013 and 2014 are not yet available for the entire vehicle fleet, average annual mileages from different car types in 2014 are still preliminary estimates. Another explanation could be an increase in fuel tourism resulting from an increasing difference in fuel prices in the Netherlands compared to Belgium and Germany.
The time series for diesel also show similar trends, but there is a larger difference in absolute levels, with fuel sold being substantially higher than fuel used. The difference between fuel used and fuel sold varies between 20 and 30 percent 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 >1000 kilometres on one 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 actually used abroad. This could at least partially explain why substantially more diesel fuel is sold than is used by road transport in the Netherlands. It is unknown though to what extent this explains the differences between diesel fuel sold and used. Other possible explanations are that the diesel fuel is used for other purposes 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 diesel used for other purposes such as mobile machinery and rail transport. Fuel tourism does not seem to be a logical explanation for the differences, because fuel prices in the Netherlands are generally higher than in neighbouring countries. This holds especially for gasoline and to a smaller extent for diesel.
In 2014, diesel fuel sold to road transport decreased by 8%, whereas fuel used only decreased by 1.6% compared to 2013. The major decrease in diesel fuel sales can probably for the most part be attributed to an increase in cross-border refuelling by international freight transport.

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

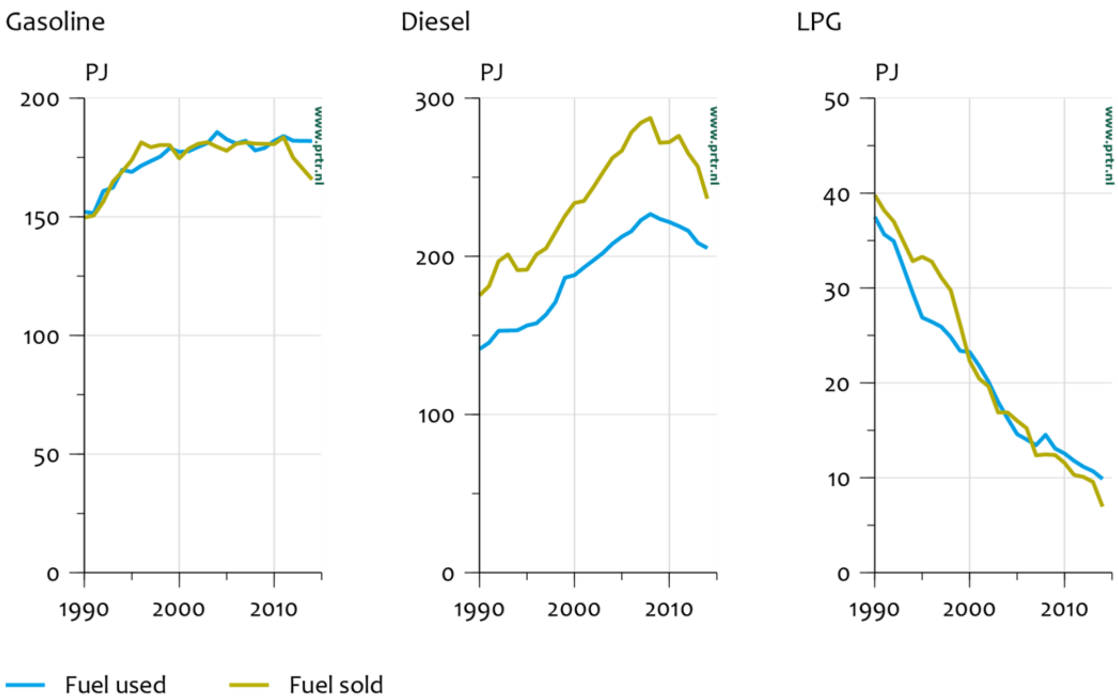

Figure 4.6 Fuel used vs. fuel sold trends, for gasoline, diesel and LPG fuelled road transport in the Netherlands

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 earlier years of the time series, as can be seen in Figure 4.7. NMVOC emissions in road transport mostly stem from gasoline vehicles. Since the difference between fuel used and fuel sold for gasoline is small, fuel used and fuel sold NMVOC emission totals do not differ much, as shown in Figure 4.7. PM emissions from brake and tyre wear and from road abrasion were not adjusted for differences between fuel used and fuel sold, since these emissions are not directly related to fuel use.

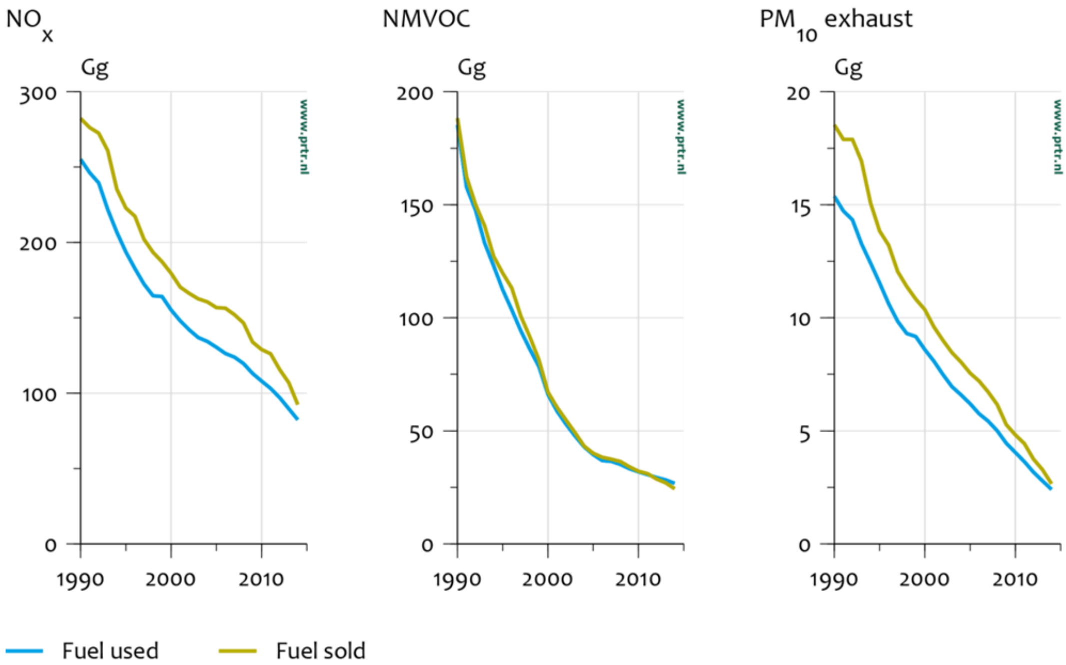

Figure 4.7 NO_x, NMVOC and PM_{10} exhaust emissions from road transport in the Netherlands based on fuel used and fuel sold

4.3.5 *Methodological issues*

The PM emission factors for brake and tyre wear and for road abrasion are rather uncertain due to a lack of measurements.

4.3.6 *Uncertainties and time series consistency*

In 2013, TNO carried out a study to improve the knowledge on uncertainties of 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 emission behaviour of the vehicles, on-road driving behaviour and 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 if these results hold for more recent generations of (diesel) passenger cars. Test procedures have been improved in recent years, but the number of vehicles tested has decreased over the years.
There was no recent and accurate information available for assessing the uncertainties of total emissions from road transport for different substances. Consistent methodologies were used throughout the time series.

4.3.7 *Source-specific QA/QC and verification*

Trends in the number of vehicle kilometres driven in the Netherlands, as calculated by Statistics Netherlands using odometer readings, were compared to trends in traffic intensities on the Dutch motorway network, as reported by *Rijkswaterstaat*. In general, both time series show good agreement, with some annual fluctuations.

4.3.8 *Source-specific recalculations*

This year's submission includes several recalculations.

NO_x emissions from Euro-4 and Euro-5 light-duty trucks

The time series for NO_x emissions from light-duty trucks has been recalculated in this year's inventory using adjusted NO_x emission factors for Euro-4 and Euro-5 light-duty trucks derived from a measurement programme by TNO (Kadijk *et al.*, 2015). TNO performed on-road measurements on ten Euro-5 compliant diesel commercial N1 class III vehicles. Resulting real-world NO_x emission levels were 5 to 6 times higher than the Euro-5 NO_x emission standard for class III trucks. Using this data, the NO_x emission factors for Euro-5 light-duty trucks were adjusted upwards by 33 to 85% compared to previous estimates. The NO_x emission factors for Euro-4 trucks were adjusted upwards as well, as is shown in Figure 4.8.

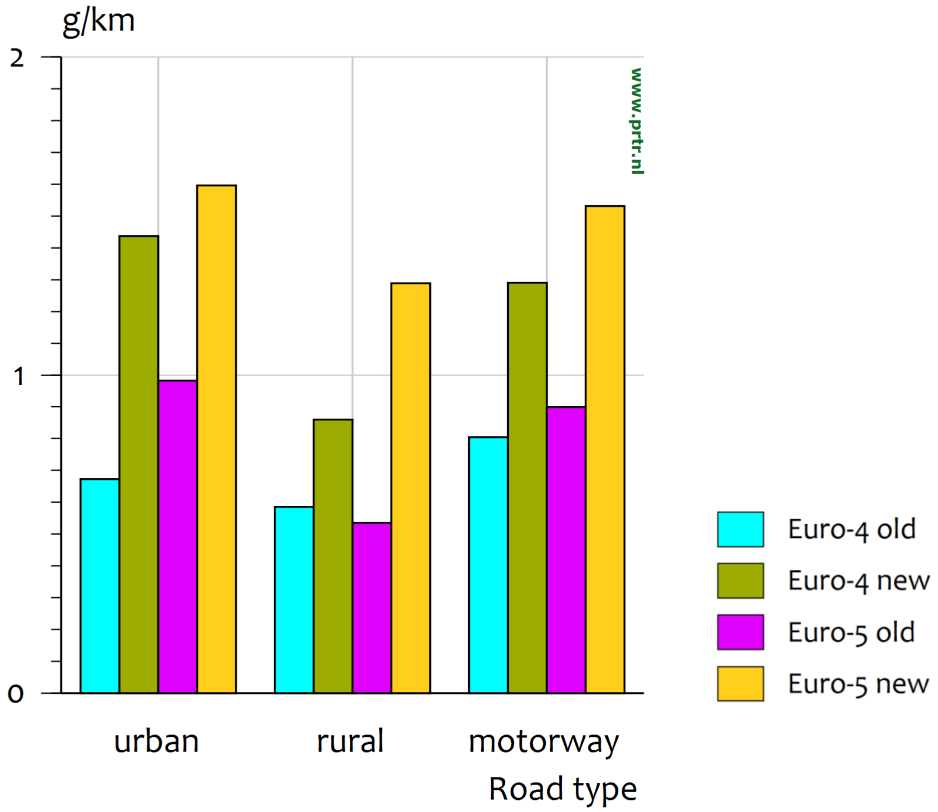

Figure 4.8 Real-world NO_x emission factors for Euro-4 and Euro-5 light-duty trucks (class III)

Previously the Euro-5 NO_x emission factors for light-duty trucks had been estimated based on real-world measurements on Euro-5 diesel passenger cars. The resulting emission factors for passenger cars were subsequently adjusted for the difference in the NO_x emission standards for light-duty trucks compared to passenger cars. These Euro-5 NO_x emission factors for passenger cars were derived from measurement programmes, which had shown that real-world NO_x emissions from Euro-5 diesel passenger cars are significantly higher than the EU emission standard as well. By correcting the real-world NO_x emission factors for the difference in emissions standards between passenger cars and Class III light-duty trucks, it had already been taken into account that real-world NO_x emissions from light-duty trucks are significantly higher than the NO_x emission standard. The recent measurement programme by TNO showed however that real-world NO_x performance by light-duty trucks is even worse than that of Euro-5 diesel passenger cars.

Figure 4.9 shows both this year's and last year's time series for NO_x emissions from light-duty trucks. Since last year's inventory only included fuel used emissions for light-duty trucks, the new time series for NO_x of light-duty trucks is shown on a fuel used basis as well as on a fuel sold basis (the later being reported in this year's NFR tables). The new insights in the NO_x emissions from Class III N1 vehicles resulted in an increase in the NO_x emissions of up to 4.4 Gg (in 2013) compared to last year's inventory.

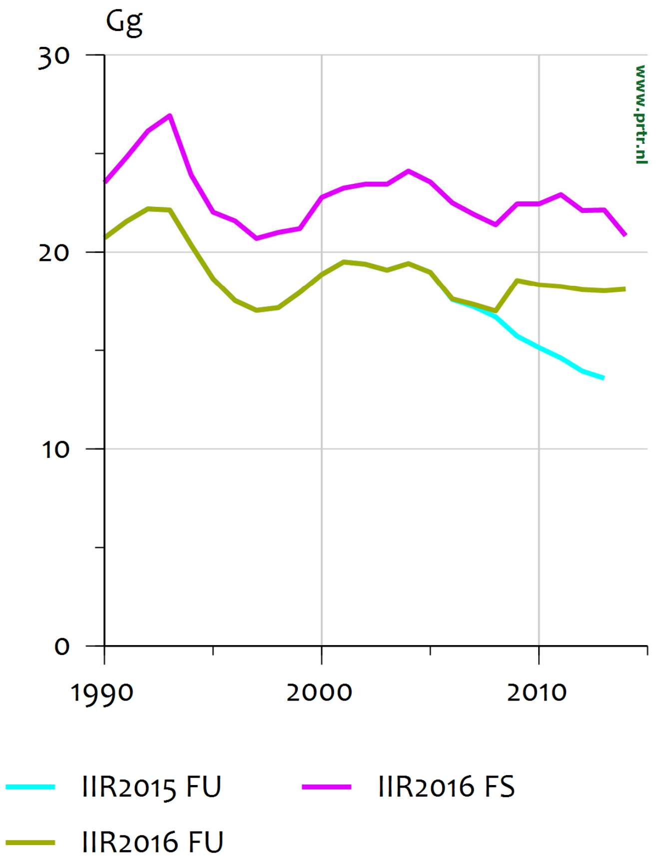

Figure 4.9 NO_x emissions from light-duty trucks

Updated real-world driving cycles for light-duty vehicles

Pollutant emission levels from road vehicles are strongly influenced by driving circumstances. Representative real-world driving cycles are required to determine emission factors. For this year's inventory, the driving cycles for light-duty vehicles in the Netherlands have been updated based on an extensive measurement programme (Ligterink, 2016). Measurements were performed on-road by a professional driver with instructions to either go with the traffic flow or, on multiple-lane roads, follow random vehicles. In total 108 hours of on-road driving

were recorded, distributed over urban roads, rural roads and motorways with varying speed limits. The vehicle that was used for the measurement programme was equipped with different velocity sensors and a video camera. Different time periods were covered, including evening trips and weekend days.
The measurement programme concluded that urban driving shows a rather large variations in driving speeds between 0 to 50 km/h. Rural driving shows a clear peak at 80 km/h, the national speed limit on rural roads, but also shows a rather large variations below 80 km/h. Highway driving shows peaks just below 100 km/h and 120 km/h, the speed limits at most highways in the Netherlands. A second peak at 100 km/h is related to the dynamic speed limits on Dutch highways (Ligterink, 2016). It was concluded that real-world driving is more dynamic than previously assumed, especially on motorways. This resulted in an increase in emission factors for light-duty vehicles.
The driving cycles that were used for previous inventories were determined in 2001. Since it is unknown how driving dynamics have evolved between 2001 and 2015, it was decided that the new driving cycles would only be used to determine emissions factors for Euro-5 and Euro-6 vehicles, being the dominant vehicle categories on the road in 2015. This means that the impact of the new driving cycles on the emission time series for passenger cars and light-duty trucks slowly phases in starting in 2009 when the first Euro-5 vehicles entered the vehicle fleet.

4.3.9 Source-specific planned improvements

For next year's inventory Statistics Netherlands will perform a study on the average annual mileages of older generations of passenger cars and light-duty trucks. Given that emission factors for some substances vary significantly between older and new generations of passenger cars and light-duty trucks, the relatively small number of older vehicles in the car fleet can still contribute substantially to the current emission totals. The average annual mileages of older generations of passenger cars have last been determined in 2012 (as described in the 2013 inventory report). This study showed a relatively steep drop-off in annual mileages for older passenger cars, especially for gasoline cars. Since then the annual circulation tax scheme for so-called *oldtimers* has been changed substantially, leading to decrease in the number of vehicles of 25 years and older in the fleet. The average annual mileages of the remaining cars need to be studied in order to see whether the results of the 2012 study still apply.

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, generated at stationary power plants. Emissions resulting from electricity generation for railways are not included in this source category. This source category only covers the exhaust emissions from diesel-powered rail transport in the Netherlands. 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. This results, among other things, in emissions of particulate matter, copper and lead from trains, trams and metros.

4.4.2 *Key sources*
Railways are a key source for emissions of lead in the inventory, accounting for 9% of Pb emissions in the Netherlands in 2014.

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 in both 1990 and 2014. 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 2014, diesel fuel consumption by rail transport increased by 4% (0.04 PJ) to 1.2 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 in the Netherlands are shown in Table 4.6. NO_x and PM_{10} emissions from railways show similar trends to the diesel fuel consumption time series. NO_x emissions from railways fluctuated around 1.9 Gg in earlier years of the time series, but decreased to 1.6 Gg in 2014. PM_{10} emissions have fluctuated around 0.08 Gg. Pb emissions have increased by 23% between 1990 and 2014. Pb emissions from railways result from wear of carbon brushes. Wear emissions were estimated based on total electricity use by railways (in kWh). Trends in Pb emissions therefore follow trends in electricity use for railways. Emissions of other heavy metals are very low and are therefore not included in Table 4.6. SO_2 emissions from railways have 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).

4.4.4 *Activity data and (implied) emission factors*
For calculating 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 national Energy Balance. Since 2010, these fuel sales data are 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 and Samaras (2000). The emission factors for railways have not been updated recently and therefore are rather uncertain.

PM_{10} emissions due to wear of overhead contact lines and carbon brushes from railways are calculated using a study by NS-CTO (1992) on the wear of overhead contact lines and carbon brushes of the collectors on electric trains. For trams and metros, the wear of the overhead contact lines has been assumed identical to railways. The wear of 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 at 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 and 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.

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**	**0.07**	**0.07**	**0.02**	**0.26**	**0.71**
1995	1.7	0.08	0.10	0.0003	0.06	0.07	0.07	0.02	0.27	0.84
2000	2.1	0.09	0.12	0.0004	0.06	0.08	0.08	0.03	0.32	0.93
2005	1.9	0.08	0.11	0.0003	0.06	0.08	0.08	0.02	0.29	0.89
2010	1.9	0.08	0.02	0.0003	0.06	0.08	0.08	0.02	0.29	0.95
2013	1.5	0.07	0.00	0.0003	0.05	0.07	0.07	0.02	0.25	0.93
2014	**1.6**	**0.07**	**0.00**	**0.0003**	**0.05**	**0.07**	**0.07**	**0.02**	**0.26**	**0.88**
1990-2014 period [1)]	-0.05	0.00	-0.10	0.0000	0.00	0.00	0.00	0.00	-0.01	0.17
1990-2014 period [2)]	-3%	-2%	-99%	-3%	1%	5%	5%	-2%	-2%	23%

[1)] Absolute difference in Gg

[2)] Relative difference to 1990 in %

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*

There was no recent and accurate information available for assessing the uncertainties of the emissions from railways. Consistent methodologies were used throughout the time series for railways.

4.4.7 *Source-specific QA/QC and verification*

Trends in fuel sales data have been compared with trends in traffic volumes. The trends in both time series show fairly good agreement, although agreement has been less good in recent years due to the increased electrification of diesel rail transport in the Netherlands.

4.4.8 *Source-specific recalculations*

There are no source-specific recalculations for railways in this year's inventory.

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 except for lead, 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)). National inland navigation includes emissions from all trips that both depart and arrive in The Netherlands, whereas international inland navigation includes emissions from trips that either depart or arrive abroad. Only emissions on Dutch territory are reported. For maritime navigation this includes emissions on the Dutch continental shelf. All three categories include both passenger and freight transport. Emissions from international maritime navigation are reported as a memo item and are not part of the national emission totals. The emissions from recreational craft are reported under *Other mobile* (1A5b) but are described in this Section as well.

4.5.2 *Key sources*

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

4.5.3 *Overview of emission shares and trends*

In total, national and international inland waterborne navigation combined was responsible for 11% of NO_x emissions and 7% of $PM_{2.5}$ emissions in The Netherlands in 2014. With emissions from road transport decreasing rapidly, the share of inland waterborne navigation in national totals has increased throughout the time series. The share of inland waterborne navigation in national emissions of PM_{10} (3.4%), NMVOC (0.9%), CO (1%) and SO_2 (0.04%) was small in 2014.

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 102 Gg in 2014, up from 97 Gg in 2013 and higher than the combined NO_x emissions from all road transport in The Netherlands. PM_{10} emissions amounted to 4.6 Gg in 2014. On the contrary, recreational craft are only a small emission source, being responsible for 2.3 Gg of NO_x, 1.7 Gg of NMVOC and 0.05 Gg of PM_{10} in 2014.

Table 4.7 Trends in emissions from Inland shipping in the Netherlands (combined emissions of national and international inland shipping)

	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	**31**	**5.4**	**1.9**	**0.005**	**1.30**	**1.37**	**1.37**	**0.58**	**22**
1995	28	5.6	1.9	0.005	1.32	1.39	1.39	0.58	23
2000	30	5.6	2.1	0.006	1.32	1.39	1.39	0.59	27
2005	28	4.9	2.0	0.006	1.14	1.20	1.20	0.50	29
2010	27	3.8	0.6	0.006	0.92	0.98	0.98	0.41	27
2013	29	3.2	0.0	0.006	0.91	0.96	0.96	0.41	27
2014	**29**	**2.9**	**0.0**	**0.006**	**0.89**	**0.95**	**0.95**	**0.40**	**27**
1990-2014 period [1)]	-2	-2.4	-1.9	0.001	-0.41	-0.42	-0.42	-0.18	4.2
1990-2014 period [2)]	-6%	-45%	-99%	20%	-31%	-31%	-31%	-31%	19%

[1)] Absolute difference in Gg

[2)] Relative difference to 1990 in %

The trends in emissions from inland shipping in the Netherlands are shown in Table 4.7. Since 2000, fuel consumption in inland navigation has fluctuated between 22 and 27 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 2014, as is shown in Figure 4.10. Emissions of NO_x, CO, NMVOC and PM from inland navigation have shown similar trends to the fuel consumption time series. Combined NO_x emissions from national and international inland navigation increased from 27 Gg in 2010 to 29 Gg in 2014. The introduction of emission standards for new ship engines (CCR stage 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 increased significantly, total NO_x emissions still increased between 2009 and 2014.

SO_2 emissions from waterborne navigation have decreased by 95% between 2009 and 2014 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 already introduced in 2009 in inland shipping in the Netherlands, therefore SO_2 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 0.01 Gg in 2014 compared to 2013.
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 2013 to 2014, resulting in small decreases in emissions. PM_{10} , $PM_{2.5}$ and CO emissions decreased by less than 1%. NMVOC emissions decreased by 13%, whereas NO_x emissions showed a minor increase (0.6%) from 2013 to 2014.

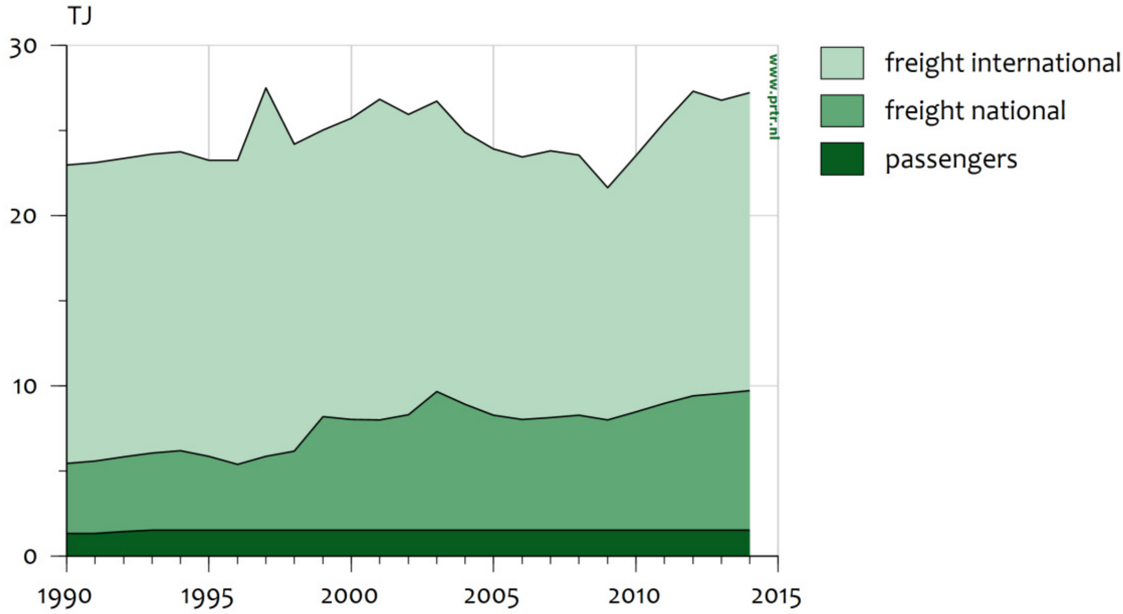

Figure 4.10 Fuel consumption in national and international inland shipping in the Netherlands

Energy use and resulting emissions from maritime navigation showed an upwards trend between 1990 and 2007. Since the start of the economic crisis, transport volumes 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 2014, total fuel consumption by maritime navigation on the Dutch part of the North Sea, the Dutch Continental Shelf (DCS), increased by 4% compared to 2013, whereas fuel consumption by maritime shipping on inland waterways increased by 9%. As a result, total NO_x emissions by maritime shipping on Dutch territory increased by 4% in 2014 and total PM_{10} emissions increased by 5%.

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 that 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 had 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

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

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)

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 (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 factor are expressed in g/kWh. The emission factors depend on the engine's year of construction and are reported in Hulskotte and 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 througout the time series are reported in Klein *et al*. (2016). The formula used to estimate the impact of lower sulphur content on PM emissions is described in Hulskotte and 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 fuel consumption of the main engines.

No recent information was available on the fuel consumption by passenger ships and ferries in the Netherlands, therefore fuel consumption data for 1994 were applied to 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 sailboats/cabin sailboats) with 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.* (2016).

Since 2008, emissions from maritime shipping on the Dutch Continental Shelf and in the Dutch port areas are calculated annually by MARIN and TNO using vessel movement data derived from AIS (Automatic Identification System). Since 2005 all merchant ships over 300 Gross Tonnage (GT) are equipped with AIS. 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 energy consumption and emissions from maritime shipping bottom-up, taking into account specific ship and voyage characteristics.
To estimate emissions from a specific ship on Dutch waters, the IMO number of the ship is linked to a ship characteristics database that is acquired from Lloyd's List Intelligence (LLI). This database contains 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 by TNO using information on the year of build and the design speed of the ship, the engine type and power, the type of fuel used and, for engines build since 2000, the engines maximum revolutions per minute (RPM). Methodologies and resulting emissions for recent years are described in more detail in MARIN (2014).

4.5.5 Methodological issues

There was no recent data available on the fuel consumption in passenger ships and ferries. Also, the available data on the number of recreational crafts and their average usage rates are rather uncertain.

4.5.6 Uncertainties and time series consistency

There was no recent and accurate information available for assessing the uncertainties of the emissions from inland waterborne navigation. Consistent methodologies were used throughout the time series for inland waterborne navigation. For maritime navigation, AIS data have only become available since 2008. For earlier years in the time series, emission totals were estimated using vessel movement data from

Lloyd's combined with assumptions on average vessel speeds (Hulskotte *et al*., 2003).

4.5.7 *Source-specific QA/QC and verification*

There are no source-specific QA/QC or verification procedures for waterborne navigation.

4.5.8 *Source-specific recalculations*

There were no source-specific recalculations for waterborne navigation in this year's submission.

4.5.9 *Source-specific planned improvements*

TNO is currently performing a study to determine whether AIS data can also be used to calculate emissions from inland navigation on 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.

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.

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 in the 2014 level assessment. Source category 1A4bii Residential: household and gardening (mobile) is a key source of emissions of CO in both the 2014 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 in the 2014 level assessment and for NO_x in the trend assessment. Source category 1A5b Other, mobile, which includes emissions from ground support equipment at airports, is a key source of CO in the 2014 level assessment.

4.6.3 *Overview of shares and trends in emissions*

NRMM was responsible for 10% of CO emissions, 8% of NO_x and $PM_{2.5}$ and 4% of PM_{10} emissions in the Netherlands in 2014. CO emissions mainly resulted from the use of gasoline 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. LPG fork lift trucks were also a major source of NO_x emissions with a contribution of 16% in total NO_x emissions from NRMM in 2014.

Total energy use in NRMM has fluctuated between 35 PJ and 45 PJ throughout the time series. Energy use in 2014 decreased by 3% (1.2 PJ) compared to 2013, 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 19.5 PJ in 2008 to 15.3 in 2014. Figure 4.11 shows total energy use within the different sectors where mobile machinery is applied. Construction and agricultural machinery were responsible for 78% of total energy use by NRMM in 2014. Diesel is the dominant fuel type, accounting for 89% of energy use in 2014. Gasoline and LPG had a share of 5% and 6% respectively. LPG is used in the industrial sector (forklift trucks) and gasoline in the agricultural, construction and commercial/institutional sectors.

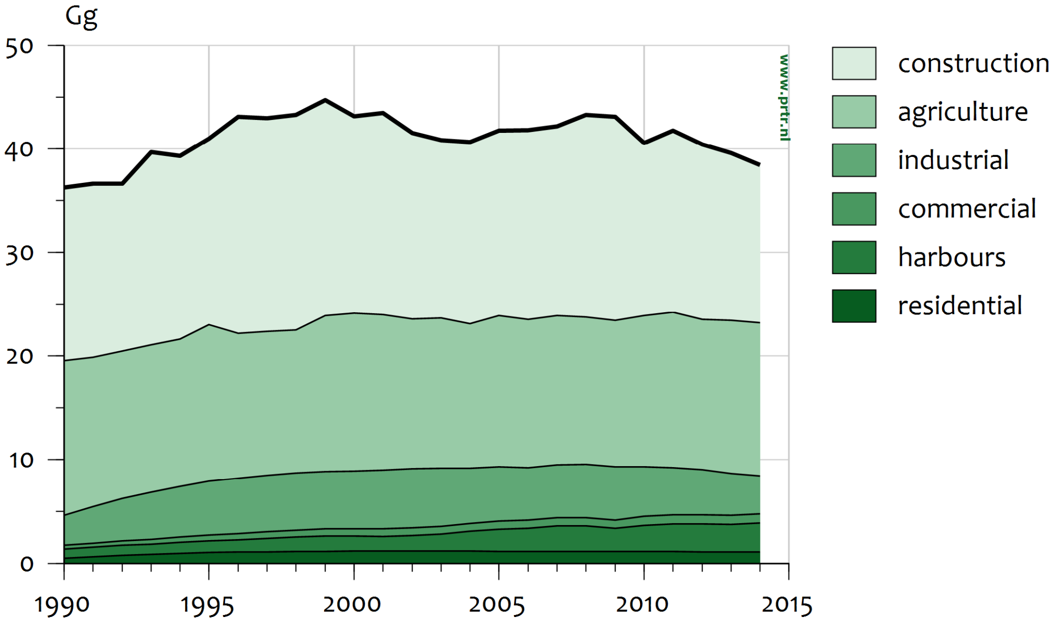

Figure 4.11 Fuel consumption in non-road mobile machinery in different sectors in the Netherlands

The trends in emissions from NRMM in the Netherlands are shown in Table 4.8. With the introduction of EU emissions 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 is shown in Figure 4.12. Since 1999, NO_x emissions have decreased by 57%, whereas fuel consumption has only decreased by 14%. NO_x emissions from gasoline-and LPG-powered machinery have steadily increased throughout the time series. In 2014, gasoline and LPG machinery had a combined share of 17% in total NO_x emissions, whereas in 1990 their combined share was only 5%. CO emissions have also increased throughout the time series.

Table 4.8 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	**34**	**7.7**	**2.9**	**0.008**	**3.3**	**3.4**	**3.4**	**1.7**	**37**
1995	39	8.3	2.9	0.009	2.9	3.1	3.1	1.5	55
2000	40	7.8	3.1	0.009	2.6	2.7	2.7	1.3	58
2005	32	5.8	3.0	0.009	2.1	2.2	2.2	1.1	55
2010	24	4.2	0.3	0.008	1.4	1.5	1.5	0.7	57
2013	20	3.6	0.0	0.008	1.1	1.2	1.2	0.6	56
2014	**18**	**3.3**	**0.0**	**0.008**	**1.0**	**1.1**	**1.1**	**0.5**	**56**
1990-2014 period [1)]	-16	-4.4	-2.8	0.000	-2.2	-2.4	-2.4	-1.2	19
1990-2014 period [2)]	-47%	-57%	-99%	1%	-69%	-69%	-69%	-70%	52%

[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_2 emissions have decreased due to the EU fuel quality standards reducing the sulphur content of the diesel fuel used by non-road mobile machinery. Since 2011, the use of sulphur free diesel fuel is required in NRMM. Consequently, SO_2 emissions have reduced significantly.

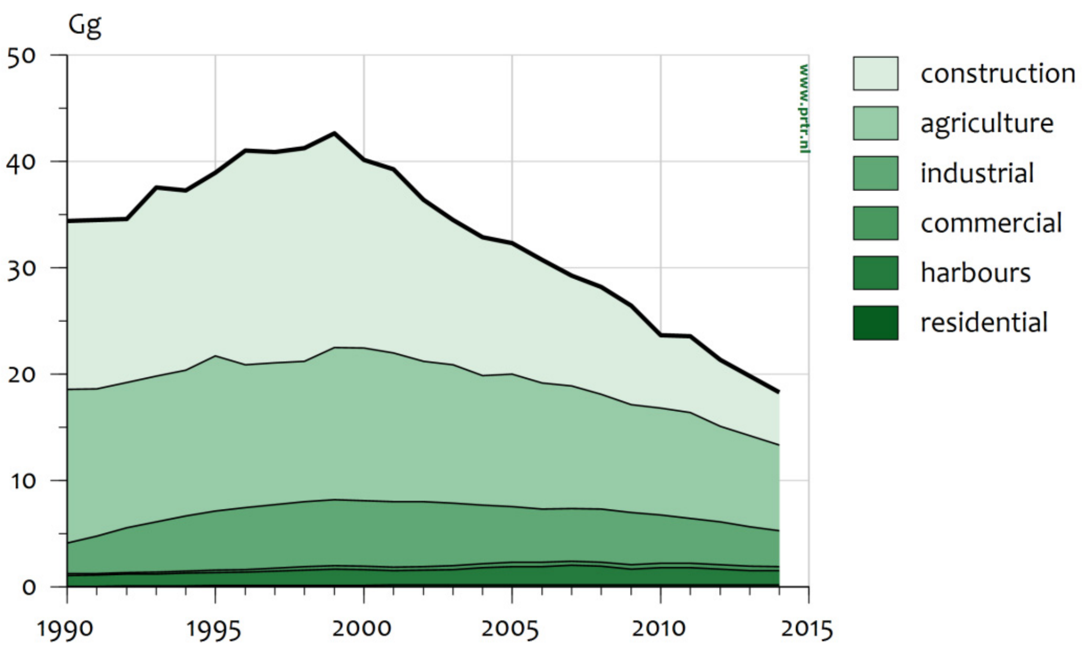

Figure 4.12 NO_x emissions by non-road mobile machinery in different sectors in the Netherlands

4.6.4 *Activity data and (implied) emission factors*

Fuel consumption by mobile machinery in the different economic sectors is not reported separately in the Energy Balance. Therefore, fuel consumption and resulting emissions from NRMM are calculated using a Tier-3 modelling approach, developed by TNO (Hulskotte and Verbeek, 2009). The so-called EMMA model uses sales data and survival rates for different types of machinery to estimate the active NRMM fleet in any given year. Combined with assumptions on the average use (annual operating hours) and the specific fuel consumption per hour of operation for the different types of machinery, 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 organization 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 TNO report on the EMMA model (Hulskotte and 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 per sales year. Emissions of SO_2 were calculated based on total fuel consumption and sulphur content per fuel type as provided in Klein *et al*. (2016). Emission factors for NH_3 were derived from Ntziachristos and 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 the LEI research institute of Wageningen 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 on the average annual use of the machinery, it is not able to properly take into account cyclical effects that do not only lead to fluctuations 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; therefore the EMMA results were adjusted based on economic indicators from Statistics Netherlands for the specific sectors where 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*. (2016).

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, provided by KLM Royal Dutch Airlines. KLM is responsible for 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 regarding:

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 if there are enterprises or institutions that have figures of diesel consumption at their disposal.
2. There is a lack of input data for several types of machinery and sectors. Data is lacking about motorized pumps and part of the mobile electricity generators (used for instance in road construction). 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 might 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 of 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 on the influence on the emissions. A specific measurement programme for investigating the effect of transient engine loads in the machine's daily practice could lead to a far better foundation of the emission data.

4.6.6 *Uncertainties and time series consistency*

There was no recent and accurate information available for assessing the uncertainties of the emissions from non-road mobile machinery. The EMMA model was used for calculating fuel consumption and emissions for the time series since 1994. For earlier years there were no reliable machinery sales data available. Fuel consumption in 1990 was derived from estimates from Statistics Netherlands, while fuel consumption in 1991, 1992 and 1993 was derived by interpolation.

4.6.7 *Source-specific QA/QC and verification*

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

4.6.8 *Source-specific recalculations*

In this year's submission the emissions from mobile machinery at Dutch container terminals have been added to the inventory. Mobile machinery typically found at container terminals are reach stackers, empty handlers, straddle carriers, tug masters, forklifts and automated guided vehicles (Dellaert, 2016). These machines are used to transfer containers from container ships to a storage location or another mode of transportation. Data on the energy use of NRMM in the Port of Rotterdam was collected from DCMR. Based on this data the average energy use per TEU was estimated at 4.5 litres, which was subsequently used to estimate energy use in the other ports in the Netherlands based on the number of containers that were handled at these ports. The methodology and emission factors used are described in Dellaert (2016).

Total diesel fuel consumption by NRMM in container terminals was estimated at 0.9 PJ in 1990, increasing to 2.8 PJ in 2014. NO_x emissions were estimated at 1 Gg in 1990 and 1.3 Gg in 2014, whereas PM_{10} and $PM_{2.5}$ emissions were estimated at 0.1 Gg in 1990 and 0.02 Gg in 2014. Since all equipment is diesel fuelled, CO and NMVOC emissions are small. The emissions from NRMM at container terminals have been reported under source category 1A4aii 'Commercial/institutional mobile'.

4.6.9 *Source-specific planned improvements*

There are no source-specific planned improvements for NRMM.

4.7 National fishing

4.7.1 *Source category description*

The source category 1A4ciii 'National fishing' covers emissions from fuel consumption to cutters operating within national waters, including the Dutch part of the Continental Shelf.

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 2014, national fishing was responsible for 2% of total NO_x emissions and 1% of $PM_{2.5}$ emissions. The contribution to the national totals for other substances was less than 1%. Fuel consumption by national fishing has been decreasing since 1995, as is shown in Figure 4.13. This is in line with the decrease in the number of cutter vessels and the installed engine power in the cutter fleet (as reported by Statistics Netherlands).

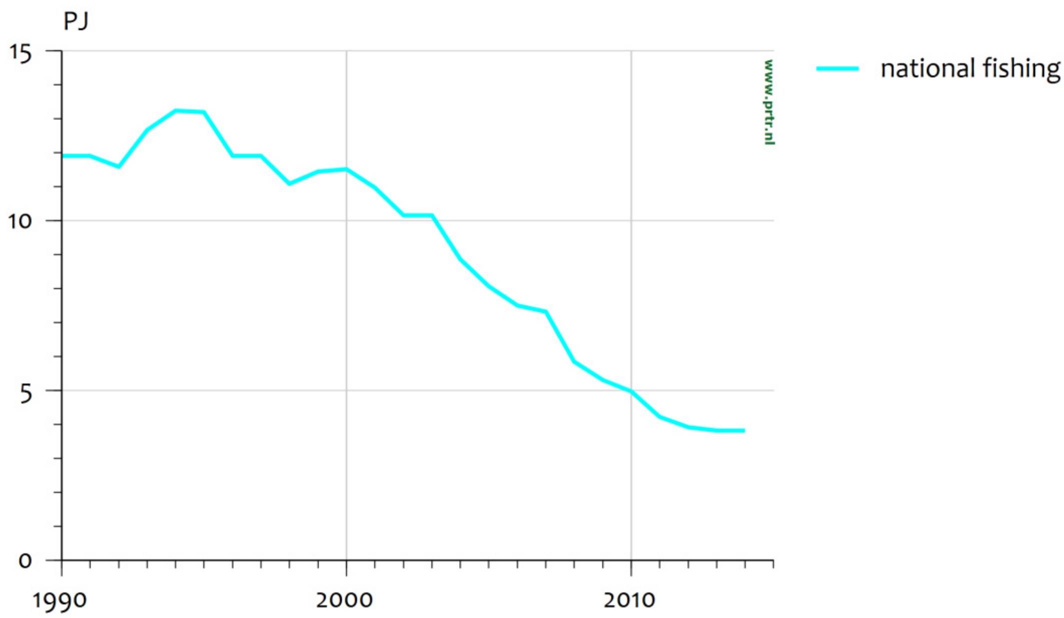

Figure 4.13 Fuel consumption by the fishing fleet in the Netherlands

The trends in emissions from national fishing are shown in Table 4.9. Since the emission factors were kept constant throughout the time series, emissions from national fishing show similar trends to fuel consumption. NO_x emissions decreased from 16.5 to 5.3 Gg between 1990 and 2014, whereas PM_{10} emissions decreased from 0.39 to 0.13 Gg. SO_2 emissions decreased by over 99% due to the use of sulphur-free diesel fuel.

Table 4.9: 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	**16.5**	**0.7**	**1.0**	**0.003**	**0.37**	**0.39**	**0.39**	**0.17**	**2.23**
1995	18.2	0.8	1.1	0.003	0.41	0.43	0.43	0.18	2.47
2000	15.9	0.7	0.9	0.003	0.36	0.38	0.38	0.16	2.16
2005	11.2	0.5	0.6	0.002	0.25	0.26	0.26	0.11	1.51
2010	6.9	0.3	0.1	0.001	0.15	0.16	0.16	0.07	0.93
2013	5.3	0.2	0.0	0.001	0.12	0.13	0.13	0.05	0.71
2014	**5.3**	**0.2**	**0.0**	**0.001**	**0.12**	**0.13**	**0.13**	**0.05**	**0.71**
1990-2014 period [1)]	-11.2	-0.5	-1.0	-0.002	-0.25	-0.27	-0.27	-0.11	-1.52
1990-2014 period [2)]	-68%	-68%	-100%	-68%	-68%	-68%	-68%	-68%	-68%

[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 calculations based on vessel movements. These calculations were performed by LEI research institute and reported in annual reports called 'Visserij in Cijfers'. Fuel consumption is calculated using the following formula:

Fuel taken on board = the sum of hp-days x fuel consumption per hp per day per vessel,

HP-days stands for the number of days a vessel spends at sea multiplied by the amount of horsepower of the vessel. With the help of data from VIRIS, a database from LEI containing log data from individual vessels, the ports of departure and arrival and the number of days at sea have been ascertained for each vessel for each fishing trip. When determining where fuel is taken on board, it has been assumed that for all fishing trips where the ports of departure and arrival were both in the Netherlands, fuel was taken on board in the Netherlands. Furthermore, vessels are assumed always to refuel after completion of a fishing trip.

The applied emission factors for NO_x, CO, NMVOC and PM_{10} were derived from Hulskotte and Koch (2000), whereas the SO_2 emission factors were derived from Van der Tak (2000). Emission factors for NH_3 were derived from Ntziachristos and Samaras (2000).

4.7.5 *Methodological issues*

Since there were no fuel sales data available specifically for national fishing, fuel consumption was calculated based on vessel movements. This method is rather uncertain. Also, the emission factors for fishing vessels have not been updated recently and therefore are rather uncertain.

4.7.6 *Uncertainties and time series consistency*

There was no recent and accurate information available for assessing the uncertainties of the emissions from national fishing. Consistent methodologies were used throughout the time series for national fishing.

4.7.7 *Source-specific QA/QC and verification*

Trends in total fuel consumption in cutter fishery, as reported by LEI, were compared with trends in the cutter fishing fleet in the Netherlands and the installed engine power on the fleet. Both trends show good agreement.

4.7.8 *Source-specific recalculations*

There are no source-specific recalculations for national fishing.

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 those 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, transportation 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 2013 Guidebook is not clear in which sources belong to 2G and 2L, 2G is included in 2D3i (Other solvent use) and 2L in 2H3 (Other industrial processes).

Table 5.1 gives 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 & Product Use (NFR 2) sector

	Main Pollutants				Particulate Matter		
	NO_x	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	**5.2**	**215**	**10.0**	**5.4**	**49**	**30**	**15**
1995	3.3	154	2.8	5.2	34	19	9.5
2000	1.9	111	1.5	4.0	18	12.1	6.2
2005	0.6	89	1.0	3.6	16	11.2	5.4
2010	0.5	89	0.9	2.6	15	10.5	5.0
2013	0.7	79	0.8	2.3	15	9.6	4.2
2014	**0.7**	**79**	**0.9**	**2.2**	**15**	**9.6**	**4.2**
1990–2014 period [1)]	-4.4	-136	-9.2	-3.2	-35	-20	-10.7
1990–2014 period [2)]	-86%	-63%	-91%	-59%	-70%	-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
2013	11	0.5	0.2	16	0.1
2014	**7**	**0.4**	**0.1**	**13**	**0.1**
1990–2014 period [1)]	-61	-0.5	-1.1	-50	-13
1990–2014 period [2)]	-90%	-52%	-89%	-79%	-99%

[1)] Absolute difference in Gg

[2)] Relative difference to 1990 in %

5.1.1 *Key sources*

The key sources of this sector are discussed in Sections 5.2 to 5.6. Because the TSP and Cd time series of most key sources were incomplete, they 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 the product use categories are included in 5.5, Solvents and product use.

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)

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

The implied emission factors were calculated as follows:

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

where Em_IF = the sum of emissions from individual facilities (since 1999, most of the emissions from individual facilities 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:

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

where n = year

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

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

where IEF = the implied emission factor; TP = Total production in (sub)category (Production Statistics, Statistics Netherlands); and P_IF = Production in individual facilities(Production Statistics, Statistics Netherlands)

The implied emission factors were calculated as follows:

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

where Em_IF = the sum of the data on the individual facilities

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

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

where n = year, and PI = production indices (Statistics Netherlands)

Product Use
The Methodological issues of the product use categories are included in 5.5, Solvents and product use

5.1.4 Uncertainties and timeseries consistency
No accurate information was available for assessing the uncertainties about the emissions from this sector’s sources. 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 Chapter 1. The source categories are

covered by the general QA/QC procedures, as discussed in Subsection 1.6.2.

5.1.6 *Source-specific recalculations*

In comparison to the previous submission NMVOC emissions from 2D3d, Coating applications and PM10/PM2.5 emissions from the storage and handling of dry bulk products (part of the 2H3 subcategory) have been recalculated. Detailed information about these recalculations can be found in Sections 5.5 and 5.6.

5.1.7 *Source-specific planned improvements*

Industrial processes

Incomplete TSP and Cd time series will be repaired, where possible, in future submissions.
Furthermore the incorrect allocation of some sources of 2B10a for the year 2000 will be corrected in next submission.

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.

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 2014 (%)
2A3	Glass production		
2A6		PM10/PM2.5	4.1/2.8

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 emission from the key sources of Mineral products (2A)

NFR Code:	**2A3**	**2A6**	
NFR NAME:	**Glass production**	**Other mineral products**	
Pollutant:	**Pb**	**PM_{10}**	**$PM_{2.5}$**
Unit:	**Mg**	**Gg**	**Gg**
Year			
1990	7.3	2.0	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	0.3
2013	0.9	1.1	0.4
2014	1.0	1.1	0.4

From 1990 to 2014, Pb emissions from 2A3 decreased from 7.3 to 1.0 Mg. This reduction is 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 2014.

5.2.4 *Methodological issues*

Method 2-IP was used for estimating the emissions from Glass production (2A3) and Other mineral products (2A6).

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. No emissions were reported under categories 2B1 and 2B2 (only the greenhouse gases CO_2 and N_2O have been reported there). Because of allocation problems and confidential reasons, all emissions from the chemical industry (2B) were allocated to the category of chemical industry: other (2B10a).

5.3.2 *Key sources*

The key sources of this category are presented in Table 5.4.

Table 5.4 Key sources of Chemical industry(2B)

	Category / Subcategory	Pollutant	Contribution to total of 2014 (%)
2B10a	Chemical industry: Other	NMVOC $PM_{10}/PM_{2.5}$	3.8 4.6/4.7

5.3.3 Overview of emission shares and trends

Table 5.5 gives 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	2.4
1995	18	3.0	1.6
2000	13	0.5	0.4
2005	7.9	1.2	0.8
2010	5.7	1.3	0.8
2013	5.6	1.4	0.7
2014	5.5	1.2	0.6

From 1990 to 2014, NMVOC emissions decreased from 33 Gg to 5.5 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.
For the year 2000 some sources of 2B10a were allocated in the 1A2c (Stationary combustion in manufacturing industries and construction: Chemicals) category. Therefore there is a dip in the 2000 PM_{10} emissions. This will be corrected in next submission.

5.3.4 Methodological issues

Method 1-IP was used for estimating the emissions from other chemical industry (2B5a).

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

Emissions from storage and handling by companies with main activities other than those above are assumed to be included in the relevant categories of this NFR sector.

5.4.2 *Key sources*

The key sources of this category are presented in Table 5.6.

Table 5.6. Key sources of Metal production (2C)

	Category / Subcategory	Pollutant	Contribution to total of 2014 (%)
2C1	Iron and Steel Production	PM_{10}/$PM_{2.5}$	4.7/6.3
		Pb	32.9
		Hg	10.3

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 (category 1A2a) and fugitive emissions under category 1B2.
Table 5.7 provides an overview of the process emissions from the key source iron and steel production (category 2C1).

Table 5.7. Overview of emissions from the iron and steel production (2C1)

NFR Code:	2C1					
NFR NAME:	Iron and steel production					
Pollutant:	PM10	PM2,5	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	1.4	0.08
2005	1.7	1.1	23	0.2	1.4	0.06
2010	1.5	1.0	30	0.2	1.7	0.08
2013	1.3	0.8	9.5	0.2	2.8	0.06
2014	1.3	0.8	3.4	0.1	0.2	0.06

In addition to PM_{10}, $PM_{2.5}$, Pb and Hg (the key source pollutants), iron and steel production is also responsible for 1% of the total in dioxins and for 1% of all PAH emissions in the Netherlands. Most types of emissions from this source decreased during the 1990–2000 period. These reductions were mainly caused by the implementation of technical measures. Over the 2000–2010 period, emissions remained rather stable. Because of the replacement of electrostatic filters and the optimisation of some other reduction technologies at Tata Steel, Pb and Hg emission decreased after 2010. Dioxin emission fluctuations were mainly caused by the varying process conditions,

Aluminium production (2C3)
Aluminium production (category 2C3) is responsible for 0.14% 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 and primary aluminium was produced at two primary aluminium smelters in the Netherlands. One anode producer and one primary aluminium smelter were closed in 2011.

Table 5.8 provides an overview of the PAH emissions from aluminium production (category 2C3).

Table 5.8. 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
2013	0.006
2014	0.006

Between 1990 and 2000, PAH emissions decreased from 7 Mg in 1990 to less than 1 Mg in 2000. These reductions were mainly caused by the implementation of technical measures.
PAH emissions decreased to 0.006 Mg in 2013, because of the closure of one of the anode production plants and, at the other production plant, it being the first full year in which all three modern fume treatment plants were in operation. 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.

5.4.4 Methodological issues
Method 1-IP was used for estimating the emissions from iron and steel production (2C1) and aluminium production (2C3).
In cases without a complete registration for the four individual PAHs, a set of specific factors was used for calculating the emissions of the other, missing individual PAHs. These factors were obtained from the study by Visschedijk et al. (2007).

5.5 Solvents and product use (2D)
Table 5.9 gives an overview of the NMVOC and dioxin emissions from source category 2D.

Table 5.9 Overview of emission totals of NMVOC and dioxin from source category 2D

Pollutant:	**NMVOC**	**Dioxin**
Unit:	**Gg**	**g I-Teq**
Year		
1990	141	25
1995	113	23
2000	83	20
2005	64	18
2010	65	15
2013	58	14
2014	58	13

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, since no activity data was available. The emissions from chemical products (category 2D3g) were included in the category of chemical industry (2B).

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 2014 (%)**
	Domestic solvent use including fungicides		
	Coating applications		
	Printing		
2D3i	Other solvent use	NMVOC $PM_{10}/PM_{2.5}$ DIOX	6.9 4.6/9.7 59.5

5.5.3 *Overview of emission shares and trends*

Table 5.11 gives 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**	**2D3h**	**2D3i**			
NFR NAME:	**Domestic solvent use including fungicides**	**Coating applications**	**Printing**	**Other solvent use**			
Pollutant:	**NMVOC**	**NMVOC**	**NMVOC**	**NMVOC**	**PM_{10}**	**$PM_{2.5}$**	**Dioxin**
Unit:	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**g I-Teq**
Year							
1990	12	92	14	15	1.9	1.9	25
1995	15	66	14	13	1.8	1.8	23
2000	17	40	12	11	1.8	1.8	20
2005	18	26	5.6	11	1.5	1.5	18
2010	20	27	3.7	11	1.5	1.5	15
2013	21	19	4.0	11	1.3	1.2	14
2014	20	20	4.0	10	1.2	1.2	13

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

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

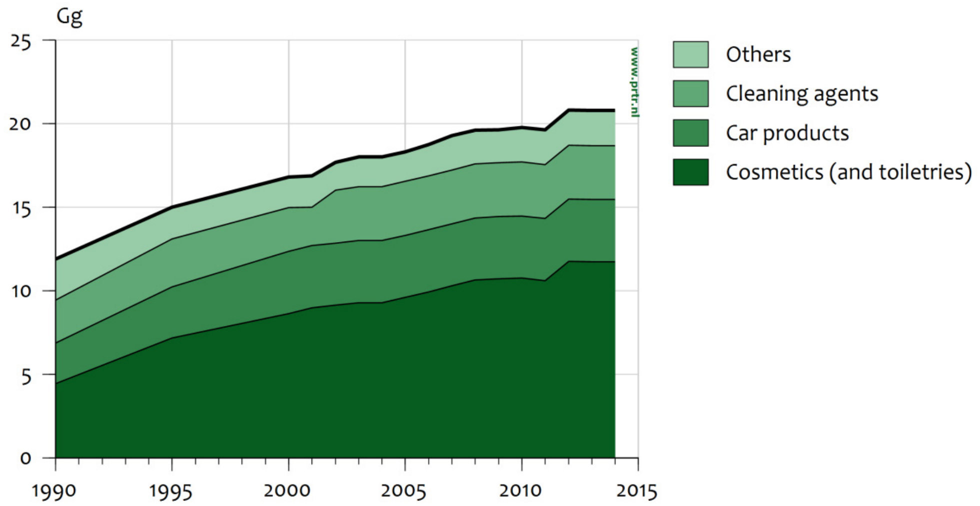

Figure 5.1 NMVOC emissions from sources of Domestic solvent use including fungicides (2D3a)

During the period 1990-2014, NMVOC emissions increased from 12 Gg in 1990 to 20 Gg in 2013. 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
- Boat building
- Construction and buildings
- Domestic use
- Car repairing

Mainly due to the lower average NMVOC content of the paints used, NMVOC emissions from Coating applications (2D3d*)* decreased from 92 Gg in 1990 to 23 Gg in 2007. As a result of the credit crunch, paint consumption decreased in 2008 and 2009; therefore, NMVOC emissions also decreased to 17 Gg in 2009.
In 2010 the biggest market segment, i.e. construction paints, continued to slide, while car repairing and the industry generally showed a modest recovery.

Because Car repairing and the Industry are market segments with high NMVOC levels, the total NMVOC emissions increased to 28 Gg in 2010. During the period 2010-2013 the paint consumption decreased again, which resulted in a decline of the NMVOC emissions to 19 Gg in 2013. In 2014 a slight increase of the paint consumption has led to an increase in the NMVOC emissions of 1 Gg.

Figure 5.2 shows the trend in NMVOC emissions from the sources of Coating applications (category 2D3d) over the 1990–2014 period.

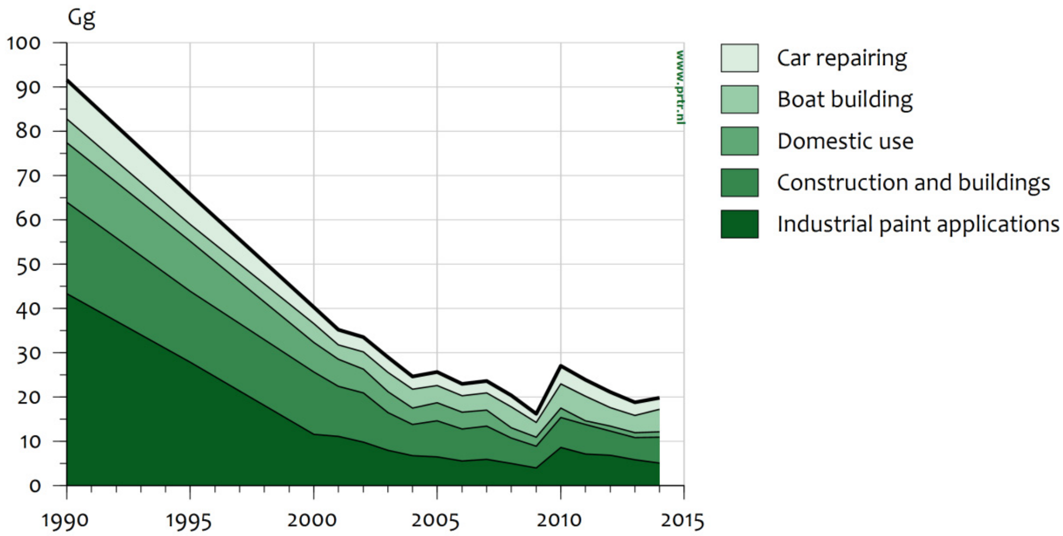

Figure 5.2 NMVOC emissions from sources of Coating applications (2D3d)

Printing (2D3h)
NMVOC emissions decreased from 14 Gg in 1990 to 4.2 Gg in 2008. These reductions were mainly the result of the implementation of technical measures (e.g. afterburners).
Due to the poor economic conditions, but also to the structural decline in demand for printed
matter, caused by the ongoing digitization of information flows, the sales of printing ink declined during the period 2008-2012. Consequently, emissions from printing decreased to 3.6 Gg in 2012. After 2012, both sales and emissions show an increase. However, this is not due to a revival of the market, but rather because the statistics of the sales has been changed. The reality is that the market is continuing to stagnate.

Other solvent use (2D3i)
The most important NMVOC sources are cleaning agents and refrigerants. NMVOC emissions in this category decreased from 15 Gg in 1990 to 10 Gg in 2014. 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 2014.
PM_{10} and $PM_{2.5}$ orginates from sources which belong to Other product use (2G).
As already mentioned in 5.1 the 2013 Guidebook is not clear in which sources belong to 2G. Therefore 2G is included in 2D3i.
The most important source of PM_{10} and $PM_{2.5}$ emissions (> 76% of the emissions) in 2D3i is Smoking of cigarettes. As a result of the drop in the number of cigarettes smoked, the emission of this source decreased from 1.8 Gg in 1990 to 0.9 Gg in 2014.

5.5.4 Activity data and (implied) emission factors

Domestic solvent use including fungicides (2D3a)
Sales data of products and the NMVOC content of products were obtained from annual reports by branch organisations, while the fraction of the NMVOC content that is emitted to 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 kton in 1990 to 154 kton in 2014 and the NMVOC content from 30% in 1990 to almost 15% in 2011. After 2011, the NMVOC contents remained rather stable.

Printing (2D3h)
Up to 2008 (including emissions of 2007), the Dutch Government had an agreement with the printing industry through which data became available for the emission inventory. For the 2008–2013 period, emissions were calculated using the annual sales figures of printing ink, which have been available since 2007.

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

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 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), 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 in 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 (ENINA, 2016).

Printing (2D3h)
Since 2009 (including emissions of 2008), the emissions have been calculated as follows:

$$EM_n = EM_{(n-1)} * AS_{(n)} / AS_{(n-1)}$$

where n = year, and AS = Annual Sales

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 air by the NMVOC content of the product.

5.5.6 Source-specific recalculations

Coating applications (2D3d)
From 2000 onwards better estimations on imported paints came available. Because imported paint is one of the components in the calculation, the NMVOC emissions have been recalculated for the period 2000-2013. This has resulted in an average NMVOC emission increase of 1.5 Gg during the period 2000-2013.

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

5.6.2 *Key sources*

The key sources of this category are presented in Table 5.13.

Table 5.13 Key sources of Other Production Industry (2H)

	Category / Subcategory	Pollutant	Contribution to total of 2014 (%)
2H2	Food and beverages industry	PM_{10}/$PM_{2.5}$	6.5/2.2
2H3	Other industrial processes	NMVOC PM_{10}/$PM_{2.5}$	7.2 9.4/5.2

5.6.3 *Overview of emission shares and trends*

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

Table 5.14 Overview of emission from the key sources of Other Production Industry (2H)

NFR Code:	2H2		2H3		
NFR NAME:	Other industrial processes				
Pollutant:	PM_{10}	$PM_{2.5}$	NMVOC	PM_{10}	$PM_{2.5}$
Unit:	Gg	Gg	Gg	Gg	Gg
Year					
1990	4.3	0.8	27	5.4	1.6
1995	2.3	0.4	14	3.1	0.8
2000	1.8	0.3	7	3.2	0.9
2005	1.8	0.3	10	2.7	0.7
2010	1.6	0.3	11	2.6	0.7
2013	1.7	0.3	10	2.4	0.6
2014	1.7	0.3	10	2.5	0.7

Food and beverages industry (2H2)

From 1990 to 2014, PM_{10} emissions decreased from 4.3 to 1.7 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 with 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 the above are assumed to be included in the relevant categories of this NFR sector.

From 1990 to 2014, NMVOC emissions decreased from 27 Gg to 10 Gg. The contribution of storage and handling of liquid bulk products was 15 Gg in 1990 and 8 Gg in 2014.

PM_{10} emissions decreased from 5.4 Gg to 2.5 Gg during the 1990–2014 period. The contribution of storage and handling of dry bulk products s was 1.4 Gg in 1990 and 0.9 Gg in 2014.

Figure 5.3 shows the trend in PM_{10} emissions from storage and handling of dry bulk products over the 1990–2014 period.

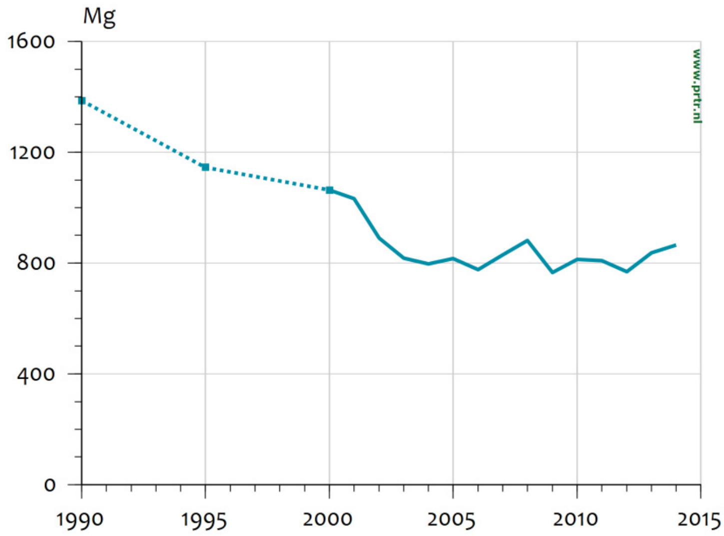

Figure 5.3 Storage and handling of dry bulk products: trend and emissions of PM_{10}

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 amounts of handling products.

5.6.4 *Methodological issues*

Method 2-IP was used for estimating the emissions from the production of food and drink (category 2H2).
Method 1-IP was used for estimating particulate matter (PM) emissions from storage and handling of 2H3; Method 2-IP was used for estimating all other emissions of 2H3.

5.6.5 *Source-specific recalculations*

Other industrial processes (2H3)

In the Netherlands a verification study "Determination emission indicator for particulate matter (PM_{10}) in handling S3 agribulk products" has been carried out in 2015. During that study a new emission factor (12 g instead of 24 g/ton handled) has been determined.
For that reason the PM_{10}/$PM_{2.5}$ emissions from the storage and handling of dry bulk products have been recalculated. Figure 5.4 shows the differences in PM_{10} emissions between the 2015IIR and the 2016IIR.

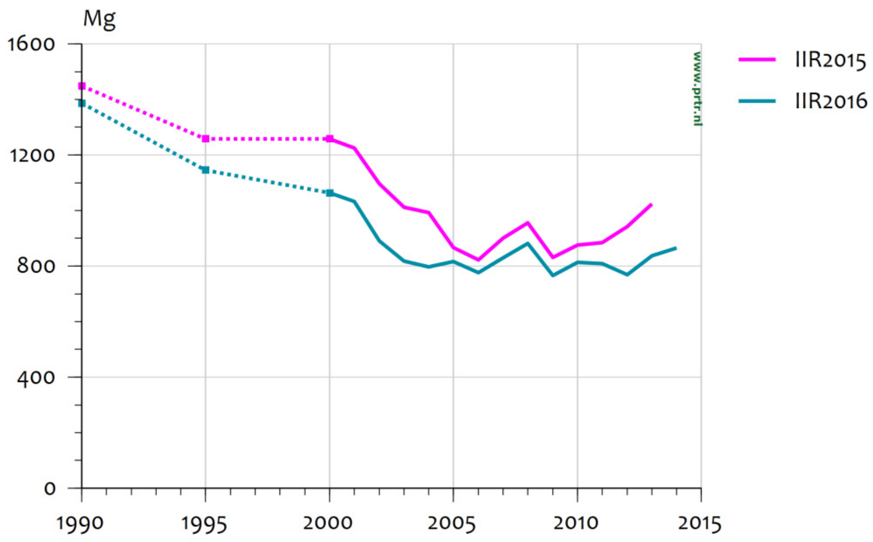

Figure 5.4 Storage and handling of dry bulk products: differences in PM_{10} emissions between the 2015IIR and the 2016IIR

6 Agriculture

6.1 Overview of the sector

The data on this sector include all anthropogenic emissions from agricultural activities. However, emissions from fuel combustion (mainly those 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

In the Netherlands, no emissions have been allocated to category 3I and as field burning of agricultural residues is prohibited by law, emissions from activities belonging to category 3F do not occur. Emissions of the greenhouse gases methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) are reported in annual National Inventory Reports (NIR). Therefore, the Informative Inventory Report (IIR) focuses on emissions of ammonia (NH_3), nitric oxide (NO, however in order to avoid confusion with the notation key further addressed as NO_x), non-methane volatile organic compounds (NMVOC), particulate matter (PM_{10}, $PM_{2.5}$) and zinc (Zn) from the source categories Manure management (3B) and Crop production and agricultural soils (3D).

At present, the agricultural sector is responsible for 89% of NH_3 emissions in the Netherlands. Emissions of NO_x from agriculture are also considerable and contribute to about 7% of the national total. However, towards compliance only emissions from animal housing and manure storage are included in the national NO_x total. NO_x emissions following the application of animal manure or inorganic N-fertilizers and from grazing are not accounted for in the current ceilings and are therefore reported as memo-items under category 11C Natural emissions. NMVOC emissions occur during the handling of manure and in crop production, but only the latter is being estimated and plays a minor role in the national total.

Agriculture is also a large source of PM_{10}, but much less so for $PM_{2.5}$ since the composition of particulate matter from animal houses tends to lean towards the coarser fraction. Zinc is not a priority heavy metal; however emissions stemming from drift following pesticide use are being reported for completeness.

6.1.1 Key sources

For NH_3 in 2014, the four main key sources originate from the agricultural sector: Animal manure applied to soils (3Da2a), Dairy cattle (category 3B1a), Swine (category 3B3) and Inorganic N-fertilizers (category 3Da1). Category 6A Other is also a key source and includes emissions from privately owned horses and emissions from inorganic N-fertilizer, animal manure and compost use outside agriculture. These emissions are also calculated according to the methods described in this chapter. In order to explain more than 80% of the NH_3 emissions, Non-dairy cattle (3B1b) and Laying hens (3B4gi) need to be included in the key source analysis, too.

In 2014, Laying hens (category 3B4gi) have the largest contribution to PM_{10} emissions. Broilers (category 3B4gii), Swine (category 3B3) and Farm-level agricultural operations including storage, handling and transport of agricultural products (3Dc) are also key sources of PM_{10} from the agricultural sector.

6.1.2 *Trends*

NH_3 emissions have decreased sharply between 1990 and 2014, as a result of policy changes, with a significant reduction in the first few years of the time-series. A ban on manure surface spreading came into force in 1991, making it mandatory to incorporate the manure into the soil either directly or shortly after application. To a large extent, this prevented the emission of NH_3 following the application of animal manure. It also became mandatory to cover manure storages, and more recently the introduction of emission low housing helped in decreasing ammonia emissions further.

Maximum application standards for manure and inorganic N-fertilizer, together with systems of production rights, also promoted efficiency. For example, milk quota led to feeding of more maize to dairy cattle in order to increase production per cow, which led to decreasing animal numbers and consequently lower emissions. Another example is the ongoing improvement in nutritional management with a profound reduction of dietary crude protein which resulted in lower N excretions per animal, and consequently NH_3 emissions were significantly reduced. Since most of the NH_3 emissions originate from the agricultural sector, the decreasing trend in NH_3 emission from agriculture also shows in the decreasing trend of the national total.

Although PM emissions for most animal categories decreased slightly over the 1990–2014 period due to decreasing animal numbers, the PM emissions in laying hens almost quadrupled for PM_{10} and more than doubled for $PM_{2.5}$. The reason for this is the almost complete transition 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.

6.2 Manure management

6.2.1 *Source category description*

This source comprises emissions from the handling and storage of animal manure. The category of Manure management (3B) has the following 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

Animals in the category 3B4a (Buffalo) do not occur in the Netherlands. Emissions from the categories 3B4giii Turkeys and 3B4giv Other poultry are reported as included elsewhere, since these are included in the category 3B4gii Broilers. Under category 3B4h (Other animals) pets, rabbits and furbearing animals are being reported. As a planned improvement, in subsequent submissions, emissions from pets will be reported in category 6A Other.

6.2.2 *Key sources*

From category 3B Manure management, Dairy cattle (category 3B1a) have the largest contribution to NH_3 emissions with 14.0% of the national total. Swine (category 3B3, 10.3%), Non-dairy cattle (category 3B1b, 7.8%) and Laying hens (category 3B4gi, 6.2%) are also NH_3 key sources from this category.

Laying hens (3B4gi) are the largest source for PM_{10} emissions, with 11.0% of the national total. Broilers (3B4gii; 5.2%) and Swine (3B3; 3.8%) are also key categories for PM_{10}.

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 the particulate matter species PM_{10} and $PM_{2.5}$ that originate from the Manure management sector.

Table 6.1 Emissions of main pollutants and particulate matter from the category of Manure management (3B)

	Main Pollutants		Particulate Matter	
	NO_x	NH_3	$PM_{2.5}$	PM_{10}
Year	Gg	Gg	Gg	Gg
1990	**3.7**	**101**	**0.4**	**4.1**
1995	3.7	98	0.4	4.1
2000	3.0	78	0.4	4.6
2005	2.8	66	0.4	4.6
2010	3.0	66	0.4	5.2
2013	2.9	54	0.5	5.5
2014	**3.1**	**56**	**0.5**	**5.6**
1990-2014 period [1)]	-0.7	-44	0.0	1.5
1990-2014 period [2)]	-18%	-44%	12%	38%

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

Between 1990 and 2014, NH_3 emissions from Manure management reduced by 44%. The combination of higher production rates per animal and quotas, resulted in a decreasing trend in animal numbers (although in recent years they have rather stabilised). An ongoing decrease in N excretions per animal due to lower dietary crude protein and an increase in low emission housing, has added to the effect, although N excretions in 2014 were slightly higher compared to 2013.

NO_x emissions from denitrification processes in animal manure are a source not considered when the National Emission Ceiling (NEC) for 2010 was set. However, the NO_x emissions from animal housing and storage have been included in the national total, as they are deemed non-natural.

NH_3 emissions resulting from the application of animal manure or during grazing are considered to be related to land use and are not reported under 3B Manure management, but included in 3D Crop production and agricultural soils.

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) for a full overview of subcategories and years). For horses, an estimated 300 000 additional animals are 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, but are reported under the source category Other (6A).

Table 6.2 Animal numbers over the 1990–2014 period (in 1 000 heads)

Animal type	**1990**	**1995**	**2000**	**2005**	**2010**	**2013**	**2014**
Cattle	4 926	4 654	4 069	3 797	3 975	3 999	4 068
- dairy cattle	1 878	1 708	1 504	1 433	1 479	1 553	1 572
- non-dairy cattle	3 048	2 946	2 565	2 364	2 497	2 446	2 496
Sheep	1 702	1 674	1 305	1 361	1 130	1 034	959
Swine (*1 000)	13.9	14.4	13.1	11.3	12.3	12.2	12.2
Goats	61	76	179	292	353	413	431
Horses[1]	70	100	117	133	141	129	126
Mules and asses	NO	NO	NO	NO	1	1	1
Poultry (*1 000)	94.9	91.6	106.5	95.2	103.4	99.4	104.7
- laying hens (*1 000)	51.6	45.7	53.1	48.4	56.5	53.5	56.0
- broilers (*1 000)[2]	43.3	45.9	53.4	46.8	46.9	45.9	48.7
Other animals[3]	1 340	951	981	1 058	1 261	1 342	1 324

[1] excluding privately owned horses
[2] including turkeys and ducks
[3] rabbits and furbearing animals
Source: CBS, 2015

Distributions are made of animals over the various housing types, using information from the agricultural census and environmental permit data, if required (Van Bruggen *et al.*, 2015). For instance, the agricultural census only gives implementation grades of abatement techniques in a very general manner (e.g. floor/cellar adaptation or air scrubber). Further subdivision is possible by using detailed information from environmental permits.

Furthermore, the N excretions per animal are calculated annually by the Working group on Uniformity of calculations of Manure and mineral data (WUM). The historic data was last recalculated on the most recent insights in 2009 based (CBS, 2012a), and is supplemented on a yearly basis by means of the publication series 'Dierlijke mest en mineralen' (Animal manure and minerals, in Dutch) ensuring consistency. Due to a higher N-content of grass silage the N excretion per animal in ruminant categories is slightly higher than in 2013.

From the N excretion data, using the method described in Vonk *et al.* (2015), the excretion of TAN and NH_3 emission factors expressed as % of TAN, are derived for several (sub-)categories of animals. The method also uses corresponding emission factors for N_2O, NO_x and N_2, based on the gross N excretion in each housing type. The Tier 1 default N_2O emission factors from the IPCC 2006 Guidelines are applied, which were also used for NO_x following research that set the ratio of these losses to 1:1 (Oenema *et al.*, 2000). According to the same study, losses in the form of N_2 were set to a factor 5 (solid manure) or 10 (liquid manure) of the NO_x factors, all expressed as percentages of the total N available.

After subtracting the amounts of N emitted in animal housing and considering the implementation grades of the different housing systems, NH_3 emissions from manure storage outside animal housing facilities are calculated (Vonk *et al.*, 2015). However, separate emissions of N_2O, NO_x and N_2 from outside storages are not being estimated, since emission factors used for animal housing already include losses during storage.

Implied emission factors for Manure management in kg NH_3/animal, are calculated for the NFR (main) categories as depicted in Table 6.3 below.

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

Animal type	**1990**	**1995**	**2000**	**2005**	**2010**	**2013**	**2014**
Cattle	6.6	6.7	5.7	6.3	6.7	6.5	7.1
- dairy cattle	11.6	11.8	9.6	11.4	11.8	10.9	11.7
- non-dairy cattle	3.5	3.7	3.4	3.2	3.7	3.7	4.2
Sheep	0.4	0.4	0.4	0.2	0.1	0.1	0.1
Swine	3.5	3.4	2.7	2.2	1.9	1.2	1.1
Goats	1.6	1.6	1.4	1.2	1.2	1.1	1.2
Horses	4.5	4.5	4.5	4.3	4.0	4.0	4.0
Mules and asses	NO	NO	NO	NO	2.8	2.8	2.8
Poultry	0.17	0.18	0.16	0.15	0.13	0.11	0.10
- laying hens	0.19	0.20	0.19	0.17	0.16	0.15	0.15
- broilers[1]	0.15	0.16	0.13	0.12	0.09	0.06	0.05
Other animals	0.40	0.38	0.32	0.28	0.22	0.22	0.23

[1] including turkeys and ducks

Generally the emission per animal has reduced due to improved efficiency. In cattle however this has been offset by an increased living space per animal, improving animal welfare. Although this was also the case in swine and poultry, emission reduction techniques like air scrubbers and manure drying more than countered the effect. The fluctuating N-content of grass silage also causes changes in the IEF of cattle.

The emission factors for PM coming from animal housing are based on a measurement programme conducted by Wageningen UR Livestock Research between 2007 and 2009. For a range of 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', in Dutch with English summary and available through www.asg.wur.nl). For housing types not included in the studies, emission factors were estimated on housing characteristics and space per animal proportional to the studies housing types. Where emission factors had to be derived within animal categories (e.g. laying hens under and over 18 weeks of age), this was done on the basis of the excreted amount of phosphorus (P). An overview of the resulting emission factors is presented in Vonk *et al.*, 2015. This is to be amended in future publications following the recalculations as presented in section 6.2.8.

6.2.5 *Methodological issues*

Emissions of NH_3 and NO_x from animal manure in animal houses and storage are calculated using the National Emission Model for Agriculture (NEMA) at a Tier 3 level. The total ammonia nitrogen (TAN) in manure was estimated, based on faecal digestibility of the nitrogen in various feed components within the rations. In the calculation the organic N mineralisation/immobilisation and excretion on pasture land during grazing are taken into account. From this, NH_3 emissions were calculated according to the method described in Vonk *et al.* (2015).

Other N losses in N_2 and N_2O from animal houses were also calculated and subtracted from the N excretion, before multiplying with the fraction outside storage. During storage again NH_3 is emitted. The sum of emissions from both animal housing and manure storage per livestock type are reported under their respective subcategories in sector 3B Manure management (losses in the form of N_2O, NO and N_2 from outside storages are accounted for in the emission from animal houses). After deduction of net export and processing and incineration of manure, the amount of N available for application is calculated. Emissions following manure application and from grazing are allocated to sector 3D Crop production and agricultural soils, to be described in Section 6.3.

Figure 6.1 presents a schematic overview of NH_3 and NO_x emissions in relationship to N flows, including their allocation to source categories. Table 6.3 provides a summary of associated N flows (in Gg N), over the 1990–2014 period for the sector of Manure management.

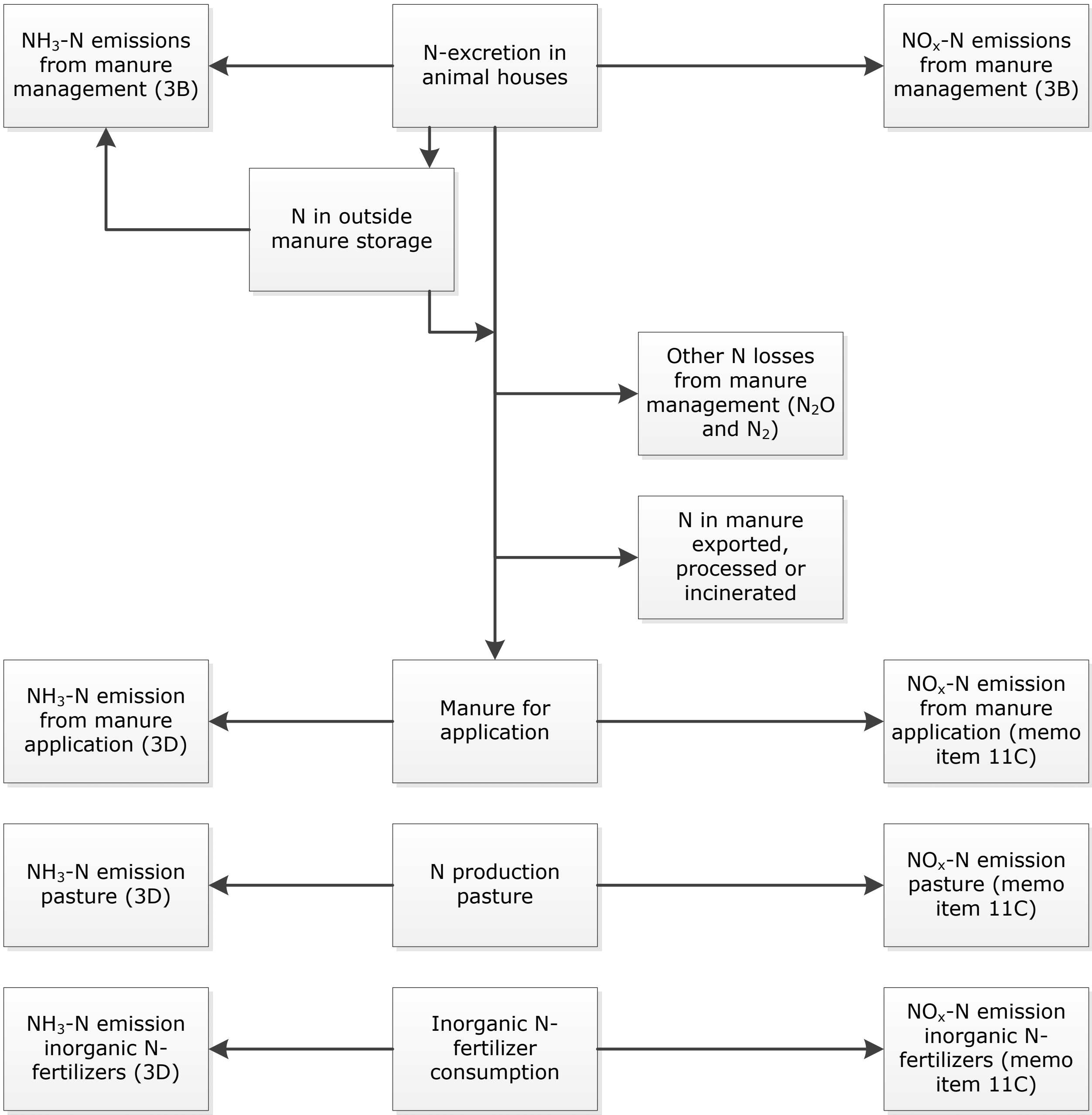

Figure 6.1 Nitrogen flows in relationship to NH_3 and NO_x emissions

Table 6.4 Nitrogen flows related to NH_3 and NO_x emissions in NFR sector 3B Manure management (in Gg N)

	1990	1995	2000	2005	2010	2013	2014	Change 2014 - 1990
3B Manure management								
Nitrogen excretion in animal housing	506.5	508.1	424.5	385.5	416.0	412.3	426.0	-16%
of which in solid manure	95.7	97.4	87.1	80.6	89.3	85.2	87.3	-9%
of which in liquid manure	410.8	410.7	337.3	304.9	326.7	327.1	338.7	-18%
NH_3-N emissions from animal housing	81.8	80.1	63.1	53.1	53.1	43.5	45.2	-45%
NO_x-N emissions from animal housing	1.1	1.1	0.9	0.8	0.9	0.9	0.9	-18%
N_2O-N emissions from animal housing	1.1	1.1	0.9	0.8	0.9	0.9	0.9	-18%
Other N losses from animal housing[1]	9.5	9.5	7.8	8.4	10.8	16.1	16.6	75%
Nitrogen in manure used outside agriculture[2]	9.6	12.5	6.9	14.7	5.5	15.3	14.1	47%
Nitrogen in exported/incinerated manure	12.2	28.4	24.4	34.1	58.3	60.7	64.6	428%
Available manure for application (to 3D)	391.1	375.5	320.5	273.6	286.6	275.0	283.6	-27%
(N excretion in animal housing – total N losses in animal housing – exported/incinerated manure)								

[1] includes N_2-N losses from animal housing, N in the washing liquid of air scrubbers and N produced in the free-range of poultry.

[2] hobby farms, application on nature terrains and use by private parties; emissions are allocated to sector 6A Other.

The N excreted by animals decreased considerably over the 1990–2014 period, while the manure exported or incinerated increased fourfold. Other N losses from animal housing and nitrogen in manure outside agriculture also increased, leading to 30 percent less nitrogen in manure to be applied on agricultural soils. Since the other N losses from animal housing also comprise washing liquid of air scrubbers which is used as an inorganic N-fertilizer, some emissions shifted to category 3D Crop production and agricultural soils. The same applies for nitrogen in manure used outside agriculture, as emissions are allocated to category 6A Other.

Particulate matter emissions from agriculture mainly consist of animal skin, manure, feed and bedding particles originating in animal housings. The general input data used for calculating the emissions are animal numbers and housing systems taken from the annual agricultural census and environmental permits. For several animal categories, country-specific emission factors are available (see Subsection 6.2.4).

6.2.6 *Uncertainties and timeseries consistency*

A propagation of error analysis on NH_3 emissions was completed this year. Using reassessed uncertainty estimates of input data (CBS, 2012) and expert judgment, an uncertainty of 16% in the total NH_3 emission from Manure management has been calculated. Including the emissions in sector 3D Crop production and agricultural soils, the combined uncertainty in NH_3 emission becomes 20%. It will be evaluated whether a Monte Carlo-analysis could improve the estimate further by taking dependent variables into account.

As annual censuses are conducted the same way for many years (even decades), and the same calculations were used for the whole series, the timeseries consistency is very good. Since last year a web-based application is implemented for the agricultural census. This enables more specific questioning and consequently enhances the obtained data.

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

6.2.8 Source-specific recalculations
Some minor error corrections were made in the Manure management of dairy cattle, regarding the ratios of excretion counted towards the liquid and solid system. As a result NH_3 emissions of 3B1a dairy cattle increased by 0.2 Gg in 1990, gradually changing over into a decrease of 0.4 Gg in the year 2013.

Calculations of PM emissions have been reconsidered, in order to improve the consistency with the general calculation method used by NEMA. This led to several corrections, most notably in the earlier years of the time-series for laying hens. As ground housing was not considered, emissions were underestimated by up to 70% in the years until 1997. On the other hand emissions of breeding swine were overestimated by about 20% for the whole time-series, as piglets before weaning had been double-counted. Overall PM_{10} emissions increase by 0.2 Gg in 1990 and decrease by 0.2 Gg in 2013.

For $PM_{2.5}$ the changes in emissions follow the same pattern, but are much smaller both in relative and absolute terms. Particulate matter emissions from animal houses tend to be of the coarse fraction, and as a result $PM_{2.5}$ EFs vary much less than those for PM_{10} between the housing systems distinguished.

6.2.9 Source-specific planned improvements
An update of the NH_3 emission factors for the animal housing of poultry is expected for the next submission. This will complete the revision of emission factors, after the earlier recalculations reported on in the IIR 2014 (dairy cattle) and IIR 2015 (non-dairy cattle and swine).

In line with the UNECE stage 3 review of the Informative Inventory Report 2015 the emissions of turkeys and ducks, which are currently included in the emissions of broilers, will be reported separately in the IIR 2017.

6.3 Crop production and agricultural soils

6.3.1 Source category description
This category consists of all emissions related to the agricultural use of land:
3Da1 Inorganic N-fertilizers (includes also urea application)
3Da2a Animal manure applied to soils
3Da2b Sewage sludge applied to soils
3Da2c Other organic fertilizers applied to soils (including compost)
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
3F Field burning of agricultural residues
3I Agriculture other

Emissions within the categories 3Db (Indirect emissions from managed soils), 3Dd (Off-farm storage, handling and transport of bulk agricultural products) and 3F (Field burning of agricultural residues) do not occur in the Netherlands, and no emissions have been allocated to category 3I (Agriculture other). Category 3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products 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 allotted to category 3De Cultivated corps and Zn emissions to category 3Df Use of pesticides.

6.3.2 *Key sources*

Animal manure applied to soils (3Da2a) is the largest key source for NH_3 with 29% of the national total. Inorganic N-fertilizers (3Da1) also is one of the key sources of NH_3 with a contribution of 10.2%.

Farm-level agricultural operations including storage, handling and transport of agricultural products (3Dc) is a key source for PM_{10} emissions at 2.3% of the national total.

6.3.3 *Overview of shares and trends in emissions*

Table 6.5 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 originates from the category of Crop production and agricultural soils (3D).

Table 6.5 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	**0.1**	**0.2**	**250**	**0.1**	**0.8**	**0**
1995	0.3	0.2	112	0.1	0.8	0
2000	0.3	0.2	85	0.1	0.8	0
2005	0.3	0.2	72	0.1	0.8	6.8
2010	0.3	0.2	56	0.1	0.8	4.5
2013	0.3	0.2	57	0.1	0.7	4.1
2014	**0.3**	**0.2**	**59**	**0.1**	**0.7**	**4.4**
1990-2014 period [1)]	0.2	0.0	-191	0.0	0.0	4.4
1990-2014 period [2)]	147%	12%	-76%	-4%	-5%	

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

Emissions of NH_3 decreased with 76% between 1990 and 2014, with an initial sharp decrease in the 1990-1995 period. This was mainly the result of mandatory changes in application methods that came into force in the early nineties (i.e. incorporation of the manure into the soil instead of spreading it over the surface). Also the use of inorganic N-fertilizer has been decreasing over the years, following policy measures aimed at reducing nutrient supply to soils.

The particulate matter emissions reported in this source category originate from inorganic N-fertilizer use, but also pesticides, supply of concentrate feed to farms, haymaking and crop harvesting contribute to the reported emissions of PM_{10} and $PM_{2.5}$.

Since NO_x emissions from Crop production and agricultural soils are not accounted for under the NEC, they are reported as a memo item under the category of Other natural emissions (11C). NO_x emissions from animal manure application, inorganic N-fertilizer use and grazing are thus included in this category (see also Subsection 6.2.3). Emissions reported under category 3D therefore originate from the application of sewage sludge and compost.

6.3.4 *Activity data and (implied) emission factors*

After subtracting the amounts of manure removed from agriculture, exported or incinerated, the remaining amount was allocated to pasture and arable land. Implementation grades of application techniques were derived from the agricultural census, and associated ammonia emission factors have been reported in Vonk *et al.*, 2015. NO_x emissions related to manure application were being 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 sold, corrected for non-agricultural use. Several types of inorganic N-fertilizer were distinguished – each with their own specific ammonia emission factor (Vonk *et al.*, 2015). These emission factors were used in the NEMA model calculations of NH_3 emissions from inorganic N-fertilizers.

The NEMA calculations also included the associated NO_x and PM emissions, using EMEP default emission factors for the former, and fixed annual amounts for the latter. PM from other agricultural processes (e.g. the supply of concentrate feed to farms, use of pesticides and haymaking), were also estimated using fixed amounts. Crop harvesting was calculated based on acreage from the agricultural census and EMEP default emission factors.

Calculations of the emissions from crop residues and crops ripening are based on the research of De Ruijter *et al.* (2013). The decrease seen in this category is mainly the result of reduced renewal of grassland. Emissions from sewage sludge application reduced strongly as usage dropped by a factor five and incorporation into the soil became mandatory. Compost use and thus associated NH_3 emission tripled over the 1990-2014 period, however this is still a relatively small source. For compost use and sewage sludge application also NO_x emissions are being calculated, using the default EMEP emission factor.

Implied emission factors for Crop production and agricultural soils in kg NH_3/kg N supply, are calculated for the NFR (main) categories as depicted in Table 6.5 below.

Table 6.6 Implied emission factors for NH_3 from 3D Crop production and agricultural soils (in kg NH_3/kg N supply)

Supply source	**1990**	**1995**	**2000**	**2005**	**2010**	**2013**	**2014**
Inorganic N-fertilizers	0.04	0.04	0.04	0.05	0.05	0.07	0.07
Animal manure	0.54	0.20	0.19	0.19	0.14	0.13	0.14
Sewage sludge	0.29	0.08	0.09	0.10	0.10	0.09	0.09
Other organic fertilizers (including compost)	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Urine and dung deposited by grazing animals	0.09	0.09	0.04	0.04	0.03	0.03	0.03
Crop residues	0.09	0.09	0.07	0.06	0.08	0.08	0.08

Implied emission factors for animal manure and sewage sludge application dropped considerably between 1990 and 1995, due to mandatory incorporation into the soil becoming effective during that period. The reduction in Urine and dung deposited by grazing animals, can mainly be allotted to less grazing cattle (producing liquid manure, where sheep and horses produce solid manure with lower emissions).

Table 6.7 NH_3 emissions (Gg) in each stage of the manure management chain for the base year 1990 and current year 2014, per NFR category.

NFR	**Livestock**	**Animal housing**			**Outside storage**			**Application**			**Pasture**		
code	**category**	**1990**	**2014**	**%**	**1990**	**2014**	**%**	**1990**	**2014**	**%**	**1990**	**2014**	**%**
3B1a	Dairy cattle	19.5	13.6	-30%	2.2	0.5	-78%	89.4	20.0	-78%	9.0	0.9	-90%
3B1b	Non-dairy cattle	9.1	10.0	11%	1.5	0.4	-72%	46.3	9.1	-80%	7.0	0.8	-89%
3B2	Sheep	0.5	0.1	-79%	0.1	0.0	-83%	0.8	0.1	-81%	1.7	0.2	-87%
3B3	Swine	48.6	13.5	-72%	0.6	0.4	-36%	52.8	6.8	-87%	NA	NA	
3B4a	Buffalo	NO	NO		NO	NO		NO	NO		NO	NO	
3B4d	Goats	0.1	0.4	448%	0.0	0.1	347%	0.2	0.9	341%	NA	NA	
3B4e	Horses	0.3	0.4	65%	0.0	0.1	33%	0.0	0.1	33%	0.2	0.1	-31%
3B4f	Mules and asses	NO	0.0		NO	0.0		NO	0.0		NO	0.0	
3B4gi	Laying hens	9.2	6.8	-25%	0.6	1.4	150%	13.6	0.4	-97%	NA	NA	
3B4gii	Broilers	5.8	2.3	-60%	0.8	0.2	-74%	6.1	0.9	-85%	NA	NA	
3B4giii	Turkeys	IE	IE		IE	IE		IE	IE		NA	NA	
3B4giv	Other poultry	NO	NO		NO	NO		NO	NO		NO	NO	
3B4h	Other animals	0.5	0.3	-45%	0.0	0.0	-30%	1.3	0.2	-86%	NA	NA	
	TOTAL	93.5	47.6	-49%	5.8	3.1	-47%	210.6	38.5	-82%	17.8	2.0	-89%

6.3.5 *Methodological issues*

NH_3, NO_x and PM emissions from the use of inorganic N-fertilizer were calculated in the NEMA model (see Subsection 6.2.5 for a general description). Specific activity data and emission factors related to inorganic N-fertilizer use are discussed in the previous Section.

Table 6.6 provides a summary of associated N flows (in Gg N), over the 1990–2014 period for Crop production and agricultural soils.

Table 6.8 Nitrogen flows related to NH_3 and NO_x emissions in NFR sector 3D Crop production and agricultural soils (in Gg N)

	1990	1995	2000	2005	2010	2013	2014	Change 2014 - 1990
3D Agricultural soils								
Available manure for application (from 3B)	391.1	375.5	320.5	273.6	286.6	275.0	283.6	-27%
NH_3-N emissions from manure application	173.9	62.9	51.1	42.3	32.1	30.3	32.1	-82%
NO_x-N emissions from manure application	4.7	4.5	3.8	3.3	3.4	3.3	3.4	-27%
N_2O-N emissions from manure application	1.6	3.2	2.8	2.4	2.5	2.4	2.5	59%
Nitrogen excretion on pasture land	188.0	171.9	124.6	93.2	73.8	60.6	60.8	-68%
NH_3-N emissions excretion on pasture land	14.7	13.2	4.2	2.7	2.0	1.6	1.6	-89%
NO_x-N emissions excretion on pasture land	2.3	2.1	1.5	1.1	0.9	0.7	0.7	-69%
N_2O-N emissions excretion on pasture land	6.2	5.7	4.1	3.1	2.4	1.9	1.9	-69%
Nitrogen from fertilizer application[1]	395.0	388.4	322.1	261.8	205.2	191.7	191.7	-51%
NH_3-N emissions from fertilizer application	11.5	11.5	9.9	10.7	8.4	11.2	11.2	-2%
NO_x-N emissions from fertilizer application	4.7	4.7	3.9	3.2	2.5	2.4	2.4	-49%
N_2O-N emissions from fertilizer application	5.1	5.0	4.2	3.4	2.7	2.6	2.6	-49%
Nitrogen from compost application	2.0	4.0	5.2	4.9	5.4	5.8	5.8	190%
NH_3-N emissions from compost application	0.1	0.2	0.3	0.3	0.3	0.4	0.4	190%
NO_x-N emissions from compost application	0.0	0.0	0.1	0.1	0.1	0.1	0.1	190%
N_2O-N emissions from compost application	0.0	0.0	0.0	0.0	0.0	0.0	0.0	190%
Nitrogen from sewage sludge application	5.0	1.5	1.5	1.2	0.9	1.2	1.2	-76%
NH_3-N emissions from sewage sludge application	1.2	0.1	0.1	0.1	0.1	0.1	0.1	-93%
NO_x-N emissions from sewage sludge application	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-76%
N_2O-N emissions from sewage sludge application	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-47%
Nitrogen from crop residues	44.5	42.4	43.7	35.9	27.9	25.7	26.8	-40%
NH_3-N emissions from crop residues	3.3	3.1	2.4	1.8	1.9	1.8	1.8	-45%
N_2O-N emissions from crop residues	0.6	0.6	0.6	0.5	0.3	0.3	0.3	-51%
NH_3-N emissions from ripening crops	1.5	1.5	1.5	1.5	1.5	1.5	1.5	0%

[1] including N in the washing liquid of air scrubbers.

N in manure available for application decreased considerably over the 1990-2014 period (see further Subsection 6.2.5). From this amount a much smaller proportion nowadays volatilizes as NH_3 compared to the first years of the time-series, as a result of mandatory incorporation into the soil during or shortly after application. On the other hand emissions of the greenhouse gas N_2O (with a high global warming potential) have increased considerably, since formation of this compound is enhanced under anaerobic conditions.

Grazing emissions decreased over the time-series with changing management, especially in dairy cattle. As they tend to be kept indoors for a longer part of the day or kept indoors all day long, the N excreted on pasture land dropped by 68%. Due to the lower N content of the rations, the emission factor (expressed as percentage of TAN) also decreases and total NH_3 emissions from grazing were reduced even more.

Inorganic N-fertilizer use reduced considerably between 1990 and 2014, as a result of maximum application standards. Emissions of NH_3 however remain at comparable level, as more urea with a relatively high emission factor is being used in recent years.

Small sources of PM emissions to be reported under category 3D, include applications of inorganic N-fertilizers and pesticides, the supply of concentrate feed to farms and haymaking. These are estimated using fixed estimates (Van der Hoek, 2002). For crop harvesting, EEA defaults are used to calculate emissions.

6.3.6 *Uncertainties and timeseries consistency*

A propagation of error analysis on NH_3 emissions was completed this year. Using reassessed uncertainty estimates of input data (CBS, 2012) and expert judgment, an uncertainty of 31% was calculated for NH_3 emissions following animal manure application, 16% for inorganic N-fertilizer use and 100% for grazing emissions. Total uncertainty in the ammonia emissions from sector 3D Crop production and agricultural soils then amounts to 30%. Including the emissions in sector 3B Manure management, the combined uncertainty in NH_3 emission becomes 20%. It will be evaluated whether a Monte Carlo-analysis could improve the estimate further by taking dependent variables into account.

As annual censuses are performed the same way for many years (even decades), and the same calculations were used for the whole series, the timeseries consistency is very good. This year a web-based application will be implemented for the agricultural census, which will enable more specific questioning and thus enhance the data being obtained.

6.3.7 *QA/QC and verification*

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

6.3.8 *Recalculations*

The agricultural census provided new information on the implementation grades of manure application techniques. As the previous data used from 2008 on was not deemed to be very accurate, it was decided to recalculate emissions from that point. Emissions in sector 3Da2a Animal manure applied to soils thus have been adjusted by -2.8 to -3.4 Gg NH_3 for these years. This decrease would be a little more if corrected for the increase in application emissions in dairy cattle following the recalculation already mentioned in section 6.2.8. As a result of a change in the allocation towards liquid and solid manure the emission following application decreases 0.4 Gg in 1990 changing over into an increase of around 0.1 Gg in recent years.

The calculation of the EF used for Urine and dung deposited by grazing animals, was reconsidered following an international review on ammonia emission and deposition in the Netherlands (Sutton *et al.*, 2015). Calculated as a function of the average N content in the ration, previously it was capped off at a minimum value of 2.6% of the TAN based on statistical analysis. This has been changed into 4.0%, the lowest value measured. Years from 2003 (with the exception of 2005) were recalculated, with emissions from 3Da3 Urine and dung deposited by grazing animals increasing by between 0.3 and 0.7 Gg NH_3.

NH_3 emissions from crop residues were taken up in last year's inventory for the first time. For this submission, the calculations have been harmonized with those of the greenhouse gas N_2O leading to changes in both time-series. For ammonia, emissions were adjusted by -0.2 Gg in 1990 and -0.1 Gg in 2013. Following the recalculation in manure management of dairy cattle, the NO_x time-series for the application of animal manure also changed slightly. Furthermore, negative amounts of laying hen manure available in 2012 and 2013 were corrected and set to zero. Even combined, the effect of the latter two corrections however is at maximum 0.04 Gg NO_x (2012).

6.3.9 Planned improvements

The current inventory report only includes NO_x emissions from housing and storage in the reported national totals. NO_x emissions from the application of inorganic N-fertilizer or animal manure and manure produced on pasture were also assessed, but these are reported as a memo item under the category of natural emissions (11C). This categorisation will be reconsidered as soon as emission ceilings also account for this new emission source.

In recent years ammonia emissions from the use of inorganic N-fertilizers increased due to an increased amount of urea fertilizer applied to soils. New inorganic fertilizers based on urea are developed and the use of these fertilizers increased. Some of these urea fertilizers are coated to reduce ammonia emissions. Other new fertilizers are applied liquid, which also reduces ammonia emissions. In 2016 a study will be conducted on the emission factors of these new urea fertilizers.

Research into new manure processing techniques is almost complete. Anaerobic digestion and solids separation do not play a major role in the Netherlands yet, but their importance is rapidly increasing. A new methodology to estimate these (reductions of) emissions is expected to be available for the next submission.

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 (1A5a)).

Composting and anaerobic digestion (5B)
Emissions from this source category comprise those from facilities for 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, these emissions are allocated to the energy sector (source category Small combustion (1A4)).

Waste incineration (5C)
Emissions from this source category comprise 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, among others. 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 and Scrap fridges/freezers”.

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.

Emissions have reduced since 1990 for most pollutants. However, with the exception of NMVOS all pollutants show lower emissions in 1990. For NH_3 this is mainly caused by an increase of industrial composting of household organic waste in the years 1990-1994. For all other pollutants this is caused by a combination of increased activity and gradual implementation of abatement technology.

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	0.006	0.006	0.006	0.06	0.00
1995	1.3	0.31	0.013	0.010	0.012	0.07	0.30
2000	1.0	0.32	0.007	0.007	0.007	0.10	0.27
2005	0.7	0.34	0.006	0.006	0.006	0.09	0.25
2010	0.5	0.25	0.003	0.003	0.003	0.05	0.09
2013	0.4	0.24	0.002	0.001	0.001	0.01	0.02
2014	0.4	0.24	0.003	0.001	0.001	0.01	0.02
1990-2014 period 1)	-1.1	0.19	-0.003	-0.005	-0.005	-0.04	0.02
1990-2014 period 2)	-73%	417%	-54%	-85%	-85%	77%	-

1) Absolute difference

2) Relative difference to 1990 in %

7.1.3 *Methodological issues*

There are no specific methodological issues.

7.1.4 *Uncertainties and timeseries consistency*

No accurate information was available for assessing uncertainties about 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*

There were no source-specific recalculations in this sector.

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 relative small amount is flared. As such the emissions from this source are included in the energy sector (source category Other Stationary (1A5a)).

In this source category all waste landfill sites in the Netherlands are included that have been managed and monitored since 1945, and concerns both historical and current public landfill, 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 wich calculates the degradation of DOC (degradable organic carbon) in the waste. From this the amount of methane is calculated using a methane conversion factor (table 7.2). Its assumed that 10% of the non-extrated methane wil be oxidized in the top layer of the landfill.

Tabel 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 1989. from 2000 reducing to 0.5 in 2005. thereafter constant 0.5	[Oonk *et al*., 1994] [Rijkswaterstaat 2014]
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] [Rijkswaterstaat 2014]
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 CH4 in landfill gas)	0.6 from 1945 through 2000; from 2000 reducing to 0.5 in 2005. thereafter constant 0.5	[Oonk *et al.*, 1994] [Rijkswaterstaat 2014]
MCF(x) = Methane correction factor for management	1	

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 the waste. A small part is produced as a by-product during 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 0.38 Gg in 1990 and 2014, 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 given 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 are 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		**Landfill gas**
	Flared	**Gas engine**	
Total hydrocarbons (incl. methane)			0.407415 kg/m^3
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_2 (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 C_xH_y – 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

Compound	Emission factor and unit		
	Combusted landfill gas		Landfill gas
	Flared	Gas engine	
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 comprise 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.

As of 1994 it’s 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 to the air. The material in the biobed is renewed periodically.
The processes for organic horticulture waste are carried out mostly in open air in rows which are regularly shifted to optimism 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_2 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 2014 respectively 0,236 Gg, 0,067 Gg and 0.004 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 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, or the literature cannot be considered relevant due to the clearly differing operational methods used in the Netherlands.

Emissionfactors for 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 emissionfactors for composting of other organic waste are based on an Austrian study (UBA, 2011). These are seen as the best available data for installations comparable with installation in the Netherlands.

The following emission factors have been used used:

- NH_3 from fermentation, 2.3 g per ton of biodegradable and other organic waste;
- NO_x from fermentation, 180 g per ton of biodegradable and other organic waste;
- SO_2 from fermentation, 10.7 g per ton of biodegradable and other organic waste.

The processed amount of other organic waste is based on the declared amount with 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 with the treatment composting. Table 7.4 gives an overview of the amounts composted.

LMA has no information on 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 ton/year. Just as the separate collection of biodegradable waste, the other organic waste also started in the ‘90’s thus the amount is assumed null ton in 1990 and increased linear to 1996 when the estimated amount is 250,000 ton. From 2000 onwards there is a slow decrease in the processed amounts of organic household waste. This is regarded to be an effect of a smaller share of garden waste in the total amount, due to the increase in paved surface of home gardens.

Table 7.4 Overview of composted organic waste

Year	Amounts of composted organic wastes (tonnes)		
	Horticulture	Household (garden, fruit and vegetable)	Total
1990	0.0	45.6	45.6
1995	31.4	282.0	313.4
2000	20.7	299.7	320.4
2005	72.5	265.2	337.8
2010	40.7	213.5	254.2
2013	45.7	189.9	235.7
2014	45.7	189.9	235.6

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 generated heat is 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 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)).
Because of a ban on both other (5C1bvi) and open waste burning (5C2), these emission sources do not occur in the Netherlands.

7.4.2 Key sources

The relevant substances that are emitted during the cremation of human remains are mercury, dioxin, PM_{10} and $PM_{2.5}$.
Up to 2010, cremations were a relevant key source for Hg. By 2012, all cremation centres complied with the Dutch Atmospheric Emissions Guideline (NeR) and were 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 relative low. Therefore, 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 publicised, online, by the Dutch National Association of Crematoria (LVC), on www.lvc-online.nl (LVC, 2014).

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

* Interpolation using year 2011

** Calculation based on an accurate list of crematoria under the NeR (LVC, 2014)

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

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

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

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 (Elzinga, 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, 1993).

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

7.5 Waste-water handling (5D)

WWPTs produce methane, among other things. 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.

Sludge spreading
WWTPs produce sewage sludge. In the Netherlands, when this sewage sludge meets the legal environmental quality criteria, it can be used in undried form as fertilizer in agriculture (Legislation on the use of fertilizers in the Netherlands). The emissions from this source are, in line with the guidebook, 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 mechanical dried at the WWTP. The dried sludge is then transported to one of the waste recycle/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 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 special 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 specialised recycling companies. During the recycling process, a small amount of NMVOCs is emitted from the fridges and freezers insulating layer.

7.6.2 *Overview of shares and trends in emissions*
Emission levels in this source category are relative low. Therefore, 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 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 Subsection 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 gr 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 publicised online, on www.wecycle.eu. In the past, these data were supplied by the NVMP (Dutch Foundation Disposal Metalelectro Products). The NVMP has 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.

8 Other

This includes emissions from privately owned horses (stable and storage only), human transpiration and respiration, and from manure sold and applied to private properties or nature parks. Category 6A describes a key source for the following components: NH_3 (8.6%) as percentage of national total in 2014. Please note that the Netherlands has included these NH_3 sources in the national total, whereas other parties have not. There is no clear guidance on whether or not these emissions should be included in the national total for NH_3.

9 Recalculations and other changes

9.1 Recalculations of certain elements of the 2015 inventory report

Compared to the 2015 inventory report (Jimmink *et al.*, 2015), several methodological changes were implemented in the Pollutant Release and Transfer (PRTR) system:

- The Dutch energy statistics were recalculated for the complete time series. The reason for this recalculation was to further streamline the Dutch energy statistics with the international requirements and definitions.
- For road transport the emissions are as of this submission calculated and reported based on the fuel sold. This correction resulted in significant emission changes for many compounds
- New activity data on the emissions from manure application were used to recalculate the ammonia emissions as of 2008.

The above changes are elaborated in Chapter 4 and affected the emissions of all relevant pollutants in all reported years.

9.2 Improvements

9.2.1 Included improvements

During the compilation of the previous IIR minor errors were detected, which have been repaired in this inventory report. The following significant improvements were carried out during the improvement process of the Dutch PRTR:

- As every year, emission factors in the road transport sector were recalculated based on the updated VERSIT+ LD model (Ligterink and De Lange, 2009).
- Update of the model for the calculation of emissions from non-road transport.

9.2.2 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. To address these issues, the inventory sector-experts were consulted regarding the necessary actions.
The issues dealing with technical aspects of the inventory are mostly corrected in this inventory report. The remaining actions with respect to content will be prioritised and planned for implementation in the inventories of 2017 and 2018. Appendix 2 gives a quick view on the planning regarding the actions on the issues from the stage 3 review.

9.3 Effects of recalculations and improvements

Tables 9.1 to 9.3 give the changes in total national emission levels for the various compounds, compared to the inventory report of 2014.

Table 9.1 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010 and 2013

National total		NO_x (as NO_2) Gg NO_2	NMVOC Gg	SO_x (as SO_2) Gg SO_2	NH_3 Gg	$PM_{2.5}$ Gg	PM_{10} Gg	TSP Gg	BC Gg	CO Gg
1990	IIR 2015	573.7	483.1	191.8	372.5	46.4	69.6	93.1	13.6	1140.6
	IIR 2016	603.1	489.5	193.1	372.1	50.2	73.5	97.0	16.7	1143.5
Difference	absolute	29.4	6.4	1.4	-0.4	3.8	4.0	3.9	3.0	2.9
	%	5.1%	1.3%	0.7%	-0.1%	8.1%	5.7%	4.2%	22.2%	0.3%
2000	IIR 2015	395.4	238.9	73.1	181.7	25.5	40.2	48.7	8.9	754.5
	IIR 2016	419.0	242.6	73.3	181.5	27.6	42.3	50.8	10.5	752.4
Difference	absolute	23.5	3.7	0.3	-0.2	2.1	2.1	2.1	1.6	-2.1
	%	6.0%	1.6%	0.4%	-0.1%	8.2%	5.3%	4.4%	17.7%	-0.3%
2010	IIR 2015	274.2	158.0	34.1	143.7	15.2	29.0	35.8	4.6	679.0
	IIR 2016	299.5	165.1	33.8	140.4	16.2	29.8	36.6	5.4	680.8
Difference	absolute	25.3	7.1	-0.3	-3.4	1.0	0.9	0.8	0.8	1.8
	%	9.2%	4.5%	-0.9%	-2.4%	6.4%	3.0%	2.4%	17.9%	0.3%
2013	IIR 2015	239.6	149.7	29.9	133.8	12.8	26.8	34.8	3.5	620.8
	IIR 2016	259.6	147.9	29.6	130.4	13.4	27.1	35.3	4.0	596.9
Difference	absolute	20.0	-1.7	-0.3	-3.4	0.7	0.4	0.5	0.5	-23.8
	%	8.3%	-1.2%	-1.1%	-2.5%	5.2%	1.3%	1.4%	14.7%	-3.8%

The recalculations in the transport sector accounted for almost all changes in the emissions shown in above table. The changes in NH_3 emissions from 2008 onwards originate from the recalculations of the manure application emissions in the agricultural sector.

Changes in the 2013 figures are also the result of using improved activity data for that year.

Table 9.2 Differences in the total national emission level between the current and previous inventory reports for the years 1990, 2000, 2010 and 2012 (metals)

National total		**Pb** Mg	**Cd** Mg	**Hg** Mg	**As** Mg	**Cr** Mg	**Cu** Mg	**Ni** Mg	**Se** Mg	**Zn** Mg
1990	IIR 2015	336.9	2.1	3.5	1.5	11.8	37.5	74.9	0.4	224.0
	IIR 2016	333.6	2.1	3.6	1.3	11.8	46.1	73.2	0.4	224.1
Difference	absolute	-3.3	0.1	0.1	-0.2	0.0	8.6	-1.6	0.0	0.1
	%	-1.0%	2.7%	1.8%	-12.4%	0.0%	23.0%	-2.2%	0.1%	0.0%
2000	IIR 2015	28.4	0.9	1.0	1.1	5.0	39.9	18.9	0.5	95.2
	IIR 2016	29.2	1.0	1.1	0.9	5.0	51.4	18.7	0.5	95.4
Difference	absolute	0.9	0.1	0.1	-0.2	0.1	11.4	-0.2	0.0	0.2
	%	3.0%	7.7%	7.6%	-19.3%	1.3%	28.6%	-1.3%	0.3%	0.3%
2010	IIR 2015	38.2	2.5	0.5	0.8	3.7	46.0	2.2	1.5	109.6
	IIR 2016	39.2	2.6	0.6	0.6	3.8	57.6	2.1	1.5	109.8
Difference	absolute	0.9	0.1	0.1	-0.2	0.1	11.5	-0.1	0.0	0.2
	%	2.5%	3.1%	15.7%	-27.6%	2.2%	25.0%	-4.8%	0.1%	0.2%
2013	IIR 2015	14.1	0.6	0.5	0.9	3.6	42.9	2.1	0.5	98.9
	IIR 2016	15.0	0.7	0.6	0.7	3.6	54.7	2.0	0.5	99.0
Difference	absolute	1.0	0.1	0.1	-0.2	0.1	11.7	-0.2	0.0	0.1
	%	7.0%	12.6%	15.9%	-24.7%	1.9%	27.4%	-7.6%	0.3%	0.1%

The major cause of the changes in the heavy metal emissions is the result of recalculations in the road transport sector. Furthermore the recalculation of the energy statistics resulted in recalculations for the metals Ni and Zn.

Table 9.3 Differences in the total national emission level between the current and previous inventory reports for the years 1990, 2000, 2010 and 2012 (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 2015	742.3	12.5	15.2	11.2	10.0	20.1
	IIR 2016	742.4	5.2	7.9	4.0	2.8	20.3
Difference	absolute	0.1	-7.2	-7.4	-7.2	-7.3	0.2
	%	0.0%	-58.0%	-48.4%	-64.4%	-72.3%	*1.0%*
2000	IIR 2015	31.0	1.8	1.7	0.9	0.9	31.0
	IIR 2016	31.0	1.8	1.7	0.9	0.8	31.0
Difference	absolute	0.0	-0.1	-0.1	-0.1	-0.1	0.0
	%	0.1%	-3.9%	-3.9%	-7.6%	-8.4%	0.1%
2010	IIR 2015	31.3	1.6	1.6	0.8	0.8	31.3
	IIR 2016	31.3	1.6	1.6	0.8	0.8	31.3
Difference	absolute	0.0	0.0	0.0	0.0	0.0	0.0
	%	0.1%	-0.3%	-0.1%	-0.7%	-0.5%	0.1%
2012	IIR 2015	24.9	1.6	1.5	0.8	0.8	24.9
	IIR 2016	24.9	1.6	1.5	0.8	0.8	24.9
Difference	absolute	0.0	0.0	0.0	0.0	0.0	0.0
	%	0.0%	-0.4%	-0.2%	-0.9%	-0.5%	0.0%

All changes shown in Table 10.3 for PCDD/F and PAH are due to recalculations of combustion emissions in the transport sector. Exception is an error correction in the PAH emission for the 1A1c category for the years 1990 to 1998, which proved to be overestimated in the latest IIR.

Changes in the 2013 figures are also the result of using improved activity data for that year.

10 Projections

This chapter consists of descriptions (per source sector) of general methods (models), data sources and assumptions used for estimating projected emissions as reported in Annex IV, Table 2a, of the Dutch CLRTAP submission. The National Energy Outlook (NEO) study by Schoots & Hammingh (2015) outlines the current state of the Dutch energy system in an international context. The Dutch energy system is not isolated from other countries' systems. In that context, the NEO describes the observed development from 2000 up to the present, as well as expected developments up to 2030. This relates to energy demand as well as to energy supply, emissions of greenhouse gases and air pollutants, and also economic factors relating to energy, such as contributions to the national product and employment. The NEO 2015 includes the baseline forecast for air pollutants, which was not included in the previous NEO. The present NEO also provides greater statistical insight into innovation within the energy system, and describes in greater detail the progress made in the context of the Energy Agreement for Sustainable Growth (hereafter 'Energy Agreement'). An overview of the historical and projected total emissions for the Netherlands per pollutant is given in Table 11.1.

Table 11.1 Historical and projected emissions from the Netherlands, calculated based on fuel sold (RIVM, 2016; Schoots and Hammingh, 2015)

		Historical					*NEC*	Projected (WM)		Projected (WAM)	
Pollutant/year		1990	2000	2005	2010	2014	*2010*	2020	2030	2020	2030
SO_2	Gg	193	73	64	34	29	*50*	30	31	30	30
NO_x	Gg	603	419	367	274	220	*260*	175	148	172	125
NH_3	Gg	372	182	160	140	134	*128*	127	120	127	118
NMVOC	Gg	489	243	180	165	143	*185*	147	150	146	149
PM_{10}	Gg	74	42	35	30	27	*NA*	*NA*	*NA*	*NA*	*NA*
$PM_{2.5}$	Gg	50	28	21	16	13	*NA*	10.6	10.2	10.4	9.6

General approach - methods and general assumptions
NEO is based on methods used in the reference projections (Verdonk & Wetzels, 2012), the energy statistics (CBS) and the economic radar of the sustainable energy sector (CBS, 2011).

Physical developments determine emissions
Starting from a macro-economic point-of-view, the production and consumption of goods and services are estimated. These are then translated to physical developments (e.g. kilometres driven, tons of steel production). In turn, these physical developments determine emissions, taking into account expected technological changes, such as energy-efficiency improvement, or a fuel mix change in power plants.

NEO uses bottom-up analyses to construct the energy balances of the Dutch energy system, both historical as well as expected up to 2030. NEO tracks the developments in the various public and economic sectors, leading to energy demand and energy production. This enabled the mapping of all energy currents. As much as possible this was done from the quantitative development of the activities itself, like the production of electricity and goods, the use of appliances, the heating of buildings and the kilometres driven.

Historical data are collected by Statistics Netherlands (CBS) from company questionnaires and registrations from mains operations and governments. For future projections expected changes are calculated based on assumed economical, demographic and energy market developments. If possible, established, announced and proposed projects from both governments and other societal actors have been accounted for.

From expected activity levels the appropriate energy use and consequently the needed energy production can be calculated. Technological developments play an important role in this, especially concerning the improvement of energy efficiency and changes in the fuel mix used for electricity production.
In turn, from the energy use CO_2 emissions are calculated. Emissions of other greenhouse gases and air polluting gases are derived from the relevant activity levels.
NEO 2015 uses a combination of models for various parts of the energy system, in which data is exchanged mutually. Jointly, the models lead to a complete and consistent energy balance for the Netherlands. As a brief explanation on the used models and correspondingly used assumptions, some background documents have been made available. Together with a 'frequently asked questions' section, they are available at the NEO-website.

Reference scenario NEO 2015

The future inherently is insecure.

An overview of the parameters and energy data used for emission projections for the Netherlands is given in Table 11.2

Table 11.2 Assumptions and activity data used for national emission projections

	Latest Historic Year		Projected Activity Data			
Activity	***Reference Year 2010***	***2014***	***2020***	***2030***	***Units (energy units are in NCV)***	***Notes on Measures included excluded***
Assumptions for general economic parameters:						
1. Gross Domestic Product (GDP)	632	663	701	829	10^9 €	G€
2. Population	16575	16829	17200	17700	Thousand People	
3. International coal prices	89	80	81	88	€ per tonne or GJ (Gigajoule), Other please specify	€ per tonne
4. International oil prices	65	86	67	105	€ per barrel or GJ	€ per barrel
5. International gas prices	0.2	0.26	0.26	0.32	€ per m3 or GJ	€ per m3
Assumptions for the energy sector:						
Total gross inland consumption						
1. Oil (fossil)	1314	1185	1217	1231	Petajoule (PJ)	energetic use
2. Gas (fossil)	1548	1252	1145	1057	Petajoule (PJ)	energetic use
3. Coal	315	438	356	378	Petajoule (PJ)	energetic use
4. Biomass without liquid biofuels (e.g. wood)	62	64	102	90	Petajoule (PJ)	biomass without liquid biofuels for transport, avoided primary use
5. Liquid biofuels (e.g. bio-oils)	10	15	36	124	Petajoule (PJ)	liquid biofuels transport
6. Solar	1	4	18	46	Petajoule (PJ)	solar PV + thermal, avoided primary
7. Other renewable (wind, geothermal etc.)	20	28	77	178	Petajoule (PJ)	avoided primary energy
Total electricity production by fuel type						
8. Oil (fossil)	59	19	908	1103	GWh	
9. Gas (fossil)	69972	63280	52528	58917	GWh	
10. Coal	23722	22106	43111	30472	GWh	
11. Renewable	10442	11534	19922	31300	GWh	

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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 2014 and 1990 level assessment, a trend assessment was also performed. In both approaches, key source categories are identified using a cumulative threshold of 80%.

Table 1.1.a SO_x key source categories identified by 2014 level assessment (emissions in Gg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
1A1b	Petroleum refining	9.7	33%	33%
1A1a	Public electricity and heat production	8.6	30%	63%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	3.2	11%	74%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	2.8	9.5%	84%

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

NFR14 Code	Longname	1990	Contribution	Cumulative contribution
1A1b	Petroleum refining	67	35%	35%
1A1a	Public electricity and heat production	48	25%	60%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	20	10%	71%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	9.1	4.7%	75%
1A3biii	Road transport: Heavy duty vehicles and buses	7.8	4.0%	79%
2A6	Other mineral products	5.5	2.9%	82%

Table 1.1.c SO_x key source categories identified by 1990-2014 trend assessment (emissions in Gg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	1.0%	18%	18%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	0.9%	16%	33%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.7%	12%	45%

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.6%	11%	56%
1A3biii	Road transport: Heavy duty vehicles and buses	0.6%	10%	66%
1A3bi	Road transport: Passenger cars	0.4%	6.2%	72%
1A1b	Petroleum refining	0.2%	3.3%	75%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.2%	2.9%	78%
1A3bii	Road transport: Light duty vehicles	0.2%	2.8%	81%

Table 1.2.a NO_x key source categories identified by 2014 level assessment (emissions in Gg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy duty vehicles and buses	42	18%	18%
1A3bi	Road transport: Passenger cars	28	12%	30%
1A3bii	Road transport: Light duty vehicles	21	8.9%	39%
1A1a	Public electricity and heat production	19	8.2%	47%
1A3di(ii)	International inland waterways	17	7.1%	54%
1A4ci	Agriculture/Forestry/Fishing: Stationary	10	4.3%	59%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	9.7	4.1%	63%
1A3dii	National navigation (shipping)	9.6	4.1%	67%
1A4bi	Residential: Stationary	8.6	3.6%	70%
1A2gvii	Mobile Combustion in manufacturing industries and construction	8.3	3.5%	74%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	8.1	3.4%	77%
1A4ai	Commercial/institutional: Stationary	7.4	3.2%	81%

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

NFR14 Code	Longname	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	145	24%	24%
1A3biii	Road transport: Heavy duty vehicles and buses	113	19%	43%
1A1a	Public electricity and heat production	83	14%	57%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	36	6.0%	62%
1A3bii	Road transport: Light duty vehicles	24	3.9%	66%
1A3di(ii)	International inland waterways	22	3.7%	70%
1A4bi	Residential: Stationary	22	3.6%	74%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	20	3.3%	77%
1A1b	Petroleum refining	19	3.1%	80%

Table 1.2.c NO_x key source categories identified by 1990-2014 trend assessment (emissions in Gg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	4.7%	26%	26%
1A1a	Public electricity and heat production	2.1%	12%	38%
1A3bii	Road transport: Light duty vehicles	1.9%	10.8%	49%
1A3di(ii)	International inland waterways	1.3%	7.4%	56%
1A3dii	National navigation (shipping)	1.2%	6.6%	63%
1A4ci	Agriculture/Forestry/Fishing: Stationary	1.1%	6.2%	69%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.70%	3.9%	73%
1A3ai(i)	International aviation LTO (civil)	0.43%	2.4%	75%
1A1c	Manufacture of solid fuels and other energy industries	0.42%	2.4%	78%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.42%	2.3%	79.9%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.41%	2.3%	82%

Table 1.3.a NH_x key source categories identified by 2014 level assessment (emissions in Gg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	39	29%	29%
3B1a	Manure management - Dairy cattle	18	14%	43%
3B3	Manure management - Swine	14	10%	53%
3Da1	Inorganic N-fertilizers (includes also urea application)	14	10%	63%
6A	Other (included in national total for entire territory)	12	8.6%	72%
3B1b	Manure management - Non-dairy cattle	10	7.8%	79.9%
3B4gi	Manure management - Laying hens	8.3	6.2%	86%

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

NFR14 Code	Longname	1990	Contribution	Cumulative contribution
3Da2a	Animal manure applied to soils	211	57%	57%
3B3	Manure management - Swine	49	13%	70%
3B1a	Manure management - Dairy cattle	22	5.8%	76%
3Da3	Urine and dung deposited by grazing animals	18	4.8%	81%

Table 1.3.c NH_x key source categories identified by 1990-2014 trend assessment (emissions in Gg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
3Da2a	Animal manure applied to soils	10%	40%	40%
3B1a	Manure management - Dairy cattle	2.9%	11%	51%
3Da1	Inorganic N-fertilizers (includes also urea application)	2.3%	9.3%	60%
3B1b	Manure management - Non-dairy cattle	1.8%	7.1%	67%
6A	Other (included in national total for entire territory)	1.7%	6.9%	74%
3B4gi	Manure mangement - Laying hens	1.4%	5.1%	79%
3Da3	Urine and dung deposited by grazing animals	1.2%	4.8%	84%

Table 1.4.a NMVOC key source categories identified by 2014 level assessment (emissions in Gg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
2D3a	Domestic solvent use including fungicides	20	14%	14%
2D3d	Coating applications	20	14%	28%
1A3bi	Road transport: Passenger cars	12	8.6%	37%
1A4bi	Residential: Stationary	11	7.9%	45%
2H3	Other industrial processes	10	7.2%	52%
2D3i	Other solvent use	9.9	6.9%	59%
1A3biv	Road transport: Mopeds & motorcycles	8.7	6.1%	65%
1B2aiv	Fugitive emissions oil: Refining / storage	8.1	5.7%	71%
2B10a	Chemical industry: Other	5.5	3.8%	74%
1B2ai	Fugitive emissions oil: Exploration, production, transport	4.9	3.4%	78%
2D3h	Printing	4.0	2.8%	81%

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

NFR14 Code	Longname	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	101	21%	21%
2D3d	Coating applications	92	19%	39%
1A3bv	Road transport: Gasoline evaporation	36	7.3%	47%
2B10a	Chemical industry: Other	33	6.8%	53%
1B2aiv	Fugitive emissions oil: Refining / storage	32	6.5%	60%
2H3	Other industrial processes	27	5.5%	65%
1A3biv	Road transport: Mopeds & motorcycles	25	5.1%	70%
1A3biii	Road transport: Heavy duty vehicles and buses	16	3.3%	74%
2D3i	Other solvent use	15	3.1%	77%
1B2ai	Fugitive emissions oil: Exploration, production, transport	14	2.9%	79.7%
2D3h	Printing	14	2.9%	83%

Table 1.4.c NMVOC key source categories identified by 1990-2014 trend assessment (emissions in Gg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	3.5%	18%	18%
2D3a	Domestic solvent use including fungicides	3.5%	18%	37%

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A3bv	Road transport: Gasoline evaporation	1.8%	9.6%	46%
1A4bi	Residential: Stationary	1.5%	7.9%	54%
2D3d	Coating applications	1.4%	7.5%	62%
2D3i	Other solvent use	1.1%	5.9%	68%
2B10a	Chemical industry: Other	0.88%	4.6%	72%
1A3biii	Road transport: Heavy duty vehicles and buses	0.74%	3.9%	76%
1A3bii	Road transport: Light duty vehicles	0.52%	2.8%	79%
2H3	Other industrial processes	0.50%	2.6%	82%

Table 1.5.a CO key source categories identified by 2014 level assessment (emissions in Gg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	226	40%	40%
1A4bi	Residential: Stationary	77	14%	53%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	63	11%	64%
1A3biv	Road transport: Mopeds & motorcycles	59	10%	75%
1A4bii	Residential: Household and gardening (mobile)	29	5.2%	79.7%
1A5b	Other, Mobile (including military, land-based and recreational	21	3.7%	83%

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

NFR14 Code	Longname	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	589	51%	51%
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%	83%

Table 1.5.c CO key source categories identified by 1990-2014 trend assessment (emissions in Gg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	5.9%	25%	25%
1A4bi	Residential: Stationary	3.4%	14%	39%
1A3biv	Road transport: Mopeds & motorcycles	3.2%	13%	53%
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	2.7%	11%	64%
1A4bii	Residential: Household and gardening (mobile)	1.9%	8.1%	72%
1A3bii	Road transport: Light duty vehicles	1.8%	7.5%	79%
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	1.2%	5.1%	84%

Table 1.6.a PM_{10} key source categories identified by 2014 level assessment (emissions in Gg)

NFR Code	Longname	2014	Contribution	Cumulative contribution
3B4gi	Manure management - Laying hens	2.9	11%	11%
2H3	Other industrial processes	2.5	9.4%	20%
1A4bi	Residential: Stationary	2.1	7.9%	28%
2H2	Food and beverages industry	1.7	6.5%	35%
3B4gii	Manure management - Broilers	1.4	5.2%	40%
1A3bvi	Road transport: Automobile tyre and brake wear	1.4	5.2%	45%
2C1	Iron and steel production	1.2	4.7%	50%
2B10a	Chemical industry: Other	1.2	4.6%	55%
2D3i	Other solvent use	1.2	4.6%	59%
1A3bvii	Road transport: Automobile road abrasion	1.1	4.2%	64%
1A3bii	Road transport: Light duty vehicles	1.1	4.1%	68%
2A6	Other mineral products	1.1	4.1%	72%
3B3	Manure management - Swine	1.0	3.8%	75%
1A3bi	Road transport: Passenger cars	1.0	3.7%	79%
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.6	2.3%	81%

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

NFR14 Code	Longname	1990	Contribution	Cumulative contribution
2C1	Iron and steel production	9.1	12%	12%
1A3biii	Road transport: Heavy duty vehicles and buses	7.0	9.5%	22%
1A3bi	Road transport: Passenger cars	6.6	8.9%	31%
1A1b	Petroleum refining	6.5	8.8%	40%
2H3	Other industrial processes	5.4	7.3%	47%
1A3bii	Road transport: Light duty vehicles	4.6	6.3%	53%
2H2	Food and beverages industry	4.3	5.9%	59%
2B10a	Chemical industry: Other	4.1	5.6%	65%
1A4bi	Residential: Stationary	2.5	3.4%	68%
1A1a	Public electricity and heat production	2.2	3.0%	71%
2A6	Other mineral products	2.0	2.8%	74%
1A2gvii	Mobile Combustion in manufacturing industries and construction:	2.0	2.7%	77%
2D3i	Other solvent use	1.9	2.6%	79%
3B3	Manure management - Swine	1.6	2.1%	81%

Table 1.6.c PM_{10} key source categories identified by 1990-2014 trend assessment (emissions in Gg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
3B4gi	Manure management - Laying hens	3.6%	13%	13%
1A1b	Petroleum refining	2.8%	10%	24%
1A3biii	Road transport: Heavy duty vehicles and buses	2.8%	10%	34%
2C1	Iron and steel production	2.8%	10%	44%
1A3bi	Road transport: Passenger cars	1.9%	6.9%	51%
1A4bi	Residential: Stationary	1.6%	5.9%	57%
1A3bvi	Road transport: Automobile tyre and brake wear	1.3%	4.8%	61%
3B4gii	Manure management - Broilers	1.2%	4.6%	66%
1A3bvii	Road transport: Automobile road abrasion	1.1%	4.0%	70%
1A3bii	Road transport: Light duty vehicles	0.78%	2.9%	73%
2H3	Other industrial processes	0.78%	2.9%	76%
2D3i	Other solvent use	0.75%	2.8%	78%
1A1a	Public electricity and heat production	0.59%	2.2%	81%

Table 1.7.a $PM_{2.5}$ key source categories identified by 2014 level assessment (emissions in Gg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	2.0	16%	16%
2D3i	Other solvent use	1.2	9.7%	25%
1A3bii	Road transport: Light duty vehicles	1.1	8.5%	34%
1A3bi	Road transport: Passenger cars	1.0	7.7%	42%
2C1	Iron and steel production	0.8	6.3%	48%
2H3	Other industrial processes	0.7	5.2%	53%
2B10a	Chemical industry: Other	0.6	4.7%	58%
1A2gvii	Mobile Combustion in manufacturing industries and construction	0.5	3.9%	62%
1A3biii	Road transport: Heavy duty vehicles and buses	0.5	3.8%	65%
1A3di(ii)	International inland waterways	0.5	3.8%	69%
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.4	3.4%	73%
2A6	Other mineral products	0.4	2.8%	75%
1A3dii	National navigation (shipping)	0.4	2.8%	78%
2H2	Food and beverages industry	0.3	2.2%	80%

Table 1.7.b $PM_{2.5}$ key source categories identified by 1990 level assessment (emissions in Gg)

NFR Code	Longname	1990	Contribution	Cumulative contribution
1A3biii	Road transport: Heavy duty vehicles and buses	7.0	14%	14%
1A3bi	Road transport: Passenger cars	6.6	13%	27%
2C1	Iron and steel production	5.8	12%	39%
1A1b	Petroleum refining	5.1	10%	49%
1A3bii	Road transport: Light duty vehicles	4.6	9.2%	58%
1A4bi	Residential: Stationary	2.4	4.8%	63%
2B10a	Chemical industry: Other	2.4	4.7%	68%
1A2gvii	Mobile Combustion in manufacturing industries and construction	1.9	3.7%	71%
2D3i	Other solvent use	1.9	3.7%	75%
1A1a	Public electricity and heat production	1.9	3.7%	79%
2H3	Other industrial processes	1.6	3.2%	82%

Table 1.7.c $PM_{2.5}$ key source categories identified by 1990-2014 trend assessment (emissions in Gg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A4bi	Residential: Stationary	2.7%	15%	15%
1A3biii	Road transport: Heavy duty vehicles and buses	2.6%	14%	30%
1A1b	Petroleum refining	2.2%	12%	42%
2D3i	Other solvent use	1.9%	8.4%	51%
1A3bi	Road transport: Passenger cars	1.4%	7.6%	58%
2C1	Iron and steel production	1.3%	7.6%	66%
1A3dii	National navigation (shipping)	0.54%	3.0%	69%
2H3	Other industrial processes	0.50%	2.8%	72%
1A3di(ii)	International inland waterways	0.50%	2.8%	75%
1A1a	Public electricity and heat production	0.41%	2.3%	77%
1A3bvi	Road transport: Automobile tyre and brake wear	0.39%	2.2%	79%
2C3	Aluminium production	0.36%	2.0%	81%

Table 1.8.a Pb key source categories identified by 2014 level assessment (emissions in Mg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
2C1	Iron and steel production	3.4	33%	33%
2C6	Zinc production	1.8	18%	51%
1A3ai(i)	International aviation LTO (civil)	1.5	15%	66%
2A3	Glass production	0.99	9.7%	75%
1A3c	Railways	0.88	8.6%	84%

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

NFR14 Code	Longname	1990	Contribution	Cumulative contribution
1A3bi	Road transport: Passenger cars	230	69%	69%
2C1	Iron and steel production	56	17%	86%

Table 1.8.c Pb key source categories identified by 1990-2014 trend assessment (emissions in Mg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A3bi	Road transport: Passenger cars	1.98%	46%	46%
2C6	Zinc production	0.54%	12%	58%
2C1	Iron and steel production	0.49%	11%	70%
1A3ai(i)	International aviation LTO (civil)	0.43%	9.9%	79%
1A3c	Railways	0.26%	5.9%	85%

Table 1.9.a Hg key source categories identified by 2014 level assessment (emissions in Mg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	0.23	42%	42%
1A3bi	Road transport: Passenger cars	0.06	11%	53%
2C1	Iron and steel production	0.06	11%	64%
2C5	Lead production	0.05	9.9%	74%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	0.04	6.7%	81%

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

NFR14 Code	Longname	1990	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	1.9	54%	54%
2B10a	Chemical industry: Other	0.7	20%	73%
2C1	Iron and steel production	0.4	11%	84%

Table 1.9.c Hg key source categories identified by 1990-2014 trend assessment (emissions in Mg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
2B10a	Chemical industry: Other	3.0%	28%	28%
1A1a	Public electricity and heat production	1.8%	17%	45%
1A3bi	Road transport: Passenger cars	1.5%	14%	59%
1A2gviii	Stationary combustion in manufacturing industries and construction: Other	1.0%	9.5%	69%

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A4bi	Residential: Stationary	0.86%	8.1%	77%
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	0.50%	4.7%	81S%

Table 1.10.a Cd key source categories identified by 2014 level assessment (emissions in Mg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
2C1	Iron and steel production	0.21	33%	33%
2C6	Zinc production	0.12	18%	51%
1A3bi	Road transport: Passenger cars	0.09	14%	65%
2B10a	Chemical industry: Other	0.09	14%	79%
1A4bi	Residential: Stationary	0.04	9.2%	88%

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

NFR14 Code	Longname	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%

Table 1.10.c Cd key source categories identified by 1990-2014 trend assessment (emissions in Mg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	12%	43%	43%
2B10a	Chemical industry: Other	4.1%	15%	58%
2C6	Zinc production	4.0%	14%	72%
1A3bi	Road transport: Passenger Cars	3.3%	12%	84%

Table 1.11.a Dioxine key source categories identified by 2014 level assessment (emissions in g I-Teq)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
2D3i	Other solvent use	13	59%	59%
1A4bi	Residential: Stationary	6.8	31%	91%

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

NFR14 Code	Longname	1990	Contribution	Cumulative contribution
1A1a	Public electricity and heat production	568	77%	77%
1A4ai	Commercial/institutional : Stationary	100	13%	90%

Table 1.11.c Dioxine key source categories identified by 1990-2014 trend assessment (emissions in g I-Teq)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A1a	Public electricity and heat production	2.1%	41%	41%
2D3i	Other solvent use	1.7%	32%	72%
1A4bi	Residential: Stationary	0.9%	17%	89%

Table 1.12.a PAH key source categories identified by 2014 level assessment (emissions in Mg)

NFR14 Code	Longname	2014	Contribution	Cumulative contribution
1A4bi	Residential: Stationary	4.08	88%	88%

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

NFR14 Code	Longname	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%
2H3	Other industrial processes	1.4	6.9%	81%

Table 1.12.c PAH key source categories identified by 1990-2014 trend assessment (emissions in Mg)

NFR14 Code	Longname	Trend	Trend contribution	Cumulative trend contribution
1A4bi	Residential: Stationary	16%	58%	58%
2C3	Aluminium production	8%	29%	87%

Appendix 2 Planned improvements; quick view

As result of the stage 3 review on the informative inventory report 2015 and 2015 NFR tables, a planning is made on the implementation of actions regarding the issues found. Table A2.1 gives a quick view on the planning of the implementation of actions from the stage 3 review.

Table A2.1 Quick view on 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 IIR 2016
6	See from issue 43 onwards	76	gradually in IIR's 2016 - 2018
7	See from issue 43 onwards	77	In IIR 2016
8	See from issue 43 onwards	78	No action necessary
9	See from issue 43 onwards	79	In IIR 2016
10	See from issue 43 onwards	80	In IIR 2016
11	See from issue 43 onwards	81	gradually in IIR's 2016 - 2018
12	See from issue 43 onwards	82	gradually in IIR's 2016 - 2018
13	See from issue 43 onwards	83	No action necessary
14	See from issue 43 onwards	84	In IIR 2016
15	See from issue 43 onwards	85	No action necessary
16	See from issue 43 onwards	86	No action necessary
17	See from issue 43 onwards	87	No action necessary
18	See from issue 43 onwards	88	No action necessary
19	See from issue 43 onwards	89	In IIR 2016
20	See from issue 43 onwards	90	In IIR 2016
21	See from issue 43 onwards	91	In IIR 2016
22	See from issue 43 onwards	92	gradually in IIR's 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 IIR 2016
26	See from issue 43 onwards	96	In IIR 2016
27	See from issue 43 onwards	97	In IIR 2016
28	See from issue 43 onwards	98	In IIR 2016
29	See from issue 43 onwards	99	In IIR 2016
30	See from issue 43 onwards	100	IIR2017
31	See from issue 43 onwards	101	IIR2017
32	See from issue 43 onwards	102	In IIR 2016

Issue in review report	Planned for	Issue in review report	Planned for
33	See from issue 43 onwards	103	IIR2017
34	See from issue 43 onwards	104	No action necessary
35	See from issue 43 onwards	105	No action necessary
36	See from issue 43 onwards	106	In IIR2017 / IIR2018
37	See from issue 43 onwards	107	No action necessary
38	See from issue 43 onwards	108	In IIR 2017
39	See from issue 43 onwards	109	No action necessary
40	See from issue 43 onwards	110	No action necessary
41	See from issue 43 onwards	111	In IIR 2016
42	See from issue 43 onwards	112	In IIR 2016
43	Not settled yet	113	In IIR 2016
44	Not settled yet	114	IIR2017
45	Not settled yet	115	In IIR 2016
46	Not settled yet	116	In IIR 2016
47	Not settled yet	117	In IIR 2016
48	In IIR 2016	118	In IIR 2017
49	In IIR 2016	119	In IIR 2016
50	In IIR 2016	120	In IIR 2016
51	In IIR 2016	121	No action necessary
52	Not settled yet	122	In IIR 2017
53	Not settled yet	123	In IIR 2017
54	Not settled yet	124	Not settled yet
55	In IIR 2016	125	Not settled yet
56	In IIR 2016	126	In IIR 2017
57	Not settled yet	127	No action necessary
58	In IIR 2016	128	In IIR 2017
59	In IIR 2016	129	In IIR 2017
60	No action necessary	130	In IIR 2017
61	In IIR 2016	131	In IIR 2017
62	In IIR 2016	132	No action necessary
63	Not settled yet	133	In IIR 2016
64	Not settled yet	134	In IIR 2016
65	In IIR 2016	135	In IIR 2016
66	In IIR 2016	136	In IIR 2016
67	Not settled yet	137	In IIR 2017
68	Not settled yet	138	In IIR 2017
69	Not settled yet	139	In IIR 2017
70	In IIR 2016		

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Ammonia emissions increased

In 2014 total Dutch ammonia emissions increased. Despite the decrease during the period 1990-2013, the ammonia emission still exceeds the maximum set to this by the European Union since 2010. Two important contributors to the increase are the growth in dairy cattle and the altered cattle feed composition. Emissions of nitrogen oxides, sulphur dioxides and non-methane volatile organic compounds continue to decrease slightly. For this end the Netherlands are complying to the ceilings set.

This is concluded by the Informative Inventory Report 2016. In this, the RIVM and partner institutes collect, analyse and report emission data. Apart from substances as mentioned above, this also includes emissions of carbon monoxide, particulate matter, heavy metals and persistent organic pollutants. The emissions of most of these substances have decreased during the 1990 – 2014 period. The downward trend may in particular be attributed to cleaner fuels, cleaner car engines and to emission reductions in industry.

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