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

Emissions of air pollutants

Emissions of transboundary air pollutants in the Netherlands 1990-2012

Informative Inventory Report 2014

Netherlands Informative Inventory Report 2014

B.A. Jimmink, H.M. ten Broeke[1], P.W.H.G. Coenen[1], R. Dröge[1], G.P. Geilenkirchen[2], A.J. Leekstra, C.W.M. van der Maas, R.A.B. te Molder, C.J. Peek, J. Vonk, D. Wever

[1] Netherlands Organisation for Applied Scientific Research (TNO)
[2] PBL Netherlands Environmental Assessment Agency

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Contacts:
Benno Jimmink (benno.jimmink@rivm.nl)
Wim van der Maas (wim.van.der.maas@rivm.nl)

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National Institute for Public Health and the Environment (RIVM), PO Box 1, 3720 BA Bilthoven,
the Netherlands; Tel: +31-30-274 9111; Fax: +31-30-278 75 31; www.rivm.nl/en

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Many colleagues from a number of organisations (CBS, LEI, Alterra, RVO.nl, PBL, RIVM and TNO) have been involved in the annual update of the Netherlands Pollutant Release & Transfer Register (PRTR), also called the Emission Registration (ER) system, which contains emission data from over 1000 facilities on about 350 pollutants. The emissions are calculated by members of the ER 'Task Forces'. This is a major task, since the Netherlands' inventory contains many detailed emission sources. Subsequently, the emissions and activity data of the Netherlands' inventory are converted into the NFR source categories and contained in the Excel files. The description of the various sources, the analysis of trends and uncertainty estimates (see Chapters 2 to 10) were made in co-operation with the following emission experts: Mr. Gerben Geilenkirchen (transport), Mr. Peter Coenen, Mr. Harm ten Broeke and Mrs. Rianne Dröge (energy), Mr. Kees Peek (industrial processes, solvents and product use), Mr. Jan Vonk (agriculture). We are particularly grateful to Mr. Bert Leekstra and Mr. Dirk Wever, for their contribution to data processing, chart production and quality control. For their continued support, we acknowledge Mr. R. Wolters and Mr. W. Prins in particular, from The Directorate for Climate Change, Air Quality and Noise of the Dutch Ministry of Infrastructure and Environment. For the design and layout of this report, we thank the RIVM's graphic department, in particular Mr. Gert Boer. We greatly appreciate the contributions of each of these groups and individuals to this Informative Inventory Report as well as the contributions of the external reviewers that provided comments on the draft report.

Publiekssamenvatting

Emissies Nederland blijven in 2012 onder nationale plafonds

De uitstoot van stikstofoxiden (NO_x), ammoniak, zwaveldioxide en niet-methaan vluchtige organische stoffen (NMVOS) is in 2012 in Nederland licht gedaald. Daarmee bleef de uitstoot onder de maxima die de Europese Unie daaraan sinds 2010 stelt. Nederland voldoet daardoor, net als in 2011, aan de vier ‘nationale emissieplafonds’ (NEC) voor deze stoffen.

Dit blijkt uit de Nederlandse emissiecijfers van grootschalige luchtverontreinigende stoffen. Het RIVM verzamelt en analyseert deze cijfers. Behalve bovengenoemde stoffen gaat het om de uitstoot van koolmonoxide, fijn stof (PM10), zware metalen en persistente organische stoffen (POP’s). De uitstoot van al deze stoffen is tussen 1990 en 2012 gedaald. Dit komt vooral door schonere auto’s en brandstoffen en door emissiebeperkende maatregelen van industriële sectoren.

Meer kilometers door bromfietsen

Door de jaren heen zijn de methoden om de emissies te berekenen verbeterd, wat nu resulteert in nauwkeurigere cijfers. De emissies van bromfietsen en motorfietsen zijn afhankelijk van het aantal gereden kilometers per jaar en daar is nu beter inzicht in. Het totale aantal gereden kilometers door bromfietsen blijkt in de afgelopen jaren bijna twee keer zo hoog is als werd gedacht. Daarmee is de uitstoot van schadelijke stoffen navenant hoger. Ten opzichte van andere typ voertuigen blijven bromfietsen echter een relatief kleine emissiebron en dragen ze beperkt bij aan de totale nationale emissies. In steden zijn ze wel een relevante bron. Het aantal gereden kilometers door motorfietsen, en daarmee de uitstoot, blijft in lijn met eerdere inzichten.

Vrachtauto’s zwaarder beladen

De uitstoot van schadelijke stoffen door vrachtauto’s is voor het eerst berekend op basis van recente inzichten in het gewicht van vrachtauto’s. Trekker-opleggers blijken zwaarder beladen dan tot nu toe werd verondersteld. Ook rijden vrachtauto’s vaker met een aanhanger dan tot nu toe werd aangenomen, waardoor ze zwaarder zijn. Een hoger gewicht betekent een hoger brandstofverbruik, en veelal ook een hogere uitstoot per gereden kilometer. De uitstoot van PM10 door vrachtauto’s is hierdoor circa 5 procent hoger dan in de vorige IIR-rapportage.

Hogere emissies ammoniak

De uitstoot van ammoniak blijkt hoger dan eerder werd verondersteld vanwege enkele nieuwe inzichten; de cijfers zijn hierdoor vanaf 1997 bijgesteld. Zo worden luchtwassers, die voornamelijk op varkensstallen zitten, niet altijd gebruikt. Ook is vanaf 2002 in melkveestallen het leefoppervlak per dier toegenomen. Door het grotere contactoppervlak van mest met lucht wordt meer ammoniak uitgestoten. Door de aangepaste aannames is het nationale totaal met 6,6 kiloton verhoogd ten opzichte van 2011.

Trefwoorden: emissies, grootschalige luchtverontreiniging, emissieregistratie

Abstract

Emissions the Netherlands in 2012 remain under national ceilings

Emissions of nitrogen oxides (NO_x), ammonia, sulphur dioxide and non-methane volatile organic compounds (NMVOC) in the Netherlands have slightly decreased in 2012. Consequently, the emissions stayed below the caps the European Union has set from 2010. Herewith, the Netherlands comply with all four so-called emission ceilings (NEC).

This has become apparent from the emission data on air pollutants from the Netherlands. RIVM collects and reports these data. Besides above-mentioned substances, emissions of carbon monoxide, particulate matter (PM_{10}), heavy metals and persistent organic pollutants (POPs) have been reported. The emissions of all substances have decreased in the 1990 – 2012 period. The downward trend may in particular be attributed to cleaner fuels, cleaner car engines and to emission reductions in the industrial sectors.

More kilometres by mopeds

Over the years emission calculation methods have been improved, resulting in higher data accuracy. In 2012, the emissions from mopeds and motorcycles have been calculated, based on improved knowledge of the mileages. The total number of kilometres driven by mopeds appears to have been nearly twice as high in recent years. As a result, the emissions of pollutants are proportionally higher. In relation to the total number of vehicles, the number of mopeds however remains relatively low and their contribution to the total national emissions is limited. In cities, they are a relevant source. The mileages by motorcycles, and consequently their emissions remain in line with previous insights.

Heavy-duty vehicles carry heavier loads

Emissions of pollutants by heavy-duty trucks have for the first time been calculated on the basis of recent insights in truck loads. Tractor-trailer combinations appear to carry heavier loads and the fraction of trailers behind rigid trucks is larger than previously assumed. A heavier load means a higher fuel use and for most substances a higher emission per kilometre driven. PM_{10} emissions by heavy-duty trucks are about 5 percent higher than in the previous IIR report.

Higher agricultural ammonia emissions

Agricultural ammonia emissions appear to be higher than previously assumed because of new insights. Air scrubbers on animal housing (predominantly pigs) were not always in use or even employed. Since 2002, the living space per animal has increased for dairy cattle housing. This resulted in a higher contact surface manure-air and thus more ammonia emitted. The new insights have raised the national total of ammonia emissions by about 6 percent compared to 2011.

Key words: emissions, transboundary air pollution, emission inventory

Glossary

AER	Annual Environmental Report
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CBS	Statistics Netherlands
CNG	Compressed Natural Gas
DCS	Dutch Continental Shelf
DPF	Diesel particulate filter
EEA	European Environment Agency
EMEP	*European Monitoring and Evaluation Programme*
ER-I	Emission Inventory data of individual point-source emissions and activities
ERT	Emission Review Team
EU	European Union
HCB	Hexachlorobenzene
IEF	Implied Emission Factor
IenM	Dutch Ministry of Infrastructure and the Environment
IIR	Informative Inventory Report
LEI	Agricultural Economics Research Institute
LPG	Liquefied petroleum gas
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
NAP	national car Passport Corporation
NEC	National Emission Ceiling
NEH	Netherlands Energy Statistics
NEMA	National Emission Model for Agriculture
NFR	Nomenclature for Reporting
NIR	National Inventory Report
NMVOC	Non-methane volatile organic compounds
NRMM	Non-Road Mobile Machinery
NS	Dutch Railways
NUSAP	Numeral Unit Spread Assessment Pedigree
PAH	Polycyclic aromatic hydrocarbon
PBL	Netherlands Environmental Assessment Agency
PM	Particulate matter
POP	Persistent organic pollutant
PRTR	Pollutant Release and Transfer Register
Rav	Dutch Ammonia and Livestock Farming Regulation
RDW	national motor vehicle and driving licence registration authority
RLD	Dutch national air traffic service
SPIN	Co-operation project on Industrial Emissions
TAN	Total ammonia nitrogen
TWC	Three-way catalyst
QA/QC	Quality Assurance/Quality Control
RIVM	National Institute for Public Health and the Environment
RVO.nl	Netherlands Enterprise Agency
RWS	Rijkswaterstaat
TNO	Netherlands Organisation for Applied Scientific Research
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
WWTP	Waste Water Treatment Plant

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 POPs is prepared using the Guidelines for Estimating and Reporting Emission Data under the CLRTAP (UNECE, 2009).
The Netherlands' IIR 2014 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 2012, 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 (POPs) in Annex IV. Moreover, this year, the spatial distributions of emission data have been reported, this has to be done every five years. A chapter on the followed methodology has therefore been included.

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 Ceilings (NEC) of the European Union, 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 (EEA, 2009), 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, 2013; 2014). 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);
- RWS Centre for Water Management (RWS-WD);
- RWS Centre for Transport and Navigation (RWS-DVS);
- Deltares;
- Alterra WUR;
- Wageningen UR Livestock Research;
- RWS Centre for Environment(RWS-Afval);
- 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 (TGL);
- Task Force on Energy, Industry and Waste Management - ENINA;
- Task Force on Traffic and Transportation;
- Task Force on Water - MEWAT;
- Task Force on Service Sector and Product Use - WESP.

Every year, after 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).

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), about 1,000 facilities, are in 2011 legally obligated to submit their emissions of pollutants to air when they exceed a certain threshold. For some pollutants, lower thresholds have been set in the Dutch implementation of the E-PRTR directive (VROM, 2008). Through this, 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 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.

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

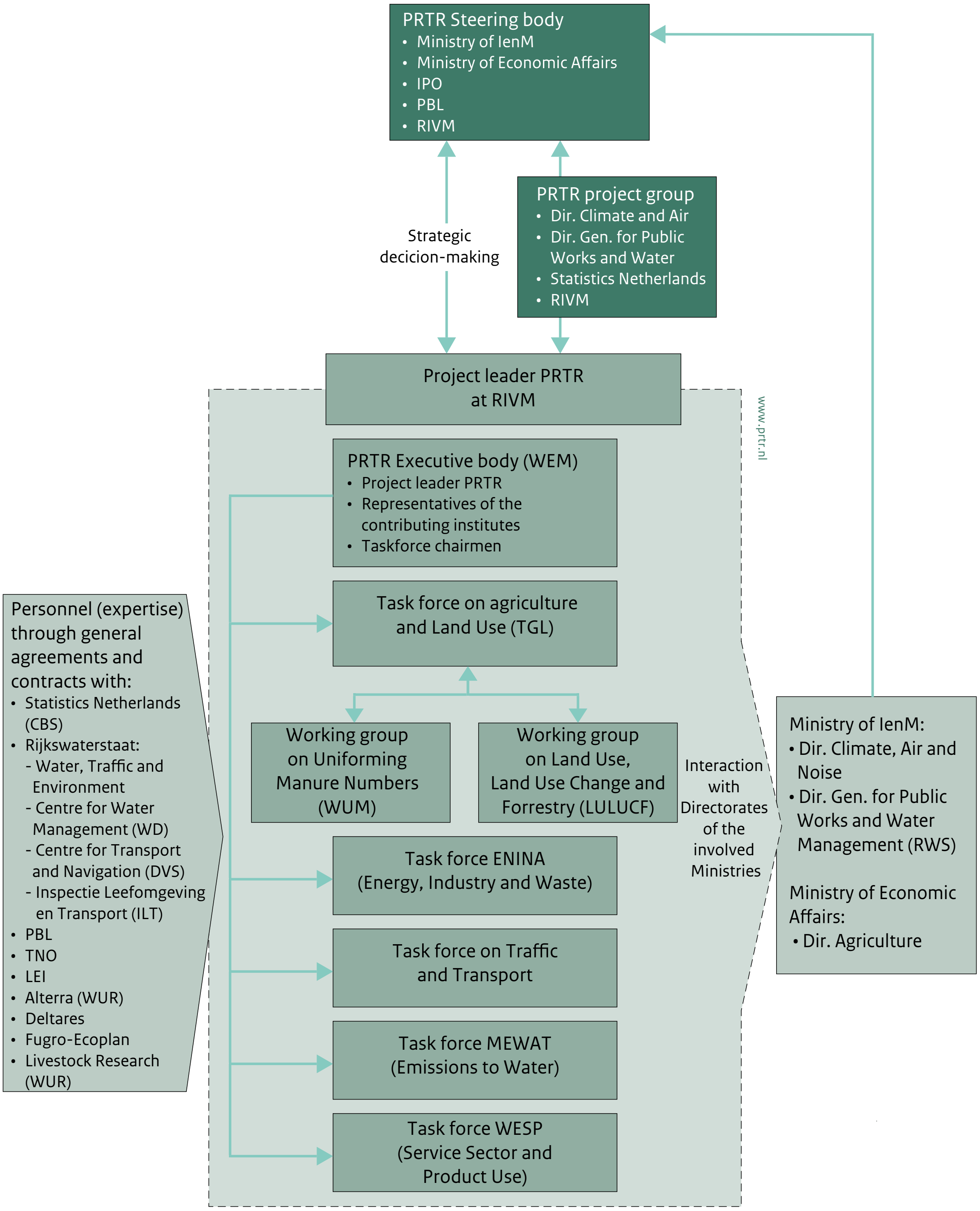
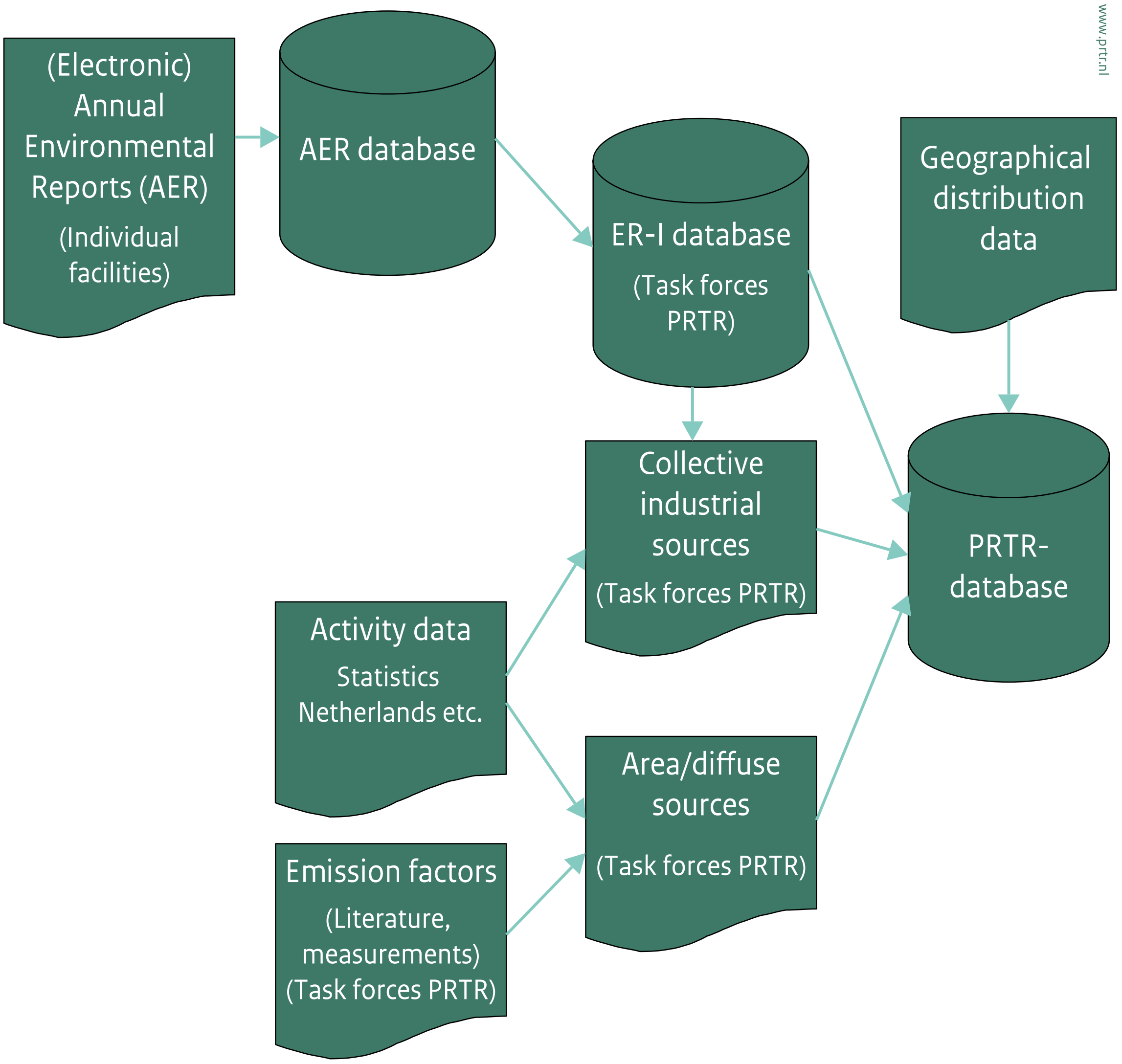


Figure 1.2 The data flow in the Netherlands Pollutant Release and Transfer Register.



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.

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 (www.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 'Cooperation project on industrial emissions').

1.5 Key source analysis

Following recommendations 9 and 10 from the Stage 3 in-depth review report for the Netherlands (UNECE, 2010), 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, 2009). The level assessments were performed for both the latest inventory year 2012, 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, 2013; 2014). The general QA/QC activities meet the international inventory QA/QC requirements described in part A, chapter 6 of the EMEP inventory guidebook (EEA, 2009).

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 2013 inventory the PRTR task forces filled in a standard-format database with emission data from 1990 to 2012. 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 taskforces 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 data processing 2013 and NFR/IIR 2014.

QC item/action	Date	Who	Result	Documentation *
Automated initial check on internal and external data consistency	During each upload	Date 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	25-11-2013	RIVM-PRTR	List of remaining issues/actions from last inventory	Actiepunten voorlopige cijfers 2012 v 25 juli 2013.xls
Input for checking allocations from de PRTR-database to the NFR tables	8-02-2013	RIVM-NIC	List of allocations	NFR-ER-Koppellijst-2013-10-22.xls
Input for checking the integrity of the time series 1990-2012	3-12-2013	RIVM-PRTR	Comparison sheets to check for accidentally changed data in in the time series 1990-2011	historische reeksen vergeleken LUCHT versie 2 december 2013.xls
Input for error checks	2-12-2013	RIVM-PRTR	Comparison sheets 2011-2012 data	Verschiltabel definitieve emissiecijfers 2 december 2013 LUCHT Actueel.xls
Input for trend analysis	02-12-2012	RIVM-PRTR	Updated list of required actions	Actiepuntendefinitieve cijfers 2012 v 2 december 2013.xls
Trend analysis workshops	04-12-2013	Sector specialists, RIVM-PRTR	Explanations for observed trends and actions to resolve before finalising the PRTR dataset	TA-dag NEC plafonds NL 4 dec 2013.xls Trendanalyse verkeer 2013.doc Trendanalyse WESP 2013.ppt Trendanalysedag dec 2013 ENINA.ppt Trendanalyse Landbouw 2013.ppt
Input for resolving the final actions before finalising the PRTR dataset	10-12-2013	RIVM-PRTR	Updated action list	Actiepuntendefinitieve cijfers 2012 v 10 december 2013.xls
Request to the contributing institutes to endorse the PRTR database	14-12-2013 till 17-12-2013	PRTR project secretary, representatives of the contributing institutes	Reactions of the contributing institutes to the PRTR-project leader.	Email with the request Actiepuntendefinitieve cijfers 2012 v 13 december 2013.xls Emails with consent from PBL, CBS and Deltares.
Input for compiling the NEC report (in NFR-format)	16-12-2013	RIVM-NIC	List of allocations for compiling from the PRTR-database to the NFR-tables	NFR-ER-Koppellijst-2013-12-16.xls
Final PRTR dataset	15-1-2014	PRTR project leader	Updated action list	Actiepuntendefinitieve cijfers 2012 v 13 januari 2014.xls
List of allocations for compiling from the PRTR-database to the NFR-tables	6-02-2014	RIVM	Input for compiling the EMEP/LRTAP report (NFR format)	NFR-ER-Koppellijst-2014-02-06.xls

* 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 subsectors. The task forces examine these time series. During the trend analysis for this inventory the emission data were checked in two ways: 1) emissions from 1990 to 2011 from the new time series were compared with the time series of last year's inventory and 2) the data for 2012 were compared with the trend development per gas since 1990. The checks of outliers are performed on a more detailed level of the subcategories 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 gives only 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 7) 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 as suggested by the ERT in their Stage 3 in-depth review will be provided (UNECE, 2010).

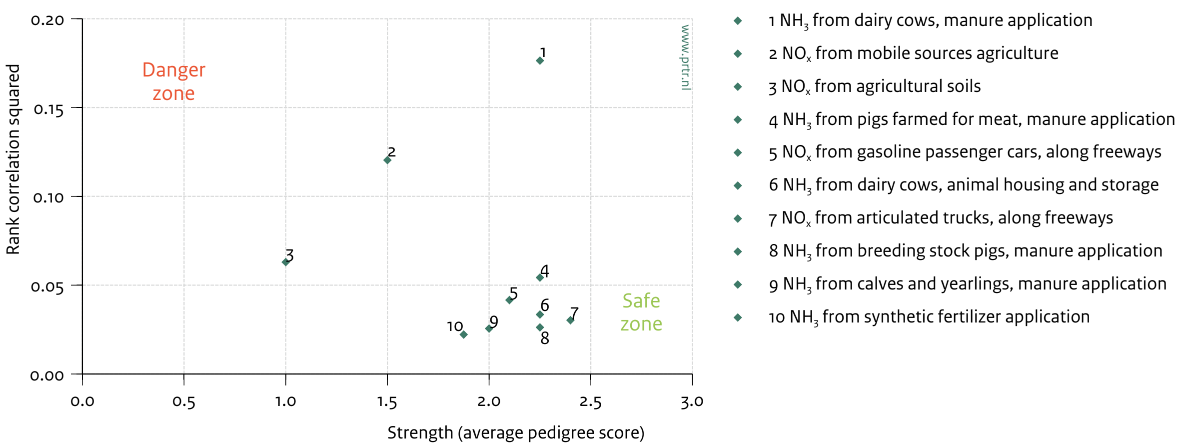
1.7.1 Quantitative uncertainty

Uncertainty estimates on national total emissions have been reported in the Dutch Environmental Balances since 2000 (PBL, 2009). 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

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%

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



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 base. 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.

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).

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.

Table 1.3 The Not Estimated (NE) notation key explained.

NFR code	Substance(s)	Reason for Not Estimated
1A2fii	Cd, Cr, Cu, Ni	Not in PRTR
1A3bv	Cr, Cu, Zn	Not in PRTR
1A3bvii	Cd, Cr, Cu, Ni, Zn	Not in PRTR
1A3c	Cd	Not in PRTR
1A3di(ii)	Cd	Not in PRTR
1A3dii	Cd	Not in PRTR
1A4aii	Cd-Ni, Zn	Not in PRTR
1A4bii	Pb-Cu, Se, Zn	Not in PRTR
1A4cii	Cd-Ni, Zn	Not in PRTR
1A4ciii	Cd	Not in PRTR
1A5b	Cd	Not in PRTR
2B2	NO_x	Not in PRTR
4B	NMVOC	Not in PRTR
4B2	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	Not in PRTR
4B3	TSP, PM_{10}, $PM_{2.5}$	Not in PRTR
4B7	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	Not in PRTR
6A	NH_3	Not in PRTR
6B	NH_3	Not in PRTR
6Cd	NH_3, Pb, Cd, As-Zn, PAHs, HCB	Not in PRTR
1A3aii(ii)	All	Not in PRTR
1A3ai(ii)	All	Not in PRTR

Table 1.4 The Included Elsewhere (IE) notation key explained.

NFR code	Substance(s)	Included in NFR code
1A3aii(i)	All	1A3ai(i)
1A3e	All	1A2fi, 1A4cii, 1B2b
1B1a	TSP, PM_{10}, $PM_{2.5}$	2G
1B2c	NMVOC, TSP, PM_{10}, $PM_{2.5}$, CO	1B2b, 1B2aiv
2A2	NO_x, NMVOC, SO_2	2A7d
2A5	NMVOC	2A7d
2A6	NO_x, NMVOC, SO_2	2A7d
2B1	NMVOC, NH_3	2B5a
2B2	NH_3	2B5a
2B4	NMVOC	2B5a
2C2	All	1A2a
2C5f	All	1A2b
3C	NMVOC	2B5a
4B3	NO_x	4B4
4B9c	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	4B9b
4B9d	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	4B9b
4D1a	NO_x	11C
4D2c	NO_x	11C
4D2c	NH_3	4B
6A	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$, CO, PAHs	1A5a
6B	NO_x, NMVOC, NH_3, TSP, PM_{10}, $PM_{2.5}$, CO, PAHs	1A4ai
6Cc	All	1A1a
6Cd	NO_x, SO_2, NH_3, CO	1A4ai

Table 1.5 Sub-sources accounted for in reporting ‘other’ codes, with NO/NA meaning not occurring or not applicable.

NFR code	Substance(s) reported	Sub-source description
1A2f		combustion (not reported elsewhere) in industries, machineries, services, product-making activities
1A5a		combustion gas from landfills
1A5b		recreational navigation
1B1c		NO/NA
1B3		NO/NA
2A7d		processes, excl. combustion, in building activities, production of building materials
2B5a		production of chemicals, paint, pharmaceutics, soap, detergents, glues and other chemical products
2B5b		NO/NA
2C5e		production of non-ferrous metals
2C5f		NO/NA
2G		making products of wood, plastics, rubber, metal, textiles, paper. Storage and handling
3A3		NO/NA
4B13	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	pets, rabbits and fur-bearing animals
4G	NMVOC, Zn	volatilization of crops and from use of pesticides
6D		handling waste
7A	NO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$	smoking tobacco products and burning candles; transpiration, breathing, manure application to private domains and nature, horses and ponies from private owners
7B		NO/NA
11C	NO_x	volatilization of NO from agricultural and non-agricultural land

1.9 Missing sources

The Netherland’s emission inventory covers all important sources.

2

Trends in emissions

2.1 Trends in national emissions

In 2012, the Dutch NO_x and NH_3 emissions have further decreased below the national emission ceiling set for the year 2010 (NEC2010). For NH_3, SO_2 and NMVOC the Netherlands already complied with the respective ceilings in 2010. The emissions of all substances showed a downward trend in the 1990-2012 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, 66% for PM, 64% for NO_x and 98% for SO_2, despite a growth in road transport of 23%. 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, 1990-2012.

	Main Pollutants					Particulate Matter			Priority Heavy Metals		
	NO_x	CO	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$	Pb	Cd	Hg
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg	Mg	Mg
1990	575	1145	482	192	355	91	69	46	331	2.1	3.5
1995	477	943	341	129	208	69	51	34	154	1.1	1.4
2000	395	792	238	73	162	46	39	24	28	0.9	1.0
2005	337	683	172	64	143	40	33	19	30	1.7	0.9
2010	272	605	168	34	127	34	28	15	38	2.5	0.5
2011	257	583	149	34	125	34	28	14	23	1.1	0.6
2012	248	561	146	34	120	31	27	13	16	0.8	0.5
NEC 2010 ceiling	260		185	50	128						
1990-2012 period 1)	-327	-584	-336	-158	-235	-60	-43	-34	-315	-1.3	-3.0
1990-2012 period 2)	-57%	-51%	-70%	-82%	-66%	-66%	-62%	-72%	-95%	-62%	-84%

1) Absolute difference in Gg

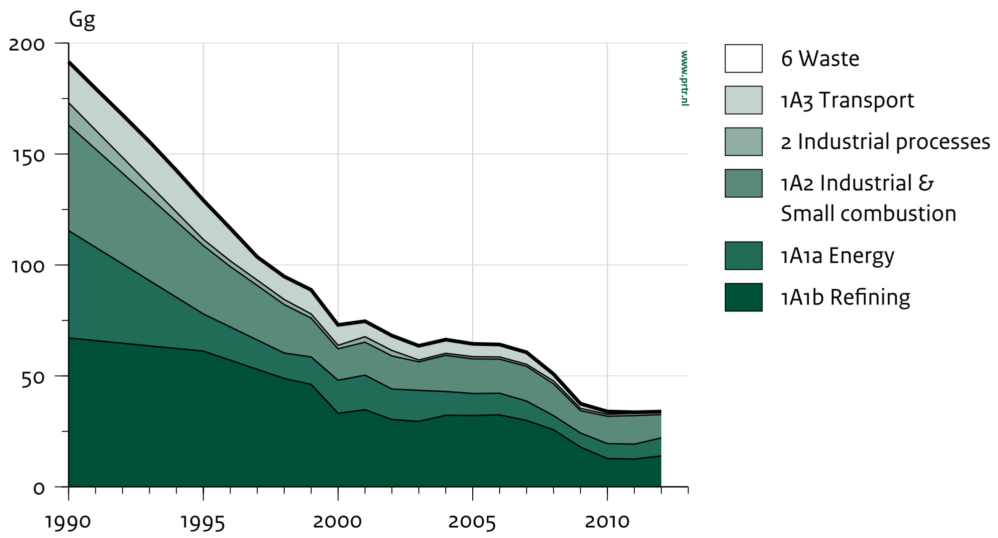
2) Relative difference to 1990 in %

	POPs		Other Heavy Metals					
	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	743	20.1	1.5	11.8	37.2	75.7	0.4	223.1
1995	69	9.8	1.0	8.5	38.5	87.0	0.3	144.4
2000	30	3.8	1.1	4.9	39.6	19.2	0.5	93.5
2005	38	3.8	1.5	4.2	41.5	11.2	2.6	85.7
2010	30	3.7	0.8	3.8	46.9	2.2	1.5	107.9
2011	30	3.8	1.2	3.6	46.4	2.5	0.8	105.1
2012	23	3.5	1.1	3.6	45.1	2.2	0.8	105.7
1990 - 2012 period 1)	-719	-16.2	-0.4	-8.2	7.9	-73.5	0.4	-117.5
1990 - 2012 period 2)	-97%	-81%	-28%	-69%	21%	-97%	104%	-53%

1) Absolute difference in Gg

2) Relative difference to 1990 in %

Figure 2.1. SO_2 emission trend, 1990-2012.



2.2 Trends in sulphur dioxide (SO_2)

The Dutch SO_x emissions (reported as SO_2) decreased by 158 Gg in the 1990-2012 period, corresponding to 82% 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 94% of the national SO_2 emissions.

2.3 Trends in nitrogen oxides (NO_x)

The Dutch NO_x emissions (NO and NO_2, expressed as NO_2) decreased by 327 Gg in the 1990-2012 period, corresponding to 57% of the national total in 1990 (Figure 2.2). Main contributors to this decrease are the road-transport and energy sectors. 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, 1990–2012.

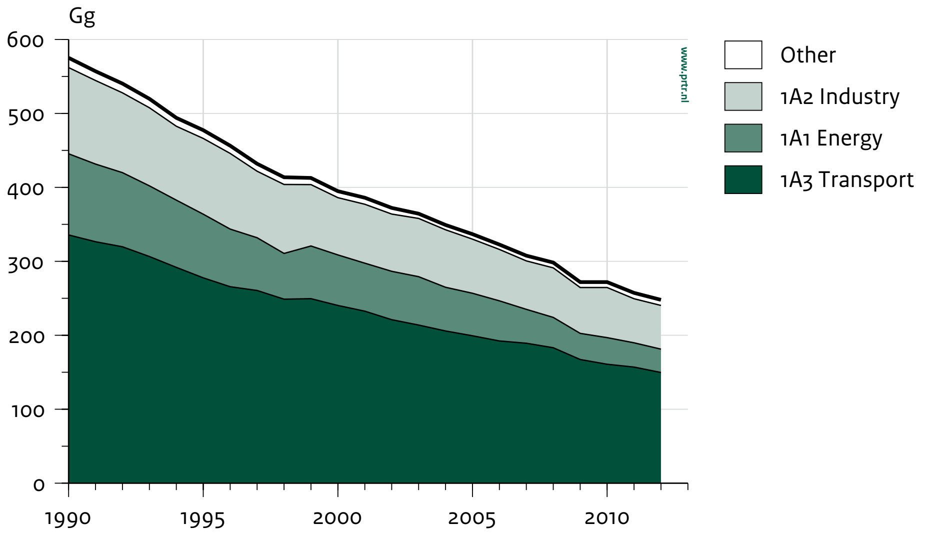
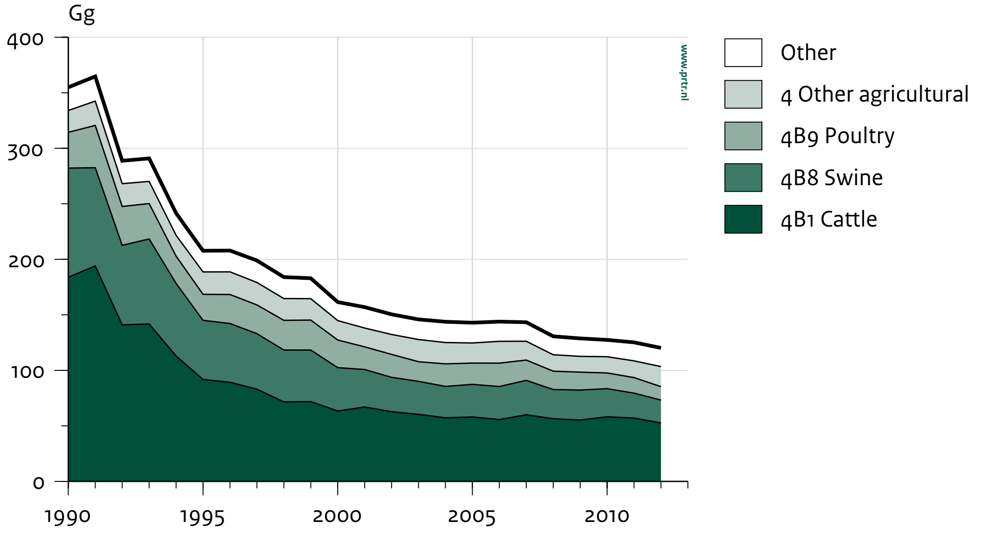


Figure 2.3 NH_3 emission trend, 1990 - 2012.



2.4 Trends in ammonia (NH_3)

The Dutch NH_3 emissions decreased by 235 Gg in the 1990-2012 period, corresponding to 66% of the national total in 1990 (Figure 2.3). This decrease was due to emission reductions from agricultural sources. The direct emissions from animal husbandry decreased slightly because of decreasing animal population and measures to reduce emissions from animal houses. Application emissions decreased because of measures taken to reduce the emissions from applying manure to soil and to reduce the total amount of N applied to soil. At present, 90% of Dutch NH_3 emissions come from agricultural sources.

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

The Dutch NMVOC emissions decreased by 336 Gg in the 1990-2012 period, corresponding with 70% 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, 1990–2012.

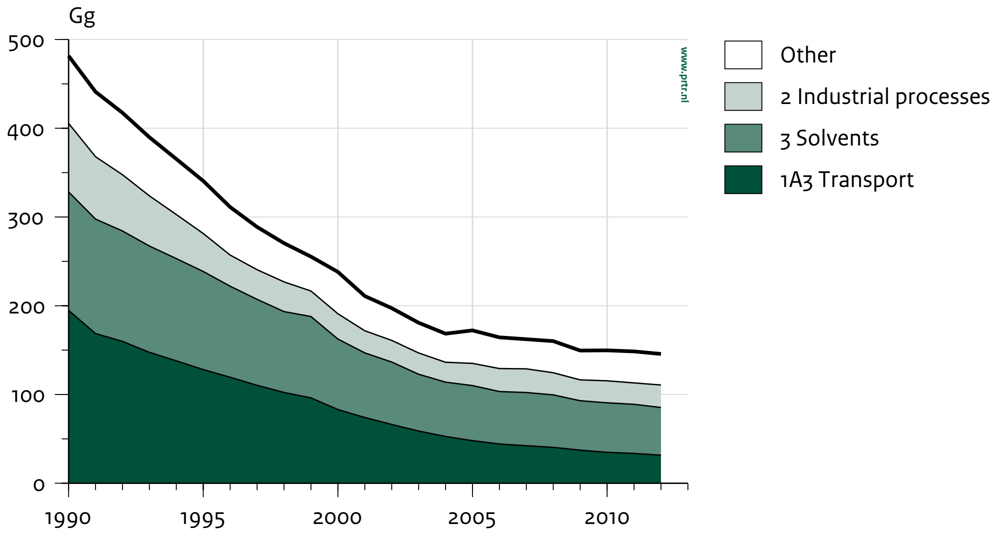
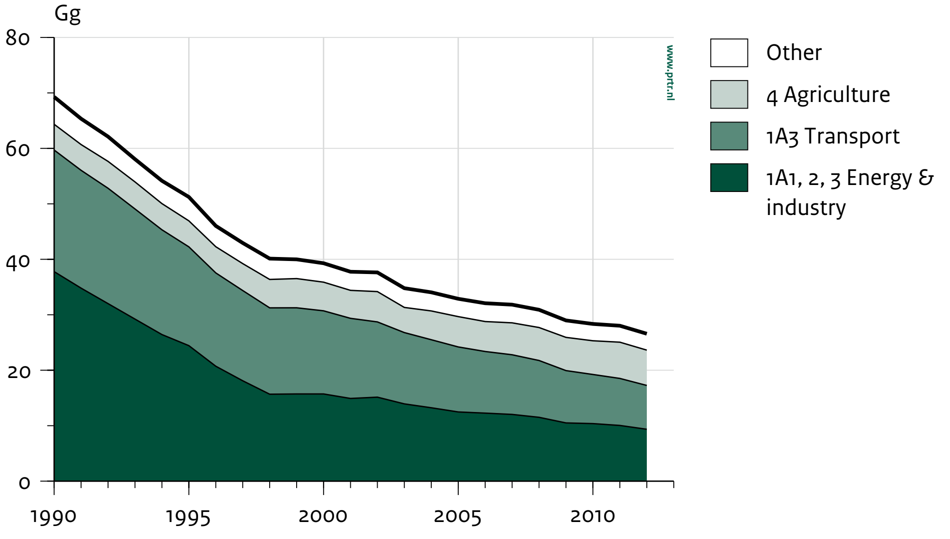


Figure 2.5 PM_{10}, emission trend, 1990–2012.



2.6 Trends in PM_{10}

Dutch PM_{10} emissions decreased by 43 Gg in the 1990-2012 period, corresponding with 62% of the national total in 1990 (Figure 2.5). 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.

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

2.7 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 34 Gg in the 1990-2012 period, corresponding with 72% of the national total in 1990 (Figure 2.6). 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 2.6 $PM_{2.5}$ emission trend, 1990–2012.

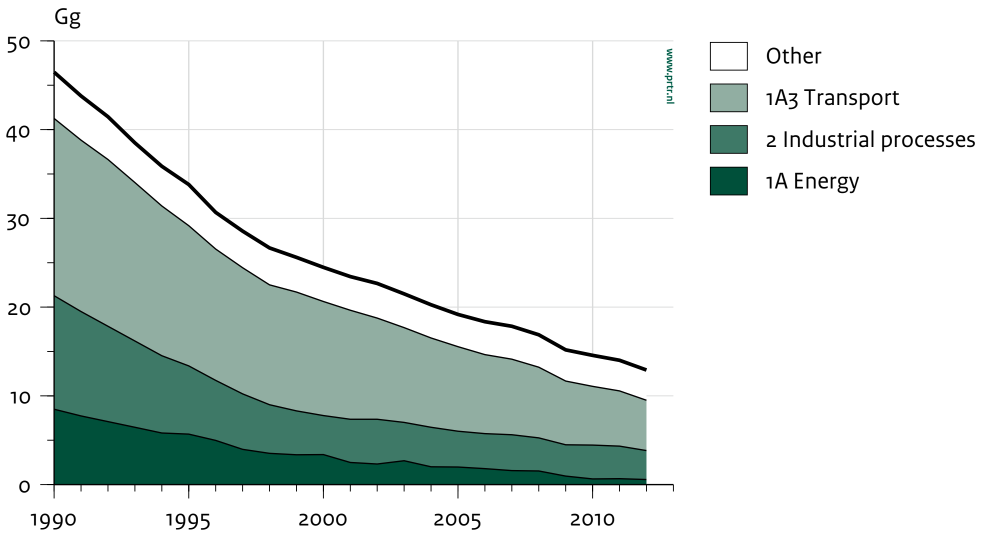
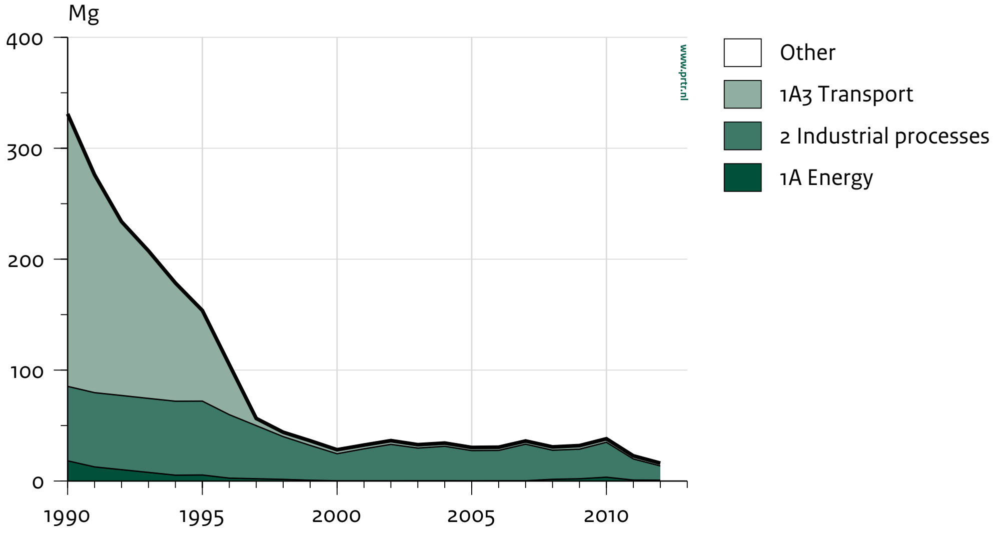


Figure 2.7 Pb, emission trend 1990-2012.



2.8 Trends in Pb

Lead (Pb) emissions in the Netherlands decreased by 315 Mg in the 1990-2012 period, corresponding with 95% 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.

3
Energy

3.1 Overview of the sector

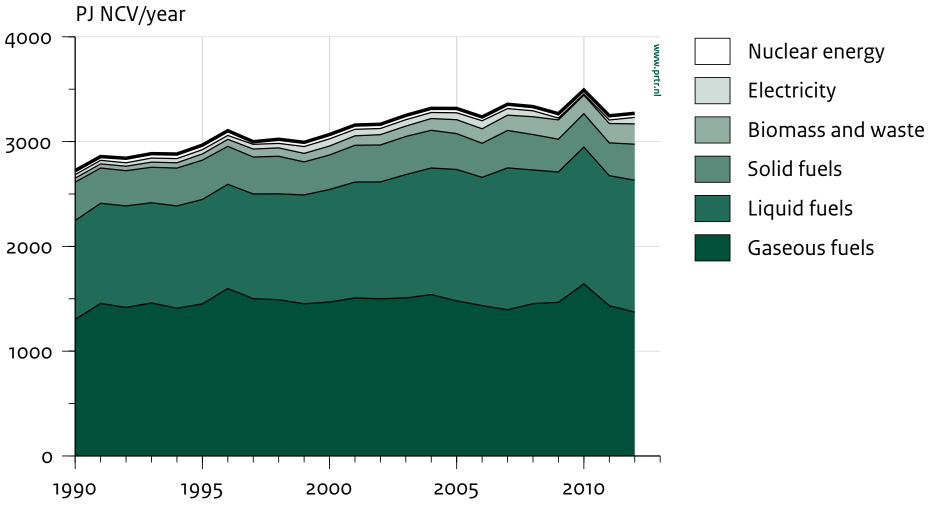
Emissions from this sector include all energy-related emissions from industrial activities and transport. Furthermore, they include fugitive emissions from the energy sector.

About 80% to 100% of the NO_x, SO_2, PM and NH_3 emissions from stationary Combustion (categories 1A1, 1A2, 1A4 and 1A5) are reported based on environmental reports by large industrial companies. The emission data in the Annual Environmental Reports (AERs) come from direct emission measurements or from calculations using fuel input and emission factors.

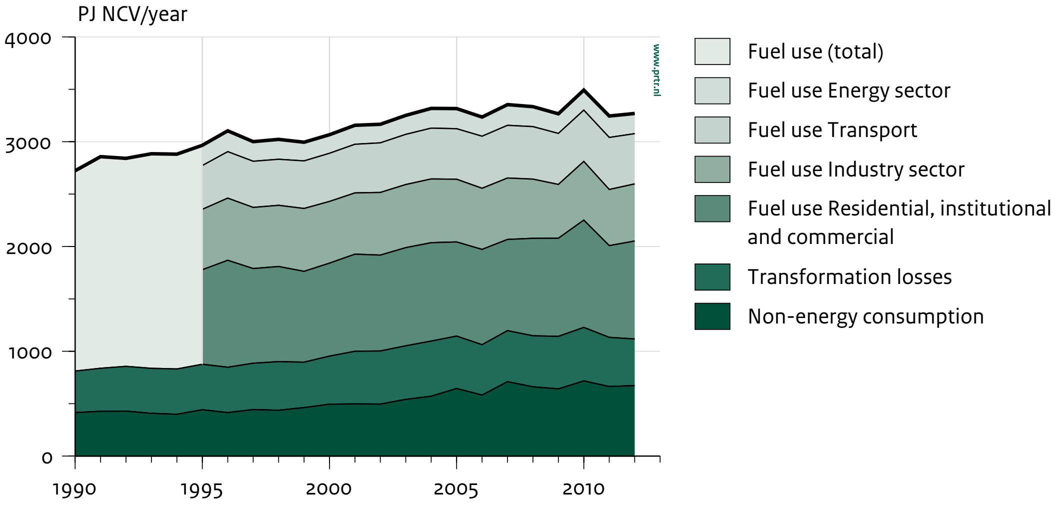
As for most developed countries, the energy system in the Netherlands is largely driven by the Combustion of fossil fuels. In 2012, natural gas supplied about 42.0% of the total primary fuels used in the Netherlands, followed by liquid fuels (38.5%) and solid fossil fuels (10.5%). The contribution of non-fossil fuels, including renewables and waste streams, is rather limited (5.9%). Figure 3.1 shows the energy supply and energy demand in the Netherlands.

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

Energy supply



Energy demand



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 (NFR 1A1a) sector is a key source.

(Sub)category	Pollutant	Contribution to national total in 2012 (%)
1A1a Public electricity and heat production	SO_x	23.9
	NO_x	8.6
	Hg	35.7
	Cd	5.5
	Dioxins	35.7
	HCB	100

The incineration of wastes (with heat recovery) is the only recognized source of HCB emission in the Netherlands.

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

	Main Pollutants					Particulate Matter			Priority Heavy Metals		
	NO_x	CO	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$	Pb	Cd	Hg
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg	Mg	Mg
1990	83	8	0.7	48	0.00	2.46	2.21	1.94	16.34	0.95	1.92
1995	62	7	1.1	17	0.04	0.98	0.62	0.41	1.56	0.16	0.38
2000	52	16	2.2	15	0.04	0.32	0.32	0.25	0.18	0.08	0.40
2005	43	8	0.6	10	0.25	0.82	0.54	0.45	0.24	0.09	0.38
2010	26	5	0.3	7	0.07	0.68	0.34	0.26	0.35	0.18	0.22
2011	23	4	0.3	7	0.08	0.69	0.21	0.18	0.37	0.09	0.22
2012	21	6	1.0	8	0.09	0.71	0.20	0.16	0.42	0.04	0.20
1990 - 2012 period 1)	-60	-4	-0.4	-42	0.08	-1.77	-2.00	-1.76	-15.97	-0.86	-1.70
1990 - 2012 period 2)	-73%	-45%	-56%	-86%		-72%	-91%	-91%	-98%	-91%	-88%

1) Absolute difference in Gg

2) Relative difference to 1990 in %

	POPs		Other Heavy Metals					
	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	568.0	0.17	0.50	0.62	2.05	2.49	0.02	40.66
1995	6.0	0.05	0.20	0.37	0.44	1.41	0.05	3.34
2000	0.1	0.00	0.08	0.19	0.17	0.08	0.45	0.26
2005	0.7	0.01	0.16	0.33	0.28	1.91	1.68	0.44
2010	1.2	0.01	0.11	0.12	0.15	0.16	1.33	11.33
2011	7.6	0.01	0.16	0.12	0.16	0.17	0.71	12.82
2012	1.2	0.02	0.15	0.13	0.23	0.17	0.73	13.45
1990 -2 011 period 1)	-560.4	-0.16	-0.34	-0.50	-1.90	-2.32	0.69	-27.85
1990 - 2012 period 2)	-98.7%	-92%	-68%	-80%	-92%	-93%	3511%	-68%

1) Absolute difference in Gg

2) Relative difference to 1990 in %

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 2012, while fuel consumption increased by 14% over the same period.

The emissions from the main pollutants decreased by 30% to 83%. Emissions from other pollutants decreased by 67% 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.

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, 80% 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.

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.

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

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 NEH (Netherlands Energy Statistics), 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).

$$\text{ER-C Emission}_{\text{(NACE category, fuel type)}} = \text{EF ER-I}_{\text{(NACE category, fuel type)}} * \text{Energy NEH}_{\text{(NACE category, fuel type)}}$$

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).

3.2.6 Uncertainties and time-series consistency

Uncertainties are explained in Section 1.7.

3.2.7 Source-specific QA/QC and verification

The emissions and fuel consumption data in the AERs are systematically examined for inaccuracies by checking the resulting implied emission factors. If environmental reports provide data of high enough quality (see Section 1.3 on QA/QC), the information is used.

3.2.8 Source-specific recalculations

Emissions of the following sources have been recalculated:

- $PM_{2.5}$ emissions of all years and many sources have been recalculated, partly as a result of a new $PM_{2.5}$ fractions and partly as a result of error corrections.
- Emissions of Hexachlorobenzene (HCB) have been recalculated for 1990 and 1995. In the previous submission a default emission factor has been used for the entire time series, but this did not take into account that the Waste combustion installations have reduced their emissions significantly in the earlier years. The mitigation measures which have been implemented for reducing Dioxin emissions will also affect the HCB emissions. Therefore, for the years 1990 and 1995, the HCB emissions have been related to the Dioxin emissions. Emissions have not been recalculated for the year 2000 and after.
- Emissions from Waste combustion and Electricity production have been recalculated for the years 2010 and 2011, based on improved emission data from individual companies.

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'

Table 3.3 Emission factors for Electricity production (g/GJ).

	Natural gas	Biogas	Cokes	Domestic fuel oil	LPG	Petroleum	Coal	Oil fuel
VOC	12	8	91	15	2	10	3	7
SO_2		2	370	87		46	300	450
NO_x	[1]	[1]	[1]	[1]	[1]	[1]	[1]	[1]
CO	15	20	12,437	30	10	10	50	10
PM_{10}	0.15	2	6	4.5	2	1.8	60	22.5
PM coarse			4	0.5		0.2	40	2.5

[1] See table on NO_x emission factors in Van Soest-Vercammen (2002)

- 1A2c ‘Chemicals’
- 1A2d ‘Pulp, paper and printing’
- 1A2e ‘Food Processing, Beverages and Tobacco’
- 1A2fi ‘Other’

The sector 1A2fi 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, 1A2a, 1A2c and 1A2fi 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.

(Sub)category	Pollutant	Contribution to total in 2012 (%)
1A1b Petroleum refining	SO_x	41.1
1A2a Stationary Combustion in manufacturing industries and construction: Iron and steel	SO_x	9.0
	CO	11.3
1A2c Stationary Combustion in manufacturing industries and construction: Chemicals	NO_x	4.6
	CO	2.8
	Cd	9.0
1A2fi Stationary Combustion in manufacturing industries and construction: Other	SO_x	7.4

3.3.3 Overview of shares and trends in emissions

An overview of the trends in emissions is shown in Table 3.5. Emissions have reduced since 1990 for most pollut-

Table 3.5 Overview of trends in emissions from Industrial combustion.

	Main Pollutants					Particulate Matter			Priority Heavy Metals		
	NOx	CO	NMVOC	SOx	NH3	TSP	PM_{10}	$PM_{2.5}$	Pb	Cd	Hg
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg	Mg	Mg
1990	101	267	10.4	110	0.58	8.95	8.12	6.63	1.89	0.14	0.18
1995	78	215	7.7	90	0.33	7.00	6.67	5.30	3.88	0.17	0.08
2000	49	161	2.5	46	0.05	4.88	4.78	3.11	0.04	0.01	0.11
2005	49	154	2.7	46	0.06	2.09	1.88	1.54	0.01	0.00	0.00
2010	40	124	5.1	24	0.45	0.77	0.53	0.38	3.08	1.28	0.02
2011	39	111	5.6	25	0.78	3.17	1.40	1.06	0.51	0.10	0.03
2012	38	105	5.3	24	0.75	0.82	0.55	0.40	0.37	0.07	0.03
1990 - 2012 period [1]	-63	-162	-5.1	-87	0.18	-8.13	-7.57	-6.22	-1.51	-0.06	-0.15
1990 - 2012 period [2]	-62%	-61%	-51%	-78%	30%	-91%	-93%	-94%	-80%	-47%	-83%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

	POPs		Other Heavy Metals					
	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	0.01	1.02	0.17	2.49	1.39	64.60	0.04	2.95
1995	1.02	0.38	0.15	3.14	2.28	79.41	0.05	58.95
2000	0.35	0.00	0.00	0.51	0.15	17.40	0.00	10.30
2005	0.94	0.10	0.78	0.08	0.09	6.50	0.08	0.51
2010	5.79	0.12	0.01	0.14	1.13	0.02	0.12	9.81
2011	0.86	0.09	0.01	0.08	0.46	0.04	0.02	4.74
2012	0.67	0.09	0.01	0.06	0.35	0.05	0.00	2.92
1990 - 2012 period [1]	0.66	-0.93	-0.17	-2.43	-1.05	-64.55	-0.04	-0.02
1990 - 2012 period [2]	6621%	-91%	-97%	-98%	-75%	-100%	-97%	-1%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

ants, 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.

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)
All emission data have been based on AERs and registered in the ER-I database.

Non-ferrous metals (1A2b)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 5% of the NMVOC and NO_x emissions and 2% of the PM emissions are collectively estimated (in 2012).

Chemicals (1A2c)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 5% NO_x emissions and 1% of the PM, CO and NMVOC emissions are collectively estimated (in 2012).

Pulp, paper and print (1A2d)
Emission data have been based on AERs and collectively estimated industrial sources. For this source category, 10% NMVOC emissions, 8% of NOx emissions and 3% of the PM and CO emissions are collectively estimated (in 2012).

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

Other (1A2f)
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 (NEH) and implied emission factors from the environmental reports.

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.

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

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 NEH (Netherlands Energy Statistics), 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).

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

	Natural gas	Biogas	Cokes	Domestic fuel oil	LPG	Petroleum	Coal	Oil fuel
VOC	12	8	91	15	2	10	3	7
SO_2		2	370	87		46	300	450
NO_x	1)	1)	1)	1)	1)	1)	1)	1)
CO	15	20	12,437	30	10	10	50	10
PM_{10}	0.15	2	6	4.5	2	1.8	60	22.5
PM coarse			4	0.5		0.2	40	2.5

1) see table on NOx emission factors in Van Soest-Vercammen et al. (2002)

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).

$$\text{ER-C Emission}_{\text{(NACE category, fuel type)}} = \text{EF ER-I}_{\text{(NACE category, fuel type)}} * \text{Energy NEH}_{\text{(NACE category, fuel type)}}$$

3.3.6 Uncertainties and time-series consistency

Uncertainties are explained in Section 1.7.

3.3.7 Source-specific QA/QC and verification

The emissions and fuel consumption data in the AERs were systematically examined for inaccuracies by checking the resulting implied emission factors. If the environmental reports provided data of high enough quality (see Section 1.3 on QA/QC), the information was used.

3.3.8 Source-specific recalculations

Emissions of the following sources have been recalculated:

- $PM_{2.5}$ emissions of all years and many sources have been recalculated, partly as a result of a new $PM_{2.5}$ fractions and partly as a result of error corrections
- Emissions from fuel use in the sectors Oil and gas production (1A1c), Metal production (1A2a), Chemical industry (A2c), Food industry (1A2e) and other industries (1A2fi) have been recalculated for the years 2010 and 2011, based on improved emission data from individual companies.
- Emissions from Metal production have been reallocated between categories 1A2a and 2C for all years after a correction in the split between combustion and process emissions.

3.3.9 Source-specific planned improvements

There are no source-specific planned improvements.

3.4 Small combustion (1A4ai, 1A4bi, 1A4ci and 1A5a)

3.4.1 Source-category description

Source category 1A4 'Other sectors' comprises the following subcategories:

- 1A4ai 'Commercial and institutional services'. 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'. This sector refers to domestic fuel consumption for space heating, water heating and cooking. About three-quarters of the sectors' consumption of natural gas is used by space heating.
- 1A4ci 'Agriculture, forestry and fisheries'. 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.

(Sub)category	Pollutant	Contribution to total in 2012 (%)
1A4ai Commercial/ institutional, stationary	NO_x	4.4
1A4bi Residential, stationary	NO_x	3.7
	NMVOC	6.2
	CO	10.3
	TSP	10.8
	PM_{10}	6.0
	$PM_{2.5}$	11.7
	Dioxins	23.5
	PAH	82.6
1A4ci Agriculture/forestry/ fishing, stationary	NO_x	4.5

3.4.3 Overview of shares and trends in emissions

An overview of the trends in emissions is shown in Table 3.8. Emissions of all pollutants have decreased since 1990, while fuel use increased by 4%.

Table 3.8 Overview of trends in emissions from Small combustion sources.

	Main Pollutants					Particulate Matter		Priority Heavy Metals		
	NO_x	CO	NMVOC	SO_x	TSP	PM_{10}	$PM_{2.5}$	Pb	Cd	Hg
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg	Mg	Mg
1990	14	3	1.1	2	0.38	0.35	0.31	0.63	0.03	0.09
1995	14	3	1.1	1	0.09	0.08	0.07	0.03	0.00	0.01
2000	13	3	0.9	1	0.03	0.03	0.03	0.00	0.00	0.00
2005	12	3	1.1	0	0.10	0.09	0.08	0.01	0.00	0.00
2010	14	4	1.4	0	0.05	0.05	0.05	0.00	0.00	0.00
2011	10	3	1.1	0	0.07	0.05	0.05	0.00	0.00	0.00
2012	11	3	1.2	0	0.05	0.05	0.05	0.00	0.00	0.00
1990 - 2012 period ¹⁾	-3	0	0.1	-2	-0.33	-0.30	-0.26	-0.63	-0.03	-0.09
1990 - 2012 period ²⁾	-19%	9%	5%	-95%	-87%	-86%	-85%	-100%	-100%	-100%

¹⁾ Absolute difference in Gg

²⁾ Relative difference to 1990 in %

	POPs		Other Heavy Metals				
	DIOX	PAH	As	Cr	Cu	Ni	Zn
Year	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg
1990	100.02	0.47	0.01	3.53	0.39	2.97	1.14
1995	0.20	0.06	0.01	0.05	0.03	0.92	0.07
2000	0.00	0.00	0.00	0.00	0.00	0.02	0.00
2005	0.01	0.01	0.00	0.01	0.01	0.31	0.02
2010	0.01	0.01	0.00	0.00	0.00	0.02	0.00
2011	0.01	0.01	0.00	0.00	0.00	0.02	0.01
2012	0.01	0.01	0.00	0.00	0.00	0.02	0.00
1990 - 2012 period ¹⁾	-100.01	-0.46	-0.01	-3.53	-0.39	-2.95	-1.14
1990 - 2012 period ²⁾	-100%	-97%	-98%	-100%	-100%	-99%	-100%

¹⁾ Absolute difference in Gg

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 (Statistics Netherlands) and emission factors (see Table 3.9).

Residential (1A4bi)
Combustion emissions from central heating, hot water and cooking have been based on fuel consumption data (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.

Table 3.9 Emission factors for Stationary combustion emissions from the services sector and agriculture (g/GJ).

	Natural gas	Domestic fuel oil	LPG	Paraffin oil	Coal	Oil fuel
VOC	30	10	2	10	35	10
SO_2	0.22	87	0.22	4.6	460	450
NO_x	¹⁾	50	40	50	300	125
CO	10	10	10	10	100	10
Black carbon		5	10	2		50
Fly ash					100	
PM_{10}	0.15	4.5	2	1.8	2	45
PM coarse		0.5		0.2	80	5

¹⁾ see table on NO_x emission factors in Van Soest-Vercammen *et al.* (2002)

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

	Natural gas	Domestic fuel oil	LPG	Paraffin oil	Coal
VOC	6.3	15	2	10	60
SO_2	0.22	87	0.22	4.6	420
NO_x	1)	50	40	50	75
CO	15.8	60	10	10	1,500
Black carbon	0.3	5	10	2	
Fly ash					200
PM_{10}	0.3	4.5	2	1.8	120
PM coarse		0.5		0.2	80

1) see table on NO_x emission factors in Van Soest-Vercammen *et al.* (2002)

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).

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 (LEI), and emission factors (Table 3.9).

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 time-series consistency

Uncertainties are explained in Section 1.7.

3.4.7 Source-specific QA/QC and verification

General QA/QC is explained in Section 1.3.

3.4.8 Source-specific recalculations

Emissions of the following sources have been recalculated:
- $PM_{2.5}$ emissions of all years and many sources have been recalculated, partly as a result of a new $PM_{2.5}$ fractions and partly as a result of error corrections.
- Activity data for the institutional sector (1A4ai), the residential sector (1A4bi) and the agricultural sector (1A4ci) have been updated for the years 2010 and 2011, and the emissions have been recalculated based on the new activity data.
- Emission factors of NOx have been updated for the use of natural gas in the Residential sector (1A4b) and the Agricultural sector (1A4c).

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 'Oil and gas production'
- 1B2aiv 'Refining'
- 1B2b 'Gas transport and gas distribution'

3.5.2 Key sources

The Fugitive emissions sector is a key source for the pollutants presented in Table 3.11.

Table 3.11 Pollutants for which the Fugitive emissions (NFR 1B sector) is a key source.

(Sub)category	Pollutant	Contribution to total in 2012 (%)
1B2ai Oil and gas production	NMVOC	4.1
1B2av Refining	NMVOC	5.9

3.5.3 Overview of shares and trends in emissions

An overview of the trends in emissions is shown in Table 3.12. The emissions from NMVOC decreased between 1990 and 2012.

Table 3.12 Overview of trends in emissions from Fugitives (NFR 1B).

Year	NMVOC Gg	PAH Mg
1990	47.3	0.01
1995	33.6	0.02
2000	29.3	0.00
2005	21.0	0.04
2010	15.4	0.00
2011	17.0	0.00
2012	16.2	0.00
1990 - 2012 period (1)	-31.1	-0.01
1990 - 2012 period (2)	-66%	-100%

(1) Absolute difference in Gg

(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 time-series consistency

Uncertainties are explained in Section 1.7.

3.5.7 Source-specific QA/QC and verification

General QA/QC is explained in Section 1.3.

3.5.8 Source-specific recalculations

Emissions of the following sources have been recalculated:

- Emissions from fuel use in the sectors Oil and gas production (1B2ai) have been recalculated for the years 2010, based on improved emission data from individual companies.

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 national emissions of NO_x, NMVOC, CO, TSP, PM_{10} and $PM_{2.5}$. Emissions of most compounds have decreased throughout the time series, mainly due to the tightening of European emission standards for new road vehicles. The source category 1A3 'Transport' comprises the following subcategories: Civil aviation (1A3a), Road Transport (1A3b), Railways (1A3c) and Waterborne navigation (1A3d). Table 4.1 gives an overview of the Transport sector and the methodologies used for calculating emissions from the different source categories within the sector. For all four source categories, national activity data and (mostly) country-specific emission factors were used. Emissions from Civil aviation, Road transport and Waterborne navigation were calculated based on fuel used, whereas emissions from railways were calculated using fuel sales data.

This chapter also covers emissions from 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. 1A2fiii, 1A4aii, 1A4bii, 1A4cii), as shown in Table 4.1. Emissions from Non-road mobile machinery were calculated using a Tier 3 method based on fuel used, using national activity data and for the most part country-specific emission factors. Emissions from recreational craft were reported under 1A5b 'Other, mobile' and were calculated using a Tier 3 methodology. Emissions from fisheries were reported under 1A4c iii 'National fishing' and were also calculated using a Tier 3 method.

In this chapter, trends and shares in emissions of the different source categories within the transport sector are described. 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.* (2014).

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 2012 level and the trend (in italics) assessment. Some source categories are key sources for both the trend and the 2012 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 4.1 Source categories and methods for 1A3 Transport and for other transport related source categories.

NFR code	Source category description	Method	AD	EF	Basis
1A3a	Civil aviation	Tier 3	NS	CS	Fuel used
1A3b	Road transport	Tier 3	NS	CS	Fuel used
1A3c	Railways	Tier 2	NS	CS	Fuel sold
1A3d	Waterborne navigation	Tier 3	NS	CS	Fuel used
1A2fii	Mobile combustion in manufacturing industries and construction	Tier 3	NS	CS	Fuel used
1A4aii	Commercial/institutional land-based mobile machinery	Tier 3	NS	CS	Fuel used
1A4bii	Residential: household and gardening (land-based mobile machinery)	Tier 3	NS	CS	Fuel used
1A4cii	Agriculture/forestry/fishing: off-road vehicles and other machinery	Tier 3	NS	CS	Fuel used
1A4ciii	National fishing	Tier 3	NS	CS	Fuel used
1A5b	Other, mobile (including military, land based and recreational boats)	Tier 3	NS	CS	Fuel used

NS = National Statistics
CS = Country-specific

Table 4.2 Key source analysis for the Transport sector. Percentages in italic are from the trend contribution calculation.

NFR code	Source category description	SO_2	NO_x	NH_3	NMVOC	CO	TSP	PM_{10}	$PM_{2.5}$	Pb
1A3ai(i)	International aviation (LTO)									10.7%
1A3bi	Passenger cars	*4.9%*	*28.2%*	*4.5%*	*18.3%*	*43.9%*	*3.9%*	*4.8%*	*9.6%*	*45.0%*
1A3bii	Light-duty trucks		5.5%		*2.7%*	*9.1%*	*3.8%*	4.5%	*9.2%*	
1A3biii	Heavy-duty vehicles	*8.7%*	19.1%		*1.9%*		5.6%	*7.5%*	*10.1%*	
1A3biv	Motorcycles and mopeds				4.2%	5.3%				
1A3bv	Gasoline evaporation				*10.1%*					
1A3bvi	Tyre and brake wear						4.8%	5.3%	2.4%	
1A3bvii	Road abrasion						*4.0%*	*4.3%*		
1A3di(ii)	International inland waterways		7.2%						4.0%	
1A3dii	National navigation		*5.7%*						*3.2%*	
1A2fii	Mobile combustion in manufacturing industries and construction		4.0%						2.9%	
1A4aii	Commercial/institutional mobile					*4.9%*				
1A4bii	Residential household gardening (mobile)					*10.7%*				
1A4cii	Agriculture/forestry/fishing: off-road vehicles and other machinery		3.7%							
1A5b	Other, mobile (including military, land based and recreational boats)					*6.7%*				

4.2 Civil aviation (1A3a)

4.2.1 Source category description

The source category 1A3a 'Civil aviation' comprises emissions from all landing and take-off cycles (LTO) from Domestic (1A3aii) and International (1A3ai) aviation in the Netherlands, excluding military aviation. It also includes emissions from auxiliary power units (APU) and general power units (GPU) used at Amsterdam Airport Schiphol, and emissions from the storage and transfer of kerosene. It does not include emissions from vehicles with combustion engines operating at airports (platform traffic), since these vehicles are classified as mobile machinery. Cruise emissions of Domestic and International aviation (i.e. all emissions occurring above 3,000 ft.) are not part of the national totals and are not estimated.

Table 4.3 Trends in emissions for 1A3a Civil aviation.

	Main Pollutants				Particulate Matter			Priority Heavy Metals	POPs	
	NO_x	CO	NMVOC	SO_x	TSP	PM_{10}	$PM_{2.5}$	Pb	DIOX	PAH
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg	g I-Teq	Mg
1990	1.36	4.32	0.41	0.11	0.034	0.034	0.030	3.49	0.0099	0.0012
1995	1.80	4.73	0.38	0.15	0.043	0.043	0.036	3.73	0.0089	0.0011
2000	2.45	4.36	0.28	0.21	0.051	0.051	0.042	2.86	0.0066	0.0008
2005	2.83	3.85	0.25	0.10	0.053	0.053	0.042	2.02	0.0061	0.0007
2010	2.79	4.15	0.25	0.09	0.052	0.052	0.040	2.34	0.0058	0.0007
2011	2.93	3.90	0.25	0.10	0.056	0.056	0.043	2.01	0.0062	0.0008
2012	2.95	3.64	0.25	0.10	0.061	0.061	0.044	1.73	0.0063	0.0008
1990 - 2012 period (1)	1.59	-0.68	-0.16	-0.01	0.027	0.027	0.014	-1.76	-0.0040	-0.0005
1990 - 2012 period (2)	117%	-16%	-38%	-11%	79%	79%	48%	-50%	-41%	-38%

1) Absolute difference in Gg

2) Relative difference to 1990 in %

4.2.2 Key sources

International Civil aviation is a key source for lead (2012 level) in the emission inventory.

4.2.3 Overview of shares and trends in emissions

Fuel consumption in Civil aviation (including APU/GPU) has more than doubled between 1990 and 2012, increasing from 4.9 to 10.0 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 2012, total (LTO and APU/GPU) fuel consumption by Civil aviation at Schiphol Airport decreased slightly (-1%). These trends are in line with the trend in the number of flights at Schiphol (+8% between 2009 and 2012).

Fuel consumption in 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 0.8 PJ in 2012. 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 92% since 2003 to 1.2 million in 2012, whereas the number of air passengers at Eindhoven Airport increased from 0.4 million to 3.0 million in this time span.

The trends in emissions from Civil aviation in the Netherlands are shown in Table 4.3. The increase in air transport and associated (LTO and APU/GPU) fuel consumption in the past 22 years has led to an increase in emissions of NO_x, TSP, PM_{10} and $PM_{2.5}$. Fleet average NO_x emission factors have not changed significantly throughout the time series, therefore NO_x emissions have more than doubled between 1990 and 2012, following the trend in fuel consumption. Fleet average PM_{10} emission factors (per unit of fuel) have decreased significantly (+/-30%) since 1990, but since total fuel consumption more than doubled between 1990 and 2012 total PM exhaust emissions also increased throughout the time series. PM_{10} emissions due to tyre and brake wear increased by 180% between 1990 and 2012, in line with the increase in the number of landings and take-offs combined with the increased maximum permissible take-off weight (MTOW) of the airplanes. The share of tyre and brake wear emissions in total PM_{10} emissions from Civil aviation increased from 14% to 25% between 1990 and 2012.

Civil aviation is a small emission source in the Netherlands and is only a key source for Pb. Aviation gasoline still contains Pb, whereas gasoline for other transport purposes has been unleaded for quite some time. With Pb emissions from other source categories decreasing substantially, the share of Civil aviation in Pb emissions in the Netherlands increased to 11% in 2012, thereby becoming a key source in the 2012 level assessment. The share of Civil aviation in total emissions of NO_x (1%) and other substances (<1%) in the Netherlands is small.

4.2.4 Activity data and (implied) emission factors

The combustion emissions of CO, NMVOC, NO_x, PM, SO_2 and heavy metals from Civil aviation in the Netherlands were calculated using a 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 from TNO to calculate fuel consumption and resulting emissions (see also Klein *et al.*, 2014). 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 (http://www.caa.co.uk/default.aspx?catid=702). The EMASA database also contains a number of emission factors for smaller engines determined by the EPA and published in the AP42 (EPA, 1985).

Per group of aircraft engines the PM emission factors were calculated from Smoke Numbers according to the method described in Kugele *et al.* (2005). Subsequently, the figures were doubled because of the OC fraction in aircraft PM (Agrawal *et al.*, 2008). The $PM_{2.5}/PM_{10}$ ratio for combustion emissions is assumed to be 1.0. The 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). Emissions of different VOC and PAH species were calculated using species profiles as reported in Klein *et al*. (2014).

The durations of the different flight modes (except the Idle mode) were derived from the 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.

4.2.5 Methodological issues

Due to a lack of data, the split of aviation 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 1A3i 'International aviation'.

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 for Civil aviation.

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 is good.

4.2.8 Source-specific recalculations

In this year's submission, the emissions of helicopters are recalculated using recent insights on emission factors for most commercial helicopters that are in use nowadays. These emission factors were derived from Rindlisbacher (2009) and specified by flight phase. Up until last year, emissions of helicopters were calculated using a much smaller set of emission factors derived from EPA (1978). Since helicopters are only a minor source of emissions within Civil aviation, the impact of the recalculation on emission totals is small. PM_{10} and $PM_{2.5}$ emissions by Civil aviation are approximately 1-2% lower throughout the time series, compared to last year's submission. CO and NMVOC emissions are 1-3% higher than previously reported. NO_x emissions are approximately 1-2% higher in recent years of the time series.

4.2.9 Source-specific planned improvements

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

4.3 Road transport (1A3b)

4.3.1 Source category description

The source category 1A3b 'Road transport' comprises all emissions from road traffic in the Netherlands, including emissions from Passenger cars (1A3bi), Light-duty trucks (1A3bii), Heavy-duty vehicles (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 are not included.

Table 4.4 Key source analysis for Road transport subcategories.

Source category		1990 level	2012 level	1990 - 2012 trend
1A3b i	Passenger cars	NO_x, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Pb, PAH	NO_x, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	NO_x, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Pb, SO_2, NH_3
1A3b ii	Light duty vehicles	NO_x, CO, TSP, PM_{10}, $PM_{2.5}$	NO_x, TSP, PM_{10}, $PM_{2.5}$	NO_x, NMVOC, CO, $PM_{2.5}$
1A3b iii	Heavy-duty vehicles	SO_2, NO_x, TSP, PM_{10}, $PM_{2.5}$	NO_x, $PM_{2.5}$	SO_2, NO_x, NMVOC, TSP, PM_{10}, $PM_{2.5}$
1A3b iv	Mopeds and motorcycles	NMVOC, CO	NMVOC, CO	CO
1A3b v	Gasoline evaporation	NMVOC		NMVOC
1A3b vi	Tyre and brake wear		TSP, PM_{10}	TSP, PM_{10}, $PM_{2.5}$
1A3b vii	Road abrasion		TSP, PM_{10}	TSP, PM_{10}

Table 4.5 Trends in emissions from 1A3b Road transport.

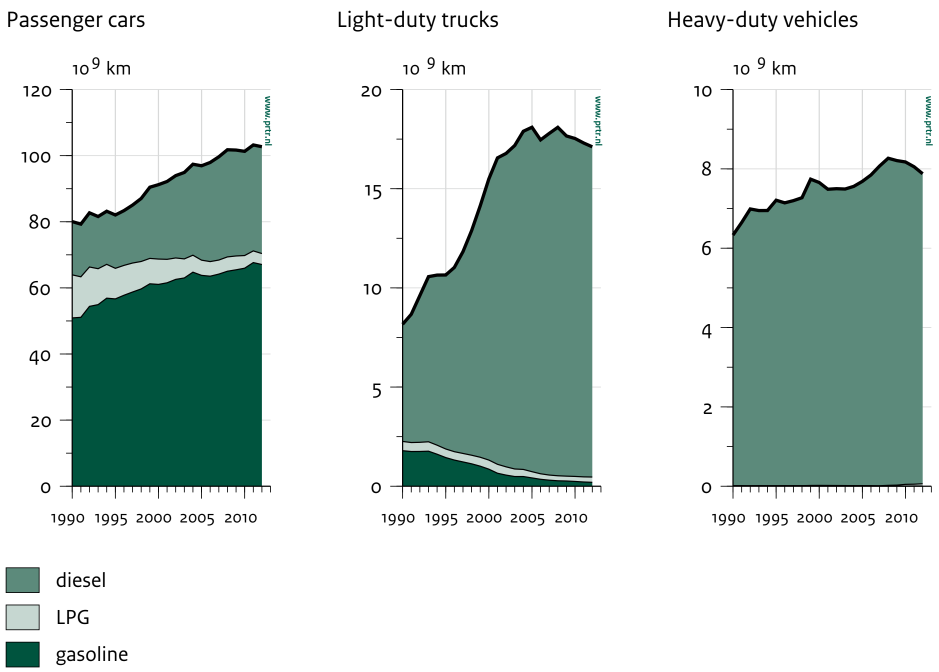
	Main Pollutants					Particulate Matter			Priority Heavy Metals	
	NO_x	CO	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$	Pb	Cd
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg	Mg
1990	252	717	180.6	13	0.90	16.8	16.8	15.1	240.9	0.03
1995	193	551	112.7	12	1.89	13.1	13.1	11.3	77.5	0.03
2000	152	461	68.1	3	2.58	10.7	10.7	8.7	0.3	0.04
2005	124	368	36.0	0	2.55	8.5	8.5	6.5	0.3	0.04
2010	101	320	26.1	0	2.54	6.6	6.6	4.4	0.3	0.04
2011	96	312	25.2	0	2.57	6.2	6.2	4.1	0.3	0.04
2012	89	295	23.6	0	2.52	5.7	5.7	3.6	0.3	0.04
1990 - 2012 period [1]	-162	-422	-157.0	-12	1.63	-11.1	-11.1	-11.5	-240.5	0.01
1990 - 2012 period [2]	-64%	-59%	-87%	-98%	182%	-66%	-66%	-76%	-100%	31%

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

	POPs		Other Heavy Metals					
	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	
1990	2.27	1.54	0.16	2.04	20.1	0.65	0.01	32.0
1995	1.34	1.07	0.17	2.01	19.7	0.66	0.01	33.4
2000	0.70	0.69	0.20	2.02	19.7	0.68	0.01	36.8
2005	0.48	0.41	0.21	2.15	20.9	0.72	0.01	39.1
2010	0.32	0.30	0.22	2.23	21.7	0.75	0.01	40.5
2011	0.31	0.28	0.22	2.25	21.9	0.76	0.01	40.9
2012	0.28	0.25	0.22	2.23	21.7	0.75	0.01	40.6
1990 - 2012 period [1]	-1.99	-1.29	0.06	0.19	1.6	0.10	0.00	8.6
1990 - 2012 period [2]	-88%	-84%	36%	9%	8%	15%	29%	27%

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

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



4.3.2 Key sources

The different subcategories within Road transport are key sources for many substances in both the trend assessment and the 1990 and 2012 level assessment, as is shown in Table 4.4.

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 36% of total NO_x emissions (national totals), 21% of PM_{10}, 28% of $PM_{2.5}$, 16% of NMVOC and 53% of CO in the Netherlands in 2012. The trends in emissions from Road transport are shown in Table 4.5.

Emissions from the main pollutants and particulate matter have all decreased significantly throughout the time series with the exception of NH_3. The introduction and subsequent tightening of EU emission standards for new road vehicles have mainly caused this decrease in emissions. Even though emission totals decreased throughout the time series, the share of Road transport in the national totals for NO_x, PM_{10} and $PM_{2.5}$ decreased only slightly between 1990 and 2012 as emissions in other sectors also decreased. The share of Road transport in the national totals did decrease for NMVOC (37% in 1990, 16% in 2012), CO (63% to 53%) and Pb (73% to 2%).

Emissions of SO_2 decreased by 98% between 1990 and 2012 due to the tightening of the EU fuel quality standards regulating the maximum allowable sulphur content for 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_2 emissions decreased subsequently from 7% in 1990 to less than 1% in 2012.

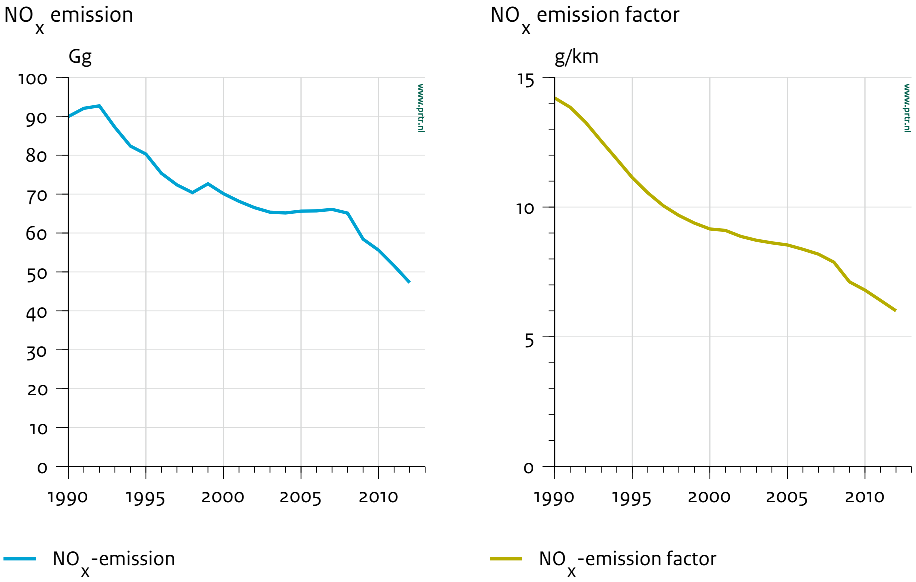
Emissions of NH_3 by Road transport have increased significantly between 1990 and 2000 due to the introduction and subsequent market penetration of the three-way catalyst (TWC) for gasoline Passenger cars. Since 2000, NH_3 emissions from Road transport have more or less stabilized. Road transport is only a minor source of NH_3 emissions with a share of 2% in national totals in 2012. Within Road transport categories, there was no key source for NH_3 in the 2012 level assessment, although Passenger cars were a key source in the trend assessment.

Emissions from heavy metals have increased, with the exception of Pb. Road transport, however, is not a key source for emissions of heavy metals. Again, Pb emissions from Passenger cars are the only exception, as a key source in the 1990 level assessment and the 1990-2012 trend assessment.

1A3bi Passenger cars

The total number of kilometres driven by Passenger cars in the Netherlands has steadily increased from approximate-

Figure 4.2 NO_x emissions and NO_x emission factors of Heavy-duty vehicles in the Netherlands.

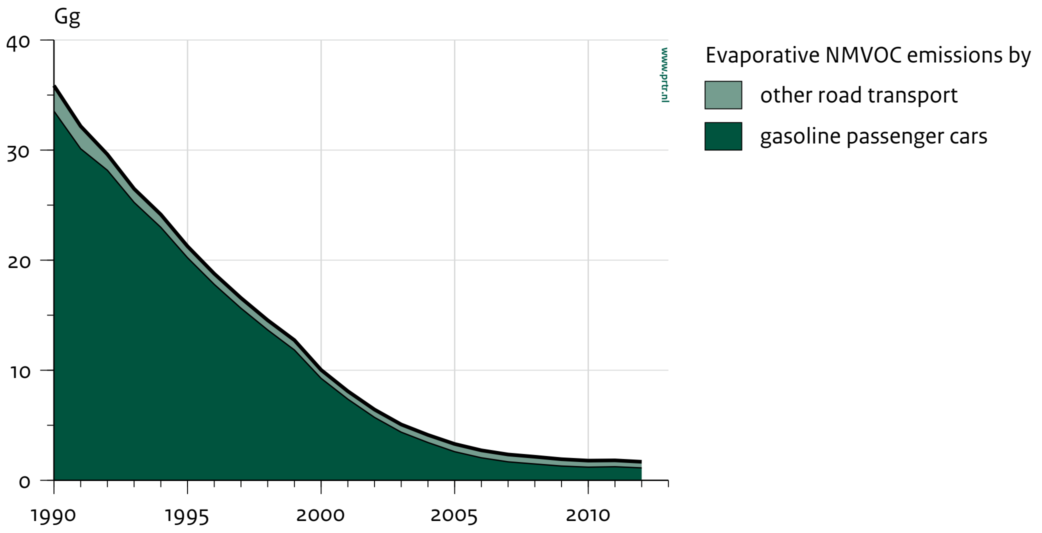


ly 80 billion in 1990 to 103 billion in 2012 (see Figure 4.1). The number of diesel kilometres has grown the fastest: since 1995, the share of diesel-powered Passenger cars in the Dutch car fleet has grown significantly, leading to an increase in diesel mileages by 100% between 1995 and 2012. In comparison: gasoline mileages have increased by 18% in the same time span. The share of LPG cars in the passenger car fleet has decreased significantly, leading to a decrease in LPG mileages by 75% between 1990 and 2012. Figure 4.1 shows that even though the number of diesel kilometres has increased significantly, gasoline cars still dominate the vehicle kilometres driven by Passenger cars. Throughout the time series, the share of gasoline in total passenger car kilometres driven in the Netherlands has fluctuated between 64% and 69%. The share of diesel cars has increased from 20% in 1990 to 31% in 2012, mostly at the cost of the market share of LPG which decreased from 16% to 3% in the same time span.

Passenger cars were responsible for 11% of total NO_x emissions in the Netherlands in 2012. NO_x emissions of Passenger cars have decreased significantly though throughout the time series: from 141 Gg in 1990 (24% of total NO_x) to 27 Gg in 2012. This decrease was mainly caused by the introduction of the (closed loop) TWC, which has led to a major decrease in NO_x emissions from gasoline Passenger cars (93% reduction between 1990 and 2012 even though traffic volumes increased by 18%). NO_x emissions from diesel-powered Passenger cars increased from 11 Gg in 1995 to 18 Gg in 2008. This was caused by the major increase in the vehicle kilometres of diesel cars combined with less stringent emission standards and disappointing real-world NO_x emission performance from recent generations of diesel Passenger cars. Since 2008, NO_x emissions from diesel cars have remained fairly constant at 18 Gg. 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 78% in 1990 to 30% in 2012, whereas the share of diesel has increased from 9% to 65% between 1990 and 2012.

The introduction of the TWC for gasoline Passenger cars also led to a significant reduction of NMVOC and CO emissions from Passenger cars. NMVOC exhaust emissions from gasoline Passenger cars decreased from 84 Gg in 1990 to 10 Gg in 2012, whereas CO emissions decreased from 558 to 222 Gg. NMVOC and CO emissions from diesel and LPG-powered Passenger cars have also decreased significantly, but both are minor sources of NMVOC and CO. Gasoline Passenger cars were responsible for 85-90% of total NMVOC exhaust emissions and over 90% of total CO emissions from Passenger cars throughout the time series. In 2012, Passenger cars (source category 1A3bi, not including evaporative NMVOC emissions) were responsible for 9% of total NMVOC emissions (down from 21% in 1990) and 44% of total CO emissions (down from 52% in 1990) in the Netherlands.

Figure 4.3 Emissions of NMVOC from evaporation by Road transport in the Netherlands.



Passenger cars (source category 1A3bi, only including exhaust emissions) were responsible of 10% of total $PM_{2.5}$ emissions and 5% of total PM_{10} emissions in the Netherlands in 2012. PM_{10} exhaust emissions from Passenger cars have decreased by 78% between 1990 and 2012. Both emissions from gasoline and diesel cars have decreased significantly throughout the time series, resulting from the tightening of EU emission standards for new Passenger cars. Emissions in 2012 were 1.2 Gg, down 0.2 Gg (13%) from 2011. The further decrease of PM_{10} (and $PM_{2.5}$) exhaust emissions in recent years is primarily caused by the introduction and increasing market penetration of diesel Passenger cars equipped with a diesel particulate filter (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 market 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 already equipped with a DPF. Since 2008, the share of new diesel Passenger cars with a DPF has been above 90%. Since the $PM_{2.5}/PM_{10}$ ratio for exhaust emissions is assumed to be 1.0, $PM_{2.5}$ emissions show the same trends as PM_{10}.

As was reported before, NH_3 emissions of Passenger cars increased since 1990 resulting from the introduction of the TWC. Since 2000, NH_3 emissions have been more or less stable at 2.5 Gg. The further growth in vehicle kilometres has been compensated by the introduction of newer generations of TWCs with lower NH_3 emissions, resulting in a decrease of the fleet average NH_3 emission factor since 2000. With the introduction of unleaded gasoline, Pb emissions from Passenger cars decreased from 225 Mg in 1990 to 0.04 Mg in 1997. Since then, Pb is no longer present in exhaust emissions from road traffic.

1A3bii Light-duty trucks

The light-duty truck fleet in the Netherlands has grown significantly since 1990, leading to a major increase in kilometres driven between 1990 and 2005 (see Figure 4.1). In 2005, private ownership of a light-duty truck became less attractive, as the tax scheme for light-duty trucks was altered. This has led to a stabilisation of the national light-duty truck fleet and the kilometres driven by 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 slowly decreased since 2001. NO_x emissions in 2012 were 33% lower than in 1990 (20.5 Gg vs. 13.7 Gg), even though the total vehicle kilometres driven have more than doubled in the same time span. Current NO_x emissions from light-duty trucks are dominated by diesel engines with a share of more than 97% in total emissions. Diesel NO_x emissions increased between 1990 and 2001 and remained constant between 2001 and 2005. The tightening of the EU emission standards for light-duty vehicles and the subsequent market penetration of light-duty diesel engines with lower NO_x emissions caused a minor decrease since 2005. Because of the poor NO_x-emission performance of recent euro-5 trucks, the fleet average NO_x emission factor for diesel Light-duty trucks only decreased by 2% in 2012 compared to 2011. The share of Light-duty trucks in total NO_x emissions in the Netherlands was approximately 6% in 2012.

The exhaust emissions of NMVOC and CO from light-duty trucks have shown a major decrease throughout the time series. NMVOC emissions decreased from 10 Gg in 1990 to 1 Gg in 2012, whereas CO emissions decreased from 47 to 4 Gg, over the same time period. The tightening of EU emissions standards for both substances has led to a decrease in the fleet average emission factors for both gasoline and diesel trucks of 70 to 80% between 1990 and 2012. Gasoline-powered trucks emit far more NMVOC and CO than diesel-powered trucks; therefore, the decrease in the number of gasoline trucks has had a major impact on the decrease in these emissions as well. Light-duty trucks are a minor source of both CO and NMVOC emissions, accounting for less than 1% of the national totals for both substances in 2012.

The exhaust emissions of PM_{10} (and subsequently also of $PM_{2.5}$) from light-duty trucks have decreased from 2002 onwards. The fleet average PM_{10} emission factor has decreased consistently over the time series, but in earlier years this decrease was offset by the increase in kilometres driven. Diesel-powered trucks are dominant in the total PM_{10} emissions from light-duty trucks, with a share of over 99%. The average PM_{10} exhaust emission factor for diesel-powered light-duty trucks decreased by approximately 3% annually between 2005 and 2012, although market penetration of DPFs in the new diesel-powered light duty truck fleet has been lacking behind compared to Passenger cars. In recent years market penetration of DPFs increased significantly though, helped by voluntary agreements between the government and the automotive sector in the Netherlands. The share of DPFs in new light duty truck sales increased from 30% in 2008 to 90% in 2010. Combined with the stabilisation of the amount of vehicle kilometres driven since 2005, PM_{10} exhaust emissions decreased by 41% between 2005 and 2012. In 2012, Light-duty trucks were responsible for 4% of total PM_{10} and 9% of total $PM_{2.5}$ emissions in the Netherlands.

1A3biii Heavy-duty vehicles including buses

Heavy-duty vehicles are a major source of NO_x emissions in the Netherlands with a share of 19% in total NO_x in 2012. The number of vehicle kilometres driven by heavy-duty vehicles (trucks and buses) in the Netherlands increased by approximately 31% between 1990 and 2008 (see Figure 4.1). The economic crisis has since led to a slight decrease in traffic volumes: total vehicle kilometres driven in 2012 was 5% lower than in 2008. Diesel dominates the vehicle fleet with a share of over 99%.

Total NO_x emissions from heavy-duty vehicles decreased from 90 Gg in 1990 to 47 Gg in 2012 (see Figure 4.2). Emission totals have decreased significantly in recent years due to the combination of a decrease in vehicle mileages and a decrease in the fleet average NO_x emission factor. The fleet average NO_x emission factor decreased by 58% between 1990 and 2012, from 14 g/km to 6 g/km. This decrease has mainly been caused by the tightening of EU emission standards for new heavy-duty engines. With recent (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 (6% average annual decrease).

NMVOC exhaust emissions decreased by 86%, from 10 Gg in 1990 to 1 Gg in 2012, whereas PM_{10} and $PM_{2.5}$ exhaust emissions decreased by 88%, from 5 Gg to less than 1 Gg. These decreases have also been caused by EU emission legislation. Heavy-duty vehicles are only a minor source of NMVOC (1%) and PM_{10} emissions (2%) in 2012. The share in $PM_{2.5}$ emissions is slightly higher at 5% of national totals.

1A3biv Motorcycles and mopeds

Motorcycles and mopeds are a small emission source in the Netherlands, being responsible for less than 1% of total emissions of most substances. They are a key source though for NMVOC and CO in both the 1990 and 2012 level assessment and (for CO only) in the trend assessment. Even though vehicle kilometres increased by 84% between 1990 and 2012, exhaust emissions of NMVOC and CO have decreased significantly due to the introduction and subsequent tightening of the EU emissions standards for two-wheelers. NMVOC exhaust emissions decreased from 25 to 6 Gg between 1990 and 2012, whereas CO emissions decreased from 45 to 30 Gg. Motorcycles and mopeds were responsible for 4% of NMVOC and 5% of CO emissions in the Netherlands in 2012. NO_x emissions increased from 0.3 to 1.3 Gg between 1990 and 2012, but the share of motorcycles and mopeds in total NO_x emissions in the Netherlands was still less than 1% in 2012.

1A3bv Gasoline evaporation

Evaporative NMVOC emissions from Road transport have decreased significantly due to EU emission legislation for evaporative emissions and the subsequent introduction of carbon canisters in newly sold 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 2 Gg in 2012 (see Figure 4.3). Evaporative emissions from motorcycles and mopeds have increased slightly from 0.4 Gg in 1990 to 0.5 Gg in 2012.

1A3bvi and vii PM emissions from Tyre and brake wear and road abrasion

PM_{10} emissions from brake wear, tyre wear and road surface wear increased by 24% between 1990 and 2012, due to the increase in vehicle kilometres driven by the different types of road vehicles. Emission factors were kept constant for the entire time series. $PM_{2.5}$ emissions were calculated 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. Automobile tyre and brake wear was responsible for 5% of PM_{10} emissions in the Netherlands in 2012, whereas road abrasion was responsible for 4% of total PM_{10}. The share of tyre and brake wear (2%) and road abrasion (1%) in total $PM_{2.5}$ emissions is smaller.

4.3.4 Activity data and (implied) emission factors

The exhaust emissions of CO, NMVOC, NO_x, NH_3 and PM from Road transport were calculated by combining statistics on vehicle kilometres driven with emission factors expressed in grams per vehicle kilometre (g km^{-1}). Emissions of SO_2 were calculated using fuel consumption data combined with the sulphur content of different fuel types, taking into account the tightening of the EU fuel quality standards regulating the maximum allowable sulphur content for fuels used in Road transportation.

Activity data

Data on the number of vehicle kilometres driven in the Netherlands by different vehicle types were derived from Statistics Netherlands. Statistics Netherlands calculates total vehicle mileages using data on:

1. The size and composition of the Dutch vehicle fleet;
2. Average annual mileages for different vehicle types, and
3. The 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 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 vehicles that have been to a garage for maintenance or repairs. Every year, Statistics Netherlands acquires a sample of the NAP database and uses this data combined with RDW-data on vehicle characteristics to derive average annual mileages for different vehicles types. This method 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*. (2014).

Statistics Netherlands derived annual mileages by motorcycles and mopeds in the Netherlands from a new survey among owners of motorcycles and mopeds, as is described in more detail in Subsection 4.3.8.

The vehicle kilometres driven in the Netherlands by foreign Passenger cars (3) were estimated using different tourism related data sources, as described in Klein *et al*. (2014). Vehicle kilometres travelled by foreign trucks were based on statistics on Road transportation in the Netherlands and in other EU countries, collected by Eurostat. The vehicle kilometres travelled 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), see also 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 recently re-estimated (Goudappel Coffeng, 2010). In this study, a national transport model was used to estimate the distribution of total vehicle kilometres travelled on urban roads, rural roads and motorways, for Passenger cars and light and heavy-duty trucks. Subsequently, data from number plates registrations alongside different road types throughout the Netherlands were used to differentiate these distributions according to fuel type and vehicle age. The road type distribution for different vehicle categories is reported in Klein *et al*. (2014).

Total fuel consumption per vehicle and fuel type, used for calculating SO_2 emissions, 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 from surveys among owners of Passenger cars, heavy-duty trucks and motorcycles.

Emission factors

The CO, NMVOC, NO_x and PM exhaust emission factors for Road transport were calculated by TNO using the VERSIT+ model (Smit *et al*., 2007). VERSIT+ derives average emission factors for different vehicle types under different driving circumstances using an extensive emission measurements database. Separate VERSIT+ models were developed for light-duty and heavy-duty vehicles. VERSIT+ LD contains statistical models for 246 vehicle classes using multiple linear regression analysis. The statistical models are used for determining empirical relationships between average emission factors, including confidence intervals, and an optimized number of vehicle and driving behaviour characteristics. Since 2009, version 3 of VERSIT+ LD is used to derive real-world emission factors for light-duty vehicles (Ligterink and De Lange, 2009).

VERSIT+ HD (Ligterink *et al.*, 2009) was used to derive emission factors for heavy-duty vehicles (trucks, tractors and buses). For older vehicle types, VERSIT+ HD is based on European measurement data, mostly derived from engine tests in laboratory settings. For new vehicle types (Euro-III, -IV and -V) results from recent on-road measurements, using a Portable Emission Measurement System (PEMS) are used in the model (e.g. Ligterink *et al.*, 2009). To derive real-world emission factors from the measurement data, VERSIT+ uses the PHEM model developed by the Graz University of Technology (Hausberger *et al.*, 2003). The input is composed of speed-time diagrams which make the model suitable for the prediction of emissions in varying traffic situations.
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.* (2014). 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.

Emissions of SO_2 and heavy metals (and CO_2) are dependent on fuel consumption and fuel type. These emissions are 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 are based on the sulphur, carbon and heavy metal contents of the fuels. 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 are based on measurements conducted by TNO (Winkel, 2002). In this study, the NH_3 emissions from different vehicle types were measured (up to Euro-2). No recent measurements were available; therefore the Euro-2 emission factors were also applied to more recent vehicle types. The NH_3 emission factors for Passenger cars without catalysts and for other road vehicles were derived from Ntziachristos and Samaras (2000).

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).

4.3.5 Methodological issues

Several parts of the Road transport inventory require improvement:

- The fuel consumption data (liters/kilometre) for all types of road vehicles have not been updated recently and require revision. These figures are used to estimate total fuel consumption, which is subsequently used to estimate emissions of SO_2 and heavy metals. The difference between total fuel consumption by Road transport and fuel sales data, as reported by Statistics Netherlands, is used to estimate fuel sold emissions which are currently reported as a memo item in the inventory.
- NH_3 emission factors for road vehicles have not been updated since 2002 and therefore require revision.
- Emissions of CNG and hybrid electric vehicles are not estimated separately in the inventory. CNG and gasoline hybrid Passenger cars are included in the kilometres driven of gasoline cars and as such emissions are included in emission totals of gasoline vehicles. CNG light and heavy duty trucks and buses are included in the diesel trucks. CNG energy use was estimated at 0.7 PJ in 2011 (0.2% of total energy use by Road transport).

4.3.6 Uncertainties and time series consistency

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

4.3.7 Source-specific QA/QC and verification

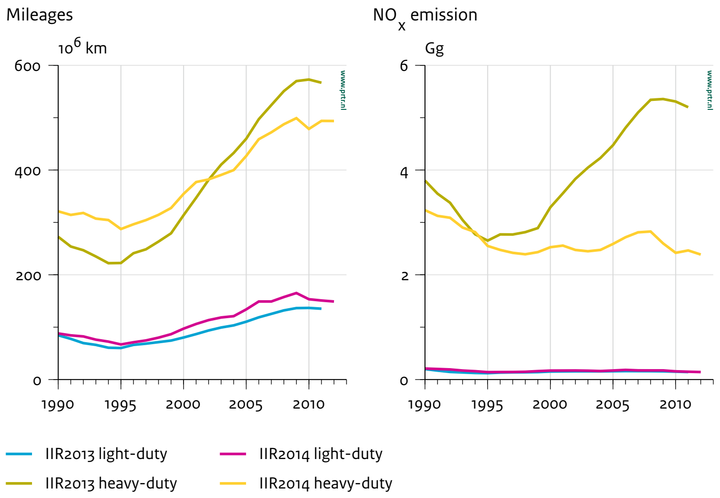
There are no source-specific QA/QC or verification procedures for Road transport.

4.3.8 Source-specific recalculations

In this year's submission, several recalculations were done, compared to last year's submission.

New annual mileages for special purpose vehicles
Statistics Netherlands has derived new average annual mileages for so-called 'special purpose vehicles'. Special purpose vehicles are a separate group in the Dutch vehicle fleet statistics that contains e.g. garbage trucks, camper vans, tow trucks and fire trucks. The mileages for special purpose vehicles that were used for last year's submission were estimated in the nineties and had since been unchanged. An update was therefore required. In order to estimate new annual mileages for different types of special purpose vehicles, Statistics Netherlands acquired odometer readings from the NAP register. Applying the

Figure 4.4 Total mileages and NO$_x$ emissions by light and heavy duty special purpose vehicles in this year's and last year's submission.



same method that is used for Passenger cars, Light-duty truck, Heavy-duty trucks and buses, as described in sub section 4.3.3., new average annual mileages were estimated for special purpose vehicles.

Since the NAP register contains odometer readings from previous years as well, the new data was used to re-estimate the historic time series for vehicle kilometres travelled by special purpose vehicles in the Netherlands. The mileages are differentiated by weight group (light and Heavy-duty vehicles), fuel type (diesel and other) and age group. The methodology and results are described in more detail in the accompanying report by Statistics Netherlands (Molnár – in 't Veld *et al.*, 2014). Figure 4.4 shows the old and new time series for the total mileages driven by light and heavy duty special purpose vehicles in the Netherlands. The new time series for light duty vehicles shows fairly good agreement with the previous time series, with total mileages approximately 10-20% higher in recent years compared to the previous estimates. The new times series for heavy-duty vehicles shows a similar trend compared to the old time series, but the increase in total mileages is less steep with the new time series being higher for previous years and lower for recent years of the time series.

The new study by Statistics Netherlands also led to a better understanding of the different types of vehicles within the special purpose vehicles group. This was used to re-estimate the road type distribution of the vehicles. The previous estimate of the road type distribution, i.e. the share of total mileages driven on urban roads, rural roads and highways, was last updated in the nineties and therefore outdated. At the time, it was assumed that the special purpose vehicles group was dominated by vehicles that for the most part were used for urban purposes, e.g. garbage trucks and fire trucks. As a result, the urban share in total mileages was assumed to be 60% for all special purpose vehicles, as is shown in Table 4.6. Statistics Netherlands showed though that the light-duty vehicle group is actually dominated by camper vans, which are responsible for over 90% of total mileages. Camper vans are for the most part used outside urban areas. The heavy duty vehicle group is more diverse. Approximately half of the total mileages of this group are driven by trucks that are used to transport other vehicles. Garbage trucks are responsible for approximately 20% of total mileages. Since data on actual road type distributions for special purpose trucks are not available, it was decided that for special purpose vehicles the same road type distributions are used to be as for light-duty and heavy-duty trucks (as shown in Table 4.6). Although this estimate is still uncertain, it is considered to be more appropriate considering the types of vehicles it concerns. Since emission factors for Heavy-duty vehicles are generally higher for urban driving than for rural and highway driving, the new road type distribution leads to lower emission totals.

Applying the new mileages and road type distributions for special purpose vehicles resulted in a decrease in emissions for most substances. Figure 4.4 shows the old and new time series for NO$_x$ emissions. Emissions of light duty vehicles are low and did not change significantly in the new time series. Emissions of Heavy-duty vehicles did change significantly though, with emission totals being significantly lower in recent years of the time series. Total NO$_x$ emissions in 2011 decreased from 5.2 Gg in last year's

Table 4.6 Road type distribution for special purpose vehicles.

	Light-duty trucks		Heavy-duty trucks	
	IIR2013	**IIR2014**	**IIR2013**	**IIR2014**
Urban	60%	16%	60%	17%
Rural	25%	32%	25%	22%
Highways	15%	54%	15%	61%

submission to 2.5 Gg in the current submission. The decrease results from a combination of 1) lower total mileages, 2) the adjusted road type distribution and 3) better insights in the age distribution (and related Euro classes) of the mileages.

Emissions from light and heavy duty special purpose vehicles are not reported separately in the inventory but are included under Light-duty trucks (1A3bii) and Heavy-duty trucks (1A3biii) respectively.

New annual mileages for motorcycles and mopeds

Statistics Netherlands also did a study on average annual mileages for motorcycles and mopeds. As was reported in last year's submission, an initial study in 2011 showed that the NAP register does not contain sufficient odometer readings to estimate average annual mileages for motorcycles. Odometer readings for mopeds are not registered in the NAP. Therefore, Statistics Netherlands carried out a survey among owners of motorcycles and mopeds. The survey was carried out in two waves: the first one in 2012 and the second one in 2013. Among other things, owners were asked to register the odometer readings for their vehicles (if equipped) or to estimate their average annual mileages. Statistics Netherlands used the available odometer readings for motorcycles and the results of the survey to estimate new average annual mileages for both motorcycles and mopeds. Methodology used and results of the study are described in more detail in Kampert and Molnár (2014).

Figure 4.5 shows the old and new time series for the total mileages by motorcycles and mopeds in the Netherlands. The time series for motorcycles show good agreement, with total mileages increasing from 0.9 billion in 1990 to 2.6 billion in 2011. The new time series is slightly higher though for the 1996-2010 period. Total mileages for mopeds have increased significantly in the new times series, especially in recent years. Previously, the total mileage of mopeds was estimated to be approximately 1 billion kilometres for the entire 1996-2011 period. This estimate was derived from an annual mobility survey by Statistics Netherlands. In the survey, respondents are asked to register all of their trips, including origin and destination and the type of vehicle used. Statistics Netherlands used the results to estimate the total mileages by the Dutch population using different modes of transportation, including mopeds. The resulting mileage varied between 0.9 and 1.1 billion vehicles kilometres. Since 2007, all mopeds are required to have a license plate and therefore are registered by the RDW. Previously, the total number of mopeds could only be estimated because registrations were incomplete. The recent data from the RDW shows a significant increase in the number of mopeds in recent years. Combined with the new annual mileages derived by Statistics Netherlands, this results in a major increase in the total mileages by mopeds, as is shown in Figure 4.5. It should be noted that the total mileages for earlier years remain rather uncertain due to a lack of insight in the total vehicle population in the Netherlands.

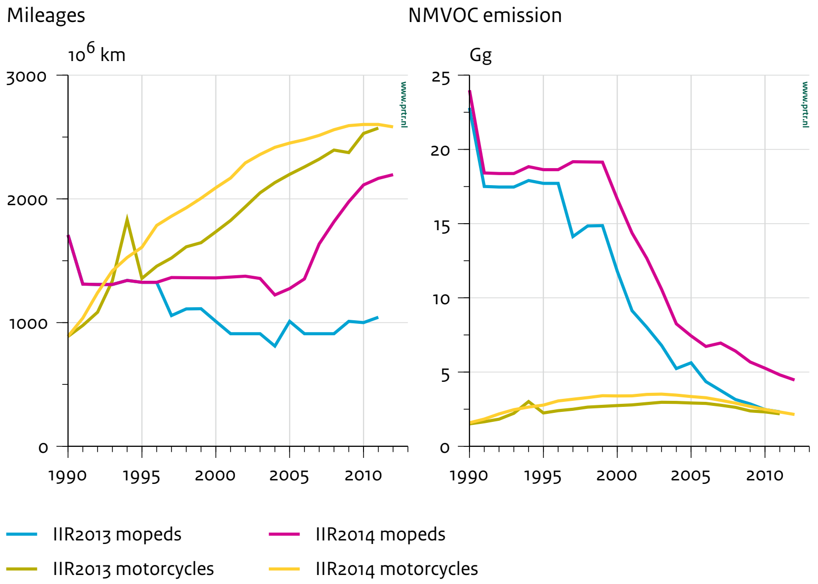
Figure 4.5 also shows the time series for NMVOC emissions by motorcycles and mopeds. Motorcycles and mopeds are a key source for NMVOC emissions in the Netherlands, responsible for approximately 4% of total NMVOC emissions in 2012. Since road type distributions and emission factors have not been changed in this year's submission, differences in the NMVOC time series only result from new mileages applied (including underlying age distribution) derived by Statistics Netherlands. The time series for motorcycles again show good agreement. Emissions from mopeds are higher than previously estimated; both the trend in emissions is similar with (exhaust) emissions of NMVOC decreasing significantly in recent years of the time series due to the tightening of EU emissions standards for mopeds. NMVOC emissions from mopeds in 2011 are estimated 4.8 Gg in the current submission, whereas in last year's submission total emissions were estimated 2.3 Gg.

Weigh-in-Motion

The fuel consumption and resulting emissions from heavy duty trucks depend foremost on the weight of the vehicles. Although information of empty weight of the vehicles and the maximum permissible weight is available from the vehicle register, up until recently there was no data on the actual weight of the vehicles in use (i.e. on payloads). Previous estimates of actual vehicle weights for different types of heavy-duty trucks were last updated in the mid-nineties and had previously remained unchanged.

In recent years, the Weigh-in-Motion (WiM) system has been installed on Dutch motorways. WiM determines the weight on each axle of all passing Heavy-duty vehicles. This data was collected by Rijkswaterstaat (RWS; part of the Ministry of Infrastructure and the Environment) and was made available to TNO for analysis in 2013. Using the WiM data, the axle configuration and the total weight of the vehicles can be determined for a large, representative group of vehicles on the Dutch roads. Using data from 4 weeks of measurements across the Netherlands, TNO

Figure 4.5 Total mileages and NMVOC emissions by motorcycles and mopeds in this year's and last year's submission.

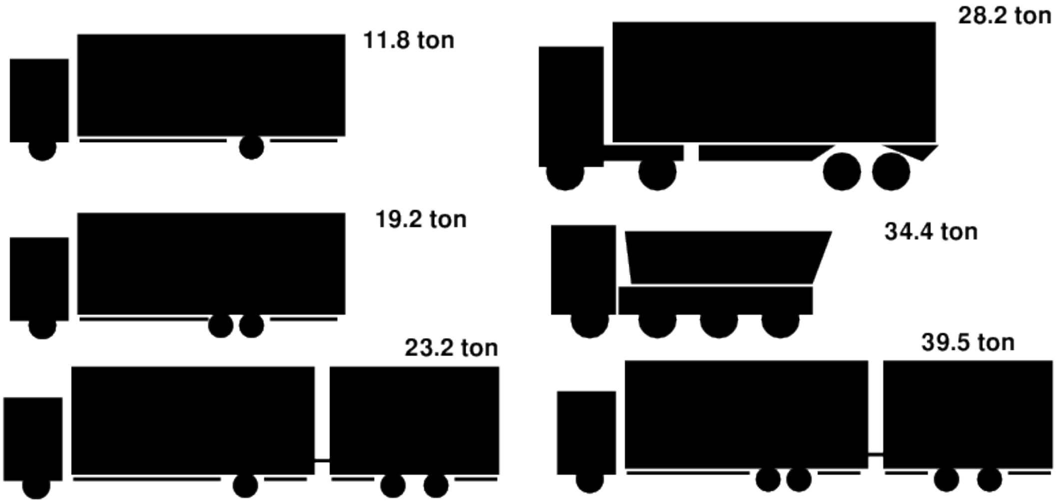


estimated average weights for the relevant vehicle categories used in emission modelling. Methodology and results are described in detail in Kuiper and Ligterink (2014). Figure 4.6 shows the main results of the study.

Kuiper and Ligterink (2014) concluded the weight of tractor-trailer combinations on the road on average to be higher than previously estimated. Previously, the average weight of a tractor-trailer combination was estimated at 22.7 ton. This estimate was applied in the VERSIT+ HD emission model (as described in section 4.3.4) to calculate emission factors for all tractor-trailer combinations. Using the WiM data, the average weight of tractor-trailer combinations was estimated at 28.2 ton. More importantly, there are two dominant groups of tractor-trailer combinations on the road in the Netherlands: one with an average weight of 23.3 ton and one with an average weight of 39.5 ton, as is shown in the bottom of Figure 4.6. Since tractor-trailer combinations are the dominant heavy-duty vehicle category on the road in the Netherlands, the category is split into two separate weight classes. Based on the WiM data, the lighter category represents approximately 65% of total mileages whereas the heavier category represents 35% of total mileages. Since the WiM data are only available for recent years and therefore are only representative for the current situation on the Dutch motorways, new average weights are asssumed only to apply to Euro-V and Euro-VI trucks. Euro-V trucks entered the Dutch market in 2005 and currently dominate the heavy-duty truck fleet.
Kuiper and Ligterink (2014) also concluded the fraction of trailers behind rigid trucks to be larger. Initially estimated only 25%, it is at least 33%, but may even be higher in the case of heavy rigid trucks with a gross vehicle weight above 20 ton. Since license plate data were not made available to TNO, the weight class of the rigid trucks (defined based on gross vehicle weight) could not be determined. Therefore, it was not possible to estimate the share of rigid trucks with a trailer separately for the different weight classes. For now, the average of 33% is applied to all rigid trucks from Euro-V onwards.

Since the findings from the WiM analysis are only applied to Euro-V and Euro-VI trucks, they only affect the emission totals in the 2005-2012 period (the impact in 2005 being very small but growing annually as more Euro-V trucks enter the vehicle fleet). The higher average weight of tractor-trailer combinations leads to higher specific fuel consumption and for the most part to higher emission factors for Euro-V and Euro-VI trucks. As a result, emission totals increased compared to last year's submission. Applying the results from the WiM study led to a 5% increase in total PM_{10} exhaust emissions from heavy duty trucks in 2011. Total NO_x emissions actually decreased due to the findings of the WiM study. Measurements by TNO show that higher payloads in Euro-V trucks actually lead to lower NO_x-emissions, resulting from higher exhaust gas temperatures which lead to better functioning of the SCR-catalyst. As such, total NO_x-emissions by heavy duty trucks (buses and special purpose vehicles excluded) in 2011 decreased by 5% (2 Gg) compared to last year's submission.

Figure 4.6 Average (on-road) vehicle weight of different heavy-duty truck configurations in the Netherlands, derived from the WiM system (source: TNO).



4.3.9 Source-specific planned improvements

There are several improvements planned for the Road transport emission inventory:

- TNO and Statistics Netherlands have initiated a study to derive improved specific fuel consumption figures for Passenger cars using fuel consumption figures from the EU type approval procedure and research by TNO on differences between type approval and real-world fuel consumption for different vehicles types. These figures should improve the bottom-up fuel consumption estimates used to calculate SO_2 emissions and heavy metals. The difference between bottom up fuel consumption and fuel sold in the Netherlands is also used to estimate fuel sold emissions. The new fuel consumption figures should therefore also help improve fuel sold estimates of Road transport emissions. A similar study will also be performed for light duty and heavy duty trucks.
- TNO will perform a study on the impact of non-compliance on emissions from Road transport. With emission factors of modern vehicles decreasing rapidly due to the further tightening of EU emission standards, the impact of non-compliance on total emissions becomes a major factor in determining emission totals. Data on the occurrence of non-compliance and the impact on emissions have not been collected recently. Therefore, a new study to improve the knowledge on non-compliance and the impact on emission totals was commissioned.

4.4 Railways (1A3c)

4.4.1 Source-category description

The source category 1A3c ‘Railways’ includes emissions from fuel sold to diesel-powered rail transport in the Netherlands. This includes both passenger transport and freight transport. It also includes PM_{10} emissions due to the wear of overhead contact lines and carbon brushes from railways.

4.4.2 Key sources

The source category ‘Railways’ is not a key source in the emission inventory.

4.4.3 Overview of emission shares and trends

The railway sector is a small source of emissions in the Netherlands, accounting for less than 1% of national totals for all substances in both 1990 and 2012. 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. For the most part, transport volumes have still increased since 2001, but this has been compensated by the increased electrification of rail freight transport. In 2012, diesel fuel consumption decreased by 17% (0.2 PJ) to 1.14 PJ compared to 2011. The share of passenger transport in total diesel fuel consumption in the railway sector is

Table 4.6 Trends in emissions from 1A3c Railways.

	Main Pollutants					Particulate Matter			Priority Heavy Metals	
	NO_x	CO	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$	Pb	Cu
Year	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Gg**	**Mg**	**Mg**
1990	1.61	0.26	0.07	0.10	0.0003	0.06	0.06	0.05	0.22	4.79
1995	1.67	0.27	0.08	0.10	0.0003	0.06	0.06	0.06	0.26	5.58
2000	2.05	0.32	0.09	0.12	0.0004	0.07	0.07	0.06	0.28	6.16
2005	1.93	0.29	0.08	0.11	0.0003	0.06	0.06	0.06	0.27	6.03
2010	1.94	0.29	0.08	0.02	0.0003	0.06	0.06	0.06	0.29	6.47
2011	1.87	0.28	0.08	0.00	0.0003	0.06	0.06	0.06	0.29	6.43
2012	1.49	0.25	0.07	0.00	0.0003	0.06	0.06	0.05	0.29	6.52
1990 - 2012 period [1]	-0.12	-0.01	0.00	-0.10	0.0000	0.00	0.00	0.00	0.07	1.73
1990 - 2012 period [2]	-8%	-5%	-5%	-99%	-7%	0%	0%	0%	34%	36%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

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 have fluctuated around 1.9 Gg in recent years, but decreased to 1.5 Gg in 2012. PM_{10} emissions have fluctuated around 0.06 Gg. Pb emissions have increased by 34% between 1990 and 2012. Pb emissions from railways result from wear of carbon brushes. Emissions are 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 maximum allowable 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 report 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 recently founded 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} were derived by the Netherlands Environmental Assessment Agency (PBL) 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 the 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 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.

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, updating the emission factors is currently not a priority.

4.5 Waterborne navigation and recreational craft (1A3d)

4.5.1 Source-category description

The source category 1A3d 'Waterborne navigation' 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 all emissions from trips that either depart or arrive abroad. Only emissions on Dutch territory are included. For maritime navigation this includes 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 1A5b 'Other mobile' 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 of NO_x and $PM_{2.5}$ emissions. The source category 1A5b 'Other Mobile (including military, land based and recreational boats) is a key source of emissions of CO.

4.5.3 Overview of emission shares and trends

Inland waterway navigation was responsible for 11% of total NO_x emissions and 7% of $PM_{2.5}$ emissions in the Netherlands in 2012. With emissions from Road transport decreasing rapidly, the share of inland waterway navigation in national emission totals has increased throughout the time series. The share of inland waterway navigation in national emissions totals of PM_{10} (4%), NMVOC (1%), CO (1%) and SO_2 (0.04%) is small. International maritime navigation is not included in the national totals but 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

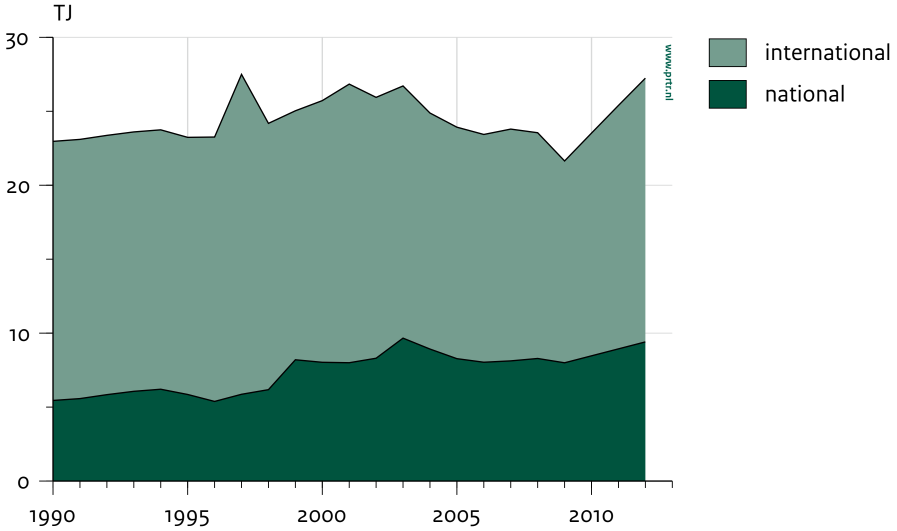
Table 4.7 Trends in emissions from Inland shipping in the Netherlands (combined emissions of national and international inland shipping).

	Main Pollutants					Particulate Matter		
	NO_x	CO	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	29	8	2.0	2	0.01	1.31	1.31	1.25
1995	25	7	1.8	2	0.01	1.32	1.32	1.25
2000	28	7	1.7	2	0.01	1.31	1.31	1.24
2005	26	6	1.5	2	0.01	1.12	1.12	1.07
2010	25	5	1.2	1	0.01	0.91	0.91	0.86
2011	26	6	1.3	0	0.01	0.91	0.91	0.85
2012	27	6	1.3	0	0.01	0.94	0.94	0.88
1990 - 2012 period [1]	-1	-2	-0.7	-2	0.00	-0.37	-0.37	-0.36
1990 - 2012 period [2]	-5%	-27%	-33%	-99%		-29%	-29%	-29%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

Figure 4.7 Fuel consumption in national and international inland shipping in the Netherlands.



regions. Total NO_x emissions of International maritime shipping on Dutch territory (including the Dutch Continental Shelf) amounted to 106 Gg in 2012, down from 112 Gg in 2011 but more than the combined NO_x emissions of all Road transport in the Netherlands. Total PM_{10} emissions amounted to 5 Gg in 2011. On the contrary, recreational craft are only a small source of emissions in the Netherlands, being responsible for 2 Gg of NO_x, 2 Gg of NMVOC and 0.05 Gg of PM_{10} in 2012.

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 gone up again resulting in an increase in fuel consumption from 22 PJ in 2009 to 27 PJ in 2012 (see Figure 4.7). 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 of National and International inland navigation increased from 23 Gg in 2009 to 27 Gg in 2012. 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 2012.

SO_2 emissions from waterborne navigation have decreased by 95% between 2009 and 2012 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, 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 and Hulskotte, 2010). $PM_{2.5}$ and PM_{10} emissions of waterborne navigation increased by 0.03 Gg in 2012 compared to 2011 due to the increase in fuel consumption.

Since fuel consumption by recreational craft has remained stable in recent years, trends in total emissions follow trend in fleet average emission factors. Average emission factors of most substances decreased slightly from 2011 to 2012, resulting in small decreases in emissions. PM_{10}, $PM_{2.5}$ and CO emissions decreased by less than 1%. NMVOC emissions decreased by 9%, whereas NO_x emissions showed a minor increase (0.6%) from 2011 to 2012.

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 2012, total fuel consumption by maritime navigation on the Dutch part of the North Sea, the Dutch Continental Shelf (DCS), decreased by 6% compared to 2011 (MARIN and TNO, 2014), resulting in a similar reduction of SO_2 and PM_{10} emissions. NO_x emission decreased by 8% due to the IMO emission standards resulting in lower fleet average NO_x emission factors. Fuel consumption during maneuvering in port areas increased by 6% in 2012, resulting in an increase in emissions of NO_x (4%), PM_{10} (3%) and SO_2 (2%).

4.5.4 Activity data and (implied) emission factors

Fuel consumption and emission totals for 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, total (annual) power demand (kW) is calculated for the 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 total number of vessel kilometres per ship type are 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 model approach, see paragraph 4.5.8.

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 Hulskottte 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. Resulting fleet average emission factors for different years of the time series are reported in Klein *et al.* (2014). The formula used to estimate the effect of lower sulphur content on PM emissions is described in Hulskotte and Bolt (2013).

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

or

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

Where:

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

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

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, therefore the 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.* (2014).

Since 2008, emissions of sea shipping on the Dutch Continental Shelf and in the Dutch port areas are calculated 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. These systems transmit information about the position, speed and course of the ship every 2 to 10 seconds. Information about the ship itself, such as the 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 of maritime shipping bottom-up, taking into account specific ship and voyage characteristics.
To estimate emissions of 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 built, installed engine power, service speed and vessel size, of nearly 123.000 seagoing merchant vessels operating worldwide. Emission factors for each individual ship are 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). Emission factors (in g/kWh) are derived from Hulskotte *et al*. (2003). Methodologies and resulting emissions for recent years are described in more detail in MARIN and TNO (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 boats 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 are 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 are estimated using vessel movement data from Lloyd's combined with assumption on average vessel speeds (Hulskotte *et al*., 2003).

4.5.7 Source-specific QA/QC and verification

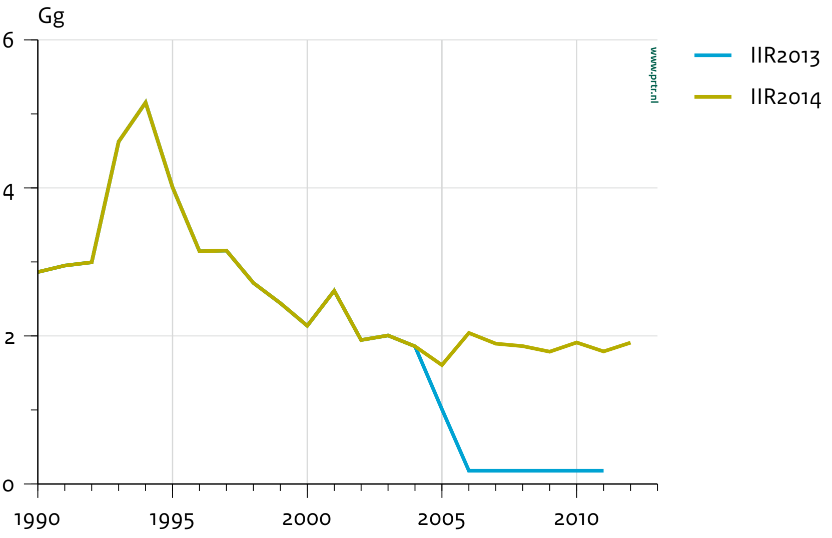
There are no source-specific QA/QC or verification procedures for waterborne navigation.

4.5.8 Source-specific recalculations

The time series for fuel use in waterborne navigation has been slightly adjusted downwards for the 2005–2011 period in this year's submission due to an error correction. Fuel use for domestic inland navigation is estimated using the Dutch Emission Monitor Shipping (EMS). In this methodology, fuel use and emissions from inland navigation are estimated using a bottom-up approach based on the ton-kilometres travelled by different ship types on the waterways of the Netherlands, as described in section 4.5.4. To accommodate the increasing size of recent generations of inland waterway vessels, two new size classes were added to the EMS methodology in 2012 (Hulskotte and Bolt, 2013). The length of one of these classes was incorrectly set to 135 meters. This has been corrected in the current inventory to 110 meter. The length of the ship influences the specific fuel consumption of the ship, therefore this error correction led to a minor adjustment of the historic time series: estimated fuel consumption by inland navigation is adjusted downwards by 0.3 to 0.8 per cent for the 2005-2011 period. Changes in emission totals are small as well.

The time series for NMVOC emissions relating to degassing of inland tank vessels has been adjusted upwards for recent years of the time series in this year's submission, as is shown in Figure 4.8. When cargos of petroleum or chemical products are exchanged, ships can be 'degassed', which can result in (NM)VOC emissions. Previously, it was

Figure 4.8 NMVOC emissions from degassing of inland tank vessels in last year's and this year's submission.



assumed that emissions from degassing of inland tank vessels had become negligible since 2006 due to new legislation that prohibited degassing in port areas. A recent study by Buck *et al*. (2013) however showed that degassing still takes place outside of the port areas. Total NMVOC emissions are estimated at 1.8 Gg in 2011 (Buck *et al*., 2013). The methodology used to estimate total NMVOC emissions from degassing is described in detail in Buck *et al*. (2013). The methodology was used to re-estimate NMVOC emissions for the 2004-2011 period.

4.5.9 Source-specific planned improvements

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

4.6 Non-road mobile machinery (NRMM)

4.6.1 Source category description

Mobile machinery covers a variety of equipment that is used in different industrial 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 is the use 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 are reported under 1A2fii 'Mobile combustion in manufacturing industries and construction', 1A4aii 'Commercial/institutional mobile', 1A4bii 'Residential: household and gardening (mobile)' and 1A4cii 'Agriculture/forestry/fishing: off-road vehicles and other machinery'.

4.6.2 Key sources

Emissions of NRMM are reported under different source categories. Mobile machinery in manufacturing industries and construction (1A2fii) is a key source for NO_x and $PM_{2.5}$ in the 2012 level assessment. The source category 1A4cii 'Agriculture/forestry/fishing: off-road vehicles and other machinery' is a key source for NO_x in the 2012 level assessment. The source category 1A4bii 'Residential: household and gardening (mobile)' is a key sources of emissions of CO in both the 2012 level and the trend assessment, whereas the source category 1A4aii 'Commercial/institutional mobile' is a key source of CO in the 1990-2012 trend assessment.

4.6.3 Overview of shares and trends in emissions

NRMM was responsible for 10% of CO emissions, 8% of NO_x, 7% of $PM_{2.5}$ and 4% of PM_{10} emissions in the Netherlands in 2012. CO emissions resulted from the use of gasoline equipment by consumers (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 were also a major source of NO_x emissions with a contribution of 17% in total NO_x of NRMM in 2012.

Total energy use in NRMM has fluctuated between 35 PJ and 40 PJ throughout the time series. Energy use in 2012 decreased by 5% (2 PJ) compared to 2011, mainly due to a reduction in the energy use by construction machinery. Since the start of the economic crisis, energy use by construction machinery decreased from 18.7 PJ in 2008 to 15.7 in 2012. Figure 4.9 shows total energy use within the different sectors where mobile machinery is applied. Construction and agricultural machinery are responsible for approximately 81% of total energy use. Diesel is the dominant fuel type, accounting for 88% of energy use in 2012. Gasoline and LPG have a share of 5% and 7% respectively in total energy use. LPG is used in the industrial sector (forklift trucks) and gasoline in the agricultural, construction and commercial/institutional sectors.

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 of NRMM have steadily decreased, as is shown in Figure 4.10. Since 1999, NO_x emissions have decreased by 49%, whereas fuel consumption has only decreased by 10%. NO_x emissions of gasoline and LPG machinery are not regulated. Combined with the increase in gasoline and LPG fuel consumption, NO_x emissions from gasoline-and LPG-powered machinery have steadily increased throughout the time series. In 2012, gasoline and LPG machinery had a combined share of 19% in total NO_x emissions, whereas in 1990 their combined share was only 5%. CO emissions have also increased throughout the time series due to the increased gasoline fuel consumption by NRMM combined with the lack of emission standards for gasoline machinery.

Emissions from most other substances have also decreased significantly throughout the time series. For PM_{10} and NMVOC, this was mainly caused by EU emissions standards. SO_2 emissions have decreased due to the EU fuel quality standards reducing the maximum allowable 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.

4.6.4 Activity data and (implied) emission factors

Fuel consumption and emissions from NRMM were calculated using a Tier 3 methodology. Energy use and emissions were derived from the EMMA-model (Hulskotte and Verbeek, 2009). This model is based on sales data for different types of mobile machinery and assumptions on the average use (hours per year) and fuel consumption (kilograms per hour) for different machine types. Emissions of CO, NO_x, PM_{10}, $PM_{2.5}$ and NMVOC are calculated using the following formula:

Emission = Number of machines x hours x Load x Power x Emission factor x TAF-factor

In which:

- Emission = Emission or fuel consumption (grams)
- Number of machines = the number of machines of a certain year of construction with emission factors applicable to the machine's year of construction
- Hours = the average annual running hours for this type of machinery
- Load = the average fraction of full power used by this type of machinery

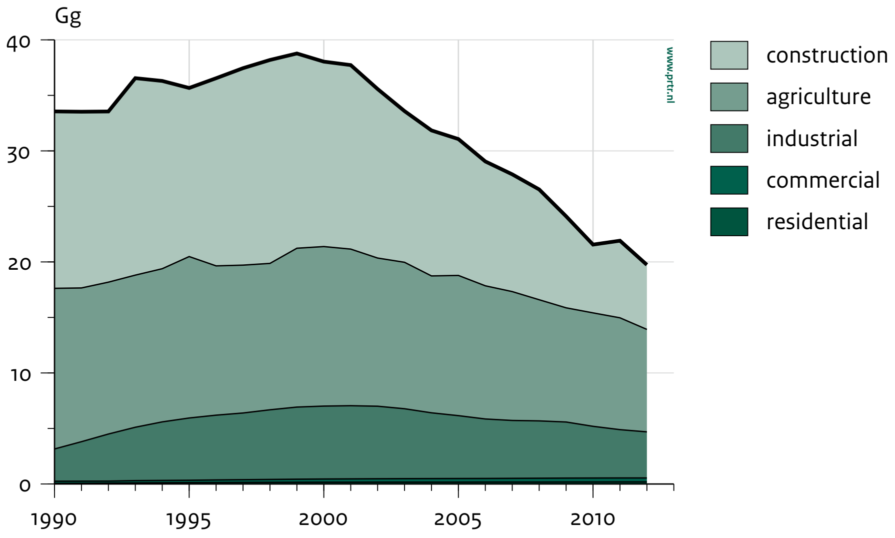
Table 4.8 Trends in emissions from non-road mobile machinery in the Netherlands.

	Main Pollutants					Particulate Matter		
	NO_x	CO	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	34	38	7.5	3	0.01	3.27	3.27	3.11
1995	36	58	8.1	3	0.01	2.83	2.83	2.69
2000	38	60	7.8	3	0.01	2.45	2.45	2.33
2005	31	55	5.9	3	0.01	1.67	1.67	1.59
2010	22	56	4.1	0	0.01	1.06	1.06	1.01
2011	22	57	4.0	0	0.01	1.08	1.08	1.02
2012	20	58	3.7	0	0.01	0.94	0.94	0.89
1990 - 2012 period [1)]	-14	20	-3.7	-3	0.00	-2.33	-2.33	-2.22
1990 - 2012 period [2)]	-41%	53%	-50%	-99%	-3%	-71%	-71%	-71%

[1)] Absolute difference in Gg

[2)] Relative difference to 1990 in %

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



- 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.

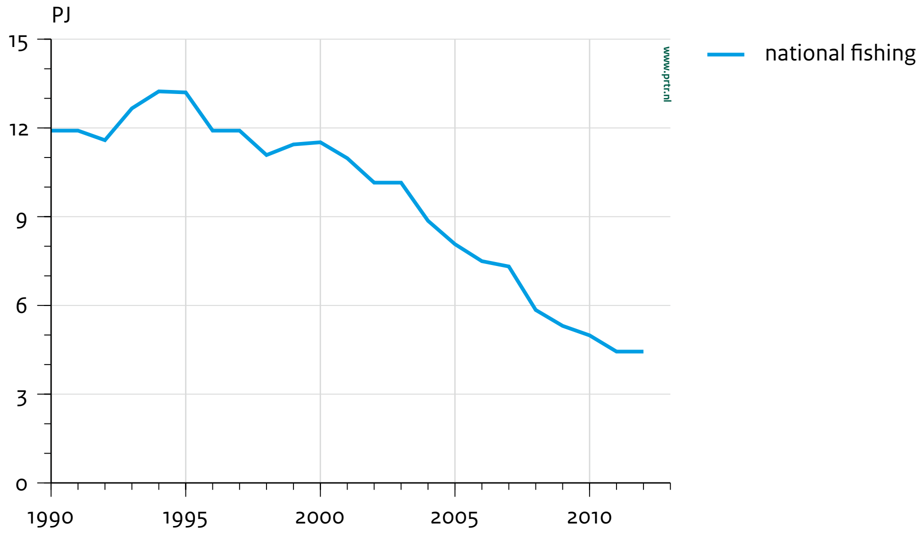
The TNO report on the EMMA model (Hulskotte and Verbeek, 2009) provides the emission factors of the various technologies and the different stages in the European emission standards. The emission factors are linked to the different machine types per sales year. Emission factors were derived from different literature sources.

Emissions of SO_2 were calculated based on total fuel consumption and sulphur content per fuel type. The use of sulphur-free diesel (S content < 10 ppm) in recent years was calculated by the EMMA model, based on the assumption that certain machinery requires the use of sulphur-free diesel in order to function properly. Emission factors for NH_3 were derived from Ntziachristos and Samaras (2000).
The distribution of total energy use to different sectors was estimated using different data sources. Total energy use by machinery in the agricultural sector (excluding agricultural contractors) was derived from the LEI research institute of Wageningen Univerity and Research Centre. Energy use by agricultural contractors was derived from CUMELA, the trade organisation for agricultural contractors in the Netherlands. Total energy use as reported by LEI and CUMULA is lower than the agricultural energy use calculated by EMMA. An explanation for this could be that some agricultural machinery (e.g. tractors) is frequently used in construction. In the EMMA model, which is based on machine types, this energy use is reported under agriculture. In the new approach this energy use is (properly) reported under construction industries. Total fuel consumption in the other sectors was derived from the EMMA model. Because the EMMA model 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 cannot only lead to fluctuations in the sales data, but also in the usage rates of the machinery (hours per year). The latter effect is not included in the model; therefore the EMMA results are adjusted based on economic indicators from Statistics Netherlands for the specific sectors where the machinery is used. The adjusted EMMA results are used to calculate emissions from non-road mobile machinery. The resulting energy use is also reported by Statistics Netherlands in the national energy statistics.

4.6.5 Methodological issues

Since there were no reliable data available on fuel sales to non-road mobile machinery, fuel consumption was estimated bottom-up with the EMMA model. This model has been based on sales data for different types of machinery since there were no data available on the total machinery fleet in the Netherlands. Emission estimates for NRMM are therefore rather uncertain.

Figure 4.11 Fuel consumption by the fishing fleet in the Netherlands.



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 linear 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

There are no source-specific recalculations of NRMM emissions in this year's inventory.

4.6.9 Source-specific planned improvements

There are no source-specific planned improvements for NRMM.

4.7 National fishing (1A4ciii)

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 2012, National fishing was responsible for 2% of NO_x emissions and 1% of $PM_{2.5}$ emissions in the Netherlands. 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 4.11. 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).

The trends in emissions from national fishing are shown in Table 4.11. Since the same emission factors were used for the entire time series, emissions from National fishing show similar trends to fuel consumption. NO_x emissions decreased from 16.5 to 6.1 Gg between 1990 and 2012, whereas PM_{10} emissions decreased from 0.39 to 0.15 Gg.

4.7.4 Activity data and (implied) emission factors

Because fuel sales to the fishing sector in the Netherlands cannot be distinguished from the sales of bunker fuels, as reported by Statistics Netherlands, fuel consumption in fishing was derived from calculations based on vessel movements. These calculations are 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 times the amount of horsepower of the vessel. With the help of data from VIRIS, the ports of departure, ports of arrival and total 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. In all other cases, it has been assumed that the vessels have taken on fuel elsewhere. 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 are 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, as reported in Section 4.7.3.

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.

4.8 Fuel used and fuel sold emissions for Road transport

The emissions as reported for the different source categories within Road transport are estimated based on vehicle kilometers driven in the Netherlands, as described in section 4.3.4. Emissions of air pollutants are not directly proportional to fuel consumption as they also depend on driving conditions, motor and exhaust gas after-treatment technology etcetera. Using the NAP register, the Netherlands has detailed information on the average

Table 4.9 Trends in emissions from National fishing in the Netherlands.

	Main Pollutants				Particulate Matter		
	NO_x	CO	NMVOC	SO_x	TSP	PM_{10}	$PM_{2.5}$
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	16.5	2.2	0.7	1.0	0.39	0.39	0.37
1995	18.2	2.5	0.8	1.1	0.43	0.43	0.41
2000	15.9	2.2	0.7	0.9	0.38	0.38	0.36
2005	11.2	1.5	0.5	0.6	0.26	0.26	0.25
2010	6.9	0.9	0.3	0.1	0.16	0.16	0.16
2011	6.1	0.8	0.3	0.0	0.15	0.15	0.14
2012	6.1	0.8	0.3	0.0	0.15	0.15	0.14
1990 - 2012 period [1]	-10.3	-1.4	-0.5	-1.0	-0.25	-0.25	-0.23
1990 - 2012 period [2]	-63%	-63%	-63%	-1.0	-63%	-63%	-63%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

annual mileages from different types of road vehicles. Since Road transport is also a key source for many substances, applying a Tier 3 methodology based on vehicle kilometers driven for different vehicle types under different driving conditions is considered the appropriate method to derive emission estimates for air pollutants by Road transport. Resulting emission totals are considered the best estimates of total emissions of air pollutants 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 fuel used (FU) or kilometers driven on national territory (UNECE, 2009). To comply with the UNECE-guidelines, emission totals for Road transport are also estimated and reported based on fuel sold in the Netherlands. Compliance checking for the 2010 national emission ceilings under the CLRTAP and the NEC directive for the Netherlands is based on the FU emission totals though, therefore the FS emissions from Road transport are reported as a memo item only and the methodology for estimating fuel sold emissions has been straightforward.

4.8.1 Deriving fuel sold emission totals for Road transport

To derive FS emissions for Road transport, the 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 in the Energy Balance. Fuel used by Road transport on Dutch territory is estimated on the basis of the vehicle kilometers driven per vehicle type, combined with specific fuel consumption factors (gram fuel per vehicle kilometer), as described in more detail in section 4.3.4. Resulting emission totals per fuel type are subsequently adjusted for differences in fuel used and fuel sold per fuel type.

Figure 4.12 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 1990-2012 time series. For gasoline, both time series show good agreement in both the absolute level and the historic trend in energy use. In recent years of the time series, differences between fuel used and fuel sold vary between 1 and 4 per cent, with fuel sold being slightly higher than fuel used. Part of this difference might be attributed to the use of gasoline for other purposes, such as recreational craft and mobile machinery.

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 has increased from 15% in

Figure 4.12 Fuel used vs. fuel sold trends, for gasoline, diesel and LPG fueled Road transport in the Netherlands.

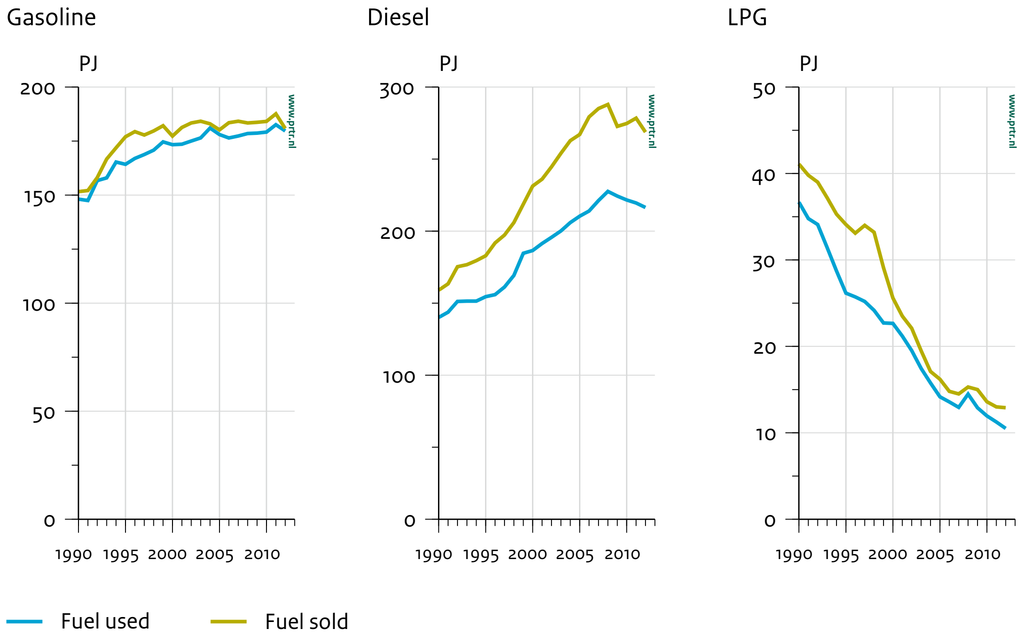
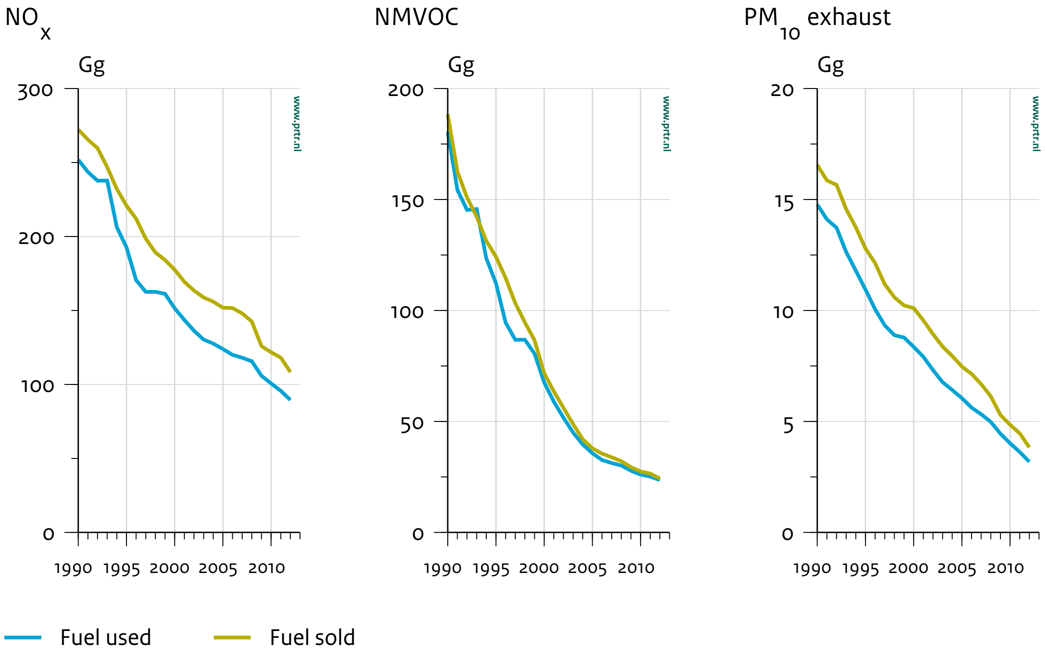


Figure 4.13 NO_x, NMVOC and PM_{10} exhaust emissions from Road transport in the Netherlands based on fuel used and fuel sold.



early years of the time series to 30% in 2006 and has since varied around 25%. Part of this difference might be explained by the use of diesel in international freight transport, with modern trucks being able to drive >1000 kilometers on one single tank of diesel. Freight transport volumes in (and through) the Netherlands are large due to, among other things, the Port of Rotterdam being the largest port in the EU. With the Netherlands also 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 extend this might explain 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. Another possible explanation is that fuel used is underestimated due to a lack of knowledge on specific fuel consumption of light and heavy duty trucks in the Netherlands. Fuel tourism does not seem to able a logical explanation for the differences, because fuel prices in the Netherlands are generally higher than in neighboring countries. This holds especially for gasoline and to a smaller extent for diesel.

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 substantial. Again, the amount of fuel sold is larger than the estimated fuel used on Dutch territory, and again the causes for these differences are currently unknown.

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 are substantially adjusted upwards, as can be seen in Figure 4.13. NMVOC emissions in Road transport mostly stem from gasoline vehicles, therefore fuel used and fuel sold NMVOC emission totals do not differ much.

4.8.2 Planned improvements of fuel sold methodology

Because fuel sold emissions from Road transport in the Netherlands were not used for compliance checking with the CLRTAP and the NEC targets for 2010, and have only been reported as a memo item, the differences between fuel used and fuel sold have not been studied extensively in the recent years. A straightforward methodology to estimate fuel sold emissions, based on a generic correction of fuel used emissions per fuel type, was deemed sufficient. The Gothenburg protocol has been amended though in 2012 to include national emission reduction commitments for 2020 and beyond. Compliance checking for the new targets in the Netherlands will now be based on fuel sold emissions. Therefore, the difference between fuel used and fuel sold for Road transport in the Netherlands will be a subject of study in the coming years, in order to improve the fuel sold emissions totals.

In order to improve the fuel sold emission totals, the bottom-up estimate of fuel used in the Netherlands by Light-duty trucks will be updated, as is described in section 4.3.9. Combined with the improved estimates of fuel used by Passenger cars and heavy duty trucks, this should result in better estimates of total fuel used by Road transport in the Netherlands and therefore in a better understanding on the actual differences between fuel used and fuel sold. To help improve this understanding, Statistics Netherlands will study to what extend the fuel sales data for Road transport might actually include fuel that is used for other purposes.

The next step to improve the fuel sold emission estimates will study the potential vehicle categories that might be responsible for the differences between fuel used and fuel sold. If for example the difference for diesel is mainly caused by international freight transport, than it could be an option to adjust only the emission totals for heavy duty trucks. If the freight transport is mainly on highways, than the emission totals for heavy duty trucks on motorways should be adjusted accordingly. And if the tractor-trailer fleet that is used for international transport is relatively new compared to the average fleet in the Netherlands, than this should also be taken into account when adjusting emission totals. This next step is currently planned for 2015.

5
Industry

5.1 Overview of the sector

Emissions from this sector include all non-energy-related emissions from industrial activities. Data on the emissions from fuel combustion related to industrial activities 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 (NFR 2) sector consists of the following categories:
2A Mineral production
2B Chemical industry
2C Metal production
2D Paper, food and wood production
2E Production of POPs
2F Consumption of POPs and heavy metals
2G 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.
Table 5.1 gives an overview of the emissions from the Industrial processes (NFR 2) sector.

Table 5.1 Overview of emissions total from the Industrial processes (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	5.1	77.2	10.0	4.1	44.6	26.4	12.4
1995	3.2	42.8	2.8	3.8	30.2	16.1	7.3
2000	1.8	28.5	1.5	2.7	14.2	9.4	4.0
2005	0.5	25.0	1.0	2.3	13.3	8.9	3.7
2010	0.5	24.8	0.9	1.2	11.6	8.4	3.4
2011	0.7	24.1	1.0	1.1	11.4	8.1	3.3
2012	0.7	25.3	0.9	0.9	9.8	7.6	2.9
1990 - 2012 period 1)	-4.4	-51.9	-9.1	-3.3	-34.8	-18.8	-9.4
1990 - 2012 period 2)	-87%	-67%	-91%	-79%	-78%	-71%	-76%

1) Absolute difference in Gg

2) Relative difference to 1990 in %

	Priority Heavy Metals			POPs	
	Pb	Cd	Hg	DIOX	PAH
Year	Mg	Mg	Mg	g I-Teq	Mg
1990	67.10	0.90	1.24	37.73	10.69
1995	66.59	0.66	0.84	25.61	3.47
2000	24.39	0.77	0.39	1.45	0.36
2005	27.22	1.50	0.36	1.41	0.29
2010	31.51	0.96	0.21	1.72	0.19
2011	19.02	0.85	0.32	1.98	0.38
2012	12.84	0.59	0.27	1.20	0.08
1990 - 2012 period 1)	-54.26	-0.31	-0.96	-36.01	-10.61
1990 - 2012 period 2)	-81%	-34%	-78%	-95%	-99%

1) Absolute difference in Gg

2) Relative difference to 1990 in %

5.1.1 Key sources

Compared to the previous submission, Food and drink (2D2) has been added as a key source of $PM_{2.5}$, and Aluminium production (2C3) is no longer a key source of PAHs.

The key sources included in this submission are presented in Table 5.2.

The key sources 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

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

5.1.3 Methodological issues

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:

Table 5.2 Key sources in the Industrial processes (NFR 2) sector.

(Sub)category		Pollutant	Contribution to total in 2011 (%)
2A7d	Other mineral products	TSP / PM_{10} / $PM_{2.5}$	3.9/4.4/3.2
2B5a	Other chemical industry	NMVOC TSP / PM_{10} / $PM_{2.5}$ Cd	4.9 6.1/4.5/4.9 15.5
2C11	Iron and steel production	TSP / PM_{10} / $PM_{2.5}$ Pb Cd Hg	7.4/4.9/6.4 69.7 53.9 34.2
2C5b	Lead production	Hg	11.3
2D2	Food and drink	NMVOC TSP / PM_{10}	3.2 6.6/6.5/2.1
2.G	Other production, consumption, storage, transportation or handling of bulk products	NMVOC TSP / PM_{10} / $PM_{2.5}$	8.1 6.0/7.0/4.9

Method 1

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

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

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:

$$\text{IEF} = \text{Em IF} / \text{P\_IF}$$

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:

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

where n = year

Method 2

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

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

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:

$$\text{IEF} = \text{Em IF} / \text{P\_IF}$$

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:

$$\text{Em Total (sub)category}_{(n)} = \text{Em Total (sub)category}_{(n-1)} * [\, \text{PI}_{(n)} / \text{PI}_{(n-1)} \,]$$

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

5.1.4 Uncertainties and time-series 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.

5.1.6 Source-specific recalculations

$PM_{2.5}$ emissions were recalculated for all years and many sources, partly as a result of new $PM_{2.5}$ fractions and partly because of error corrections.
Furthermore, NMVOC emissions from some sources in the 1A2c (Stationary combustion in manufacturing industries and construction: chemicals) category were not properly allocated in previous submissions and have been reallocated . For this submission, the NMVOC emissions from these sources were allocated to the 2B5a category. As a result, the Other chemicals category 2B5a was added as a key source of NMVOC, and the 1A2c category and 3B1 (Degreasing) category are no longer key sources of NMVOC. Please note that the above reallocations do not change the national emissions total.

5.1.7 Source-specific planned improvements

Because emissions could not be separated per bulk product, the planned improvement of reallocating the emissions from the storage and handling of bulk products was cancelled. Furthermore, incomplete TSP and Cd time series will be repaired, where possible, in future submissions.

5.2 Mineral production (2A)

5.2.1 Source-category description

This category comprises emissions related to the production and use of non-metallic minerals in:

2A1 Cement clinker production
2A2 Lime production
2A3 Limestone and dolomite use
2A4 Soda ash production and use
2A5 Asphalt roofing
2A6 Road paving with asphalt
2A7 Other (the production of glass and other mineral production and use)

Emissions from lime production (2A2) were included in the subcategory of Food and drink process emissions (2D2); those from Asphalt roofing (2A5) and Asphalt road paving (2A6) were not estimated, since no activity data was available.
Because of allocation problems, the emissions total from Mineral products (2A) was reported in the category of Other mineral production (2A7d). Only emissions from 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

Other mineral production (2A7d) was identified as key source of TSP, PM_{10} and $PM_{2.5}$.

5.2.3 Overview of emission shares and trends

From 1990 to 2012, PM_{10} emissions from Mineral production (2A7d) decreased from 2.6 Gg to 1.2 Gg, and for $PM_{2.5}$ emissions the decrease was from 1.2 Gg to 0.4 Gg. These reductions were mainly caused by the implementation of technical measures.

5.2.4 Methodological issues

Method 2 was used for estimating the emissions from Other mineral production (2A7d) and Method 1 for those from Cement clinker production (2A1).

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
2B4 Carbide production
2B5 Other chemical industry

Adipic acid (included in 2B3) and calcium carbide (included in 2B4) 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, all emissions from the Chemical industry (2B) were allocated to the category of Other chemical industry (2B5a).

5.3.2 Key sources

The category of Other chemical industry (2B5a) was identified as a key source for TSP, PM$_{10}$, PM$_{2.5}$ and Cd.

5.3.3 Overview of emission shares and trends

From 1990 to 2012, NMVOC emissions decreased from 33.4 Gg to 7.2 Gg, and PM$_{10}$ emissions from 4.1 Gg to 1.2 Gg. These reductions were mainly caused by the implementation of technical measures.

5.3.4 Methodological issues

Method 1 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
2C5a Copper production
2C5b Lead production
2C5c Nickel production
2C5d Zinc production
2C5e Other metal production
2C5f 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

Iron and steel production (category 2C1) was identified as key source of TSP, PM$_{10}$, PM$_{2.5}$, Pb, Cd and Hg. Lead production (category 2C5b) is also one of the key sources of Hg.

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 5.3 provides an overview of the process emissions from Iron and steel production (category 2C1).

Table 5.3 Overview of emissions from Iron and steel production (2C1).

Pollutant	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
PM$_{10}$	*Gg*	9.13	4.80	2.03	1.92	1.75	1.84	1.87	1.72	1.66	1.79	1.57	1.44	1.53	1.46	1.30
PM$_{2.5}$	*Gg*	5.88	3.00	1.31	1.23	1.12	1.18	1.20	1.10	1.06	1.15	1.01	0.92	0.98	1.04	0.83
Pb	*Mg*	55.74	57.85	18.84	23.01	26.93	24.65	25.42	22.95	22.39	28.84	23.38	24.45	29.86	17.47	11.29
Cd	*Mg*	0.69	0.45	0.41	0.63	0.92	0.71	0.69	0.66	0.69	0.91	0.73	0.69	0.83	0.67	0.43
Hg	*Mg*	0.39	0.35	0.09	0.12	0.12	0.12	0.21	0.21	0.20	0.24	0.26	0.24	0.19	0.25	0.19
DIOX	*g I-Teq*	23.00	25.50	1.40	1.47	2.10	1.65	1.78	1.40	1.77	2.15	2.15	1.98	1.72	1.98	1.20
PAHs	*Mg*	1.64	1.62	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.12	0.20	0.06	0.08	0.08	0.08

1) This is the correct value; value in the NFR is not correct

Table 5.4 Overview of PAH emissions from Aluminium production (2C3).

Pol-lutant	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
PAHs	*Mg*	6.909	1.664	0.128	0.162	0.131	0.087	1.554	0.132	0.043	0.545	0.729	0.440	0.108	0.290	0.001

In addition to TSP, PM_{10}, $PM_{2.5}$, Pb, Cd and Hg (the key source pollutants), Iron and steel production is also responsible for 5.1% of the total in dioxins and for 2.2% 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 Cd emission decreased in both 2011 and 2012.

Aluminium production (2C3)

Aluminium production (category 2C3) is responsible for 0.02% 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 5.4 provides an overview of the PAH emissions from Aluminium production (category 2C3).

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. 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 0.001 Mg in 2012, 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.

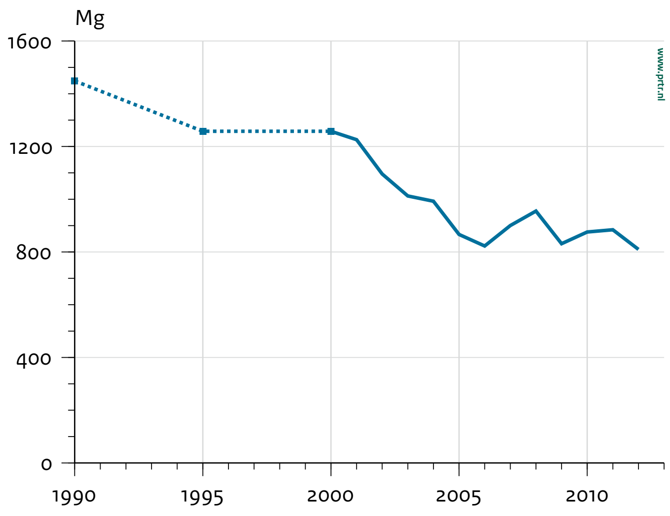
Lead production (category 2C5b)

The level of Hg emissions during Lead production strongly depends on the contamination of the raw material.

5.4.4 Methodological issues

Method 1 was used for estimating the emissions from Iron and steel production (2C1), Aluminium production (2C3) and Lead production (2C5b).

Figure 5.2 Storage and handling of dry bulk products: trend and emissions of PM_{10}.



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 Other production industry (2D)

5.5.1 Source-category description

This category comprises emissions related to the following sources:

2D1 Pulp and paper
2D2 Food and drink
2D3 Wood processing

5.5.2 Key sources

The category of Food and drink (2D2) is a key source for NMVOC, TSP, PM_{10} and $PM_{2.5}$.

5.5.3 Overview of emission shares and trends

From 1990 to 2011, NMVOC emissions decreased from 7 to 5 Gg, and for PM_{10} the decrease was from 4 to 2 Gg. These reductions were mainly caused by the implementation of technical measures.

5.5.4 Methodological issues

Method 2 was used for estimating the emissions from the production of Food and drink (category 2D2) and Method 1 for Pulp and paper (2D1) and Wood processing (2D3).

5.6 Other production, consumption, storage, transportation or handling of bulk products (category 2G)

The 2G category 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 2G category. 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.

5.6.1 Key sources

The category of Other production, consumption, storage, transportation or handling of bulk products (2G) is a key source for NMVOC, TSP, PM_{10} and $PM_{2.5}$.

5.6.2 Overview of emission shares and trends

From 1990 to 2012, NMVOC emissions decreased from 30 Gg to 12 Gg. The contribution of storage and handling was 15 Gg in 1990 and 8 Gg in 2011. PM_{10} emissions decreased from 4.9 Gg to 1.9 Gg during the 1990–2012 period. The contribution of storage and handling was 1.4 Gg in 1990 and 0.8 Gg in 2012.

Figure 5.2 shows the trend in PM_{10} emissions from the 2G category (storage and handling) over the 1990–2012 period.

After 2000, the PM_{10} emission fluctuations have mainly been caused by the quantities of the various dry bulk products handled.

Reductions in NMVOC and PM_{10} emissions were mainly caused by the implementation of technical measures.

5.6.3 Methodological issues

Method 1 was used for estimating particulate matter (PM) emissions; Method 2 was used for estimate all other emissions.

6

Solvents and product use

6.1 Overview of the sector

Emissions from this sector include those from the use of paints, degreasing and dry cleaning, the printing industry, domestic solvent use and other product use. Solvents and product use (NFR 3) consist of the following categories:

3A Paint application
3B Degreasing and dry cleaning
3C Chemical products, manufacture and processing
3D Other solvent use

Emissions from Chemical products, manufacture and processing (category 3C) were included in the category of Chemical industry (2B).

Table 6.1 provides an overview of emissions from Solvents and product use (NFR 3).

Table 6.1 Overview of emission total of Solvents and product use (NFR sector 3).

	Main Pollutants		Particulate Matter			POPs	
	NMVOC	NH_3	TSP	PM_{10}	$PM_{2.5}$	DIOX	PAH
Year	Gg	Gg	Gg	Gg	Gg	g I-Teq	Mg
1990	133.5	0.98	1.05	1.05	0.42	25.0	2.48
1995	110.5	1.04	1.03	1.03	0.36	23.0	1.05
2000	79.5	1.06	1.21	1.21	0.40	20.0	0.06
2005	62.1	1.11	1.14	1.14	0.38	18.0	0.05
2010	55.8	1.08	1.11	1.11	0.37	15.0	0.04
2011	55.3	1.09	1.08	1.08	0.36	14.5	0.04
2012	53.8	1.08	1.00	1.00	0.33	14.0	0.04
1990 - 2012 period 1)	-79.7	0.10	-0.06	-0.06	-0.08	-11.0	-2.45
1990 - 2012 period 2)	-60%	10%	-5%	-5%	-20%	-44%	-99%

1) Absolute difference in Gg

2) Relative difference to 1990 in %

6.1.1 Key sources

As mentioned in Chapter 5, NMVOC emissions from some sources in the category of Stationary combustion in manufacturing industries and construction: chemicals (1A2c) were not properly allocated in previous submissions and were therefore reallocated. In this submission, NMVOC emissions from these sources were allocated to the category of Other chemical industry (2B5a). As a result, the category of Degreasing (3B1) is no longer considered one of the key sources of NMVOC.

The key sources in this sector are presented in Table 6.2.

Table 6.2 Key sources in the solvents and product use sector (NFR 3).

(Sub)category	Pollutant	Contribution to total in 2011 (%)
3A2 Industrial coating application	NMVOC	10.6
3D1 Printing	NMVOC	2.3
3D2 Domestic solvent use, including fungicides	NMVOC	13.9
3D3 Other product use	NMVOC TSP / PM_{10} / $PM_{2.5}$ DIOX	67.1 3.2 / 3.8 / 2.6 60.1

The key sources are discussed in Sections 6.2 and 6.3.

6.1.2 Source-specific QA/QC and verification

The source categories are covered by the general QA/QC procedures, as discussed in Subsection 1.6.2.

6.1.3 Source-specific recalculations

In the totals in the paint consumption time series, two errors (for 2010 and 2011) were detected and subsequently repaired in this submission.

6.1.4 Source-specific planned improvements

There are no source-specific improvements planned for this category.

6.2 Paint Application (3A)

6.2.1 Source-category description

This category comprises emissions related to the following sources:

3A1 Decorative paint application
3A2 Industrial coating application
3A3 Other coating application

Table 6.3 provides an overview of total paint consumption in the Netherlands and its NMVOC content.

Table 6.3 Overview of total paint consumption in the Netherlands and its NMVOC content.

Year	Total paint consumption (kt)	VOC content in %
1990	197	30.0
1995	207	20.0
2000	272	14.8
2001	262	13.9
2002	251	13.6
2003	240	12.1
2004	224	11.1
2005	239	10.7
2006	236	9.8
2007	243	9.9
2008	233	10.2
2009	203	10.0
2010	206	10.3
2011	202	10.2
2012	190	10.2

Table 6.3 shows a decrease in NMVOC content, from 30% in 1990 to almost 10% in 2006. After 2006, the NMVOC contents remained rather stable.

6.2.2 Key sources

Industrial coating application (category 3A2) was identified as one of the key sources of NMVOC.

6.2.3 Overview of shares and trends in emissions

Mainly due to the lower average NMVOC content of the paints used (see Table 6.3), NMVOC emissions from the industrial use of paint decreased from 71 Gg in 1990 to 18 Gg in 2008. As a result of the credit crunch, paint consumption decreased over the 2009–2012 period; therefore, NMVOC emissions also decreased to 15.5 Gg in 2012. Figure 6.1 shows the trend in NMVOC emissions from Industrial coating application (category 3A2) over the 1990–2012 period.

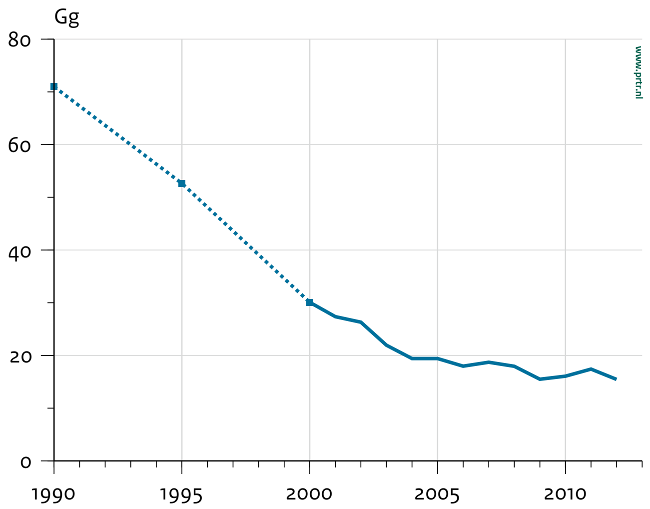
6.2.4 Activity data and (implied) emission factors

In the paint application sector, annual statistics on sales are provided by the Dutch Paint and Ink Producers Association (VVVF).

6.2.5 Methodological issues

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

Figure 6.1 NMVOC emissions from Industrial coating application (3A2).



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, 2014: in preparation).

6.3 Other solvent use (category 3D)

6.3.1 Source-category description

The category of other solvent use (3D) comprises emissions related to the following sources:
3D1 Printing
3D2 Domestic solvent use, including fungicides
3D3 Other product use

6.3.2 Key sources

Printing (category 3D1), Domestic solvent use (category 3D2) and Other product use (category 3D3) have been identified as three of the key sources of NMVOC. Other product use (3D3) is also one of the key sources of dioxin.

6.3.3 Overview of emission shares and trends

Printing (category 3D1)
NMVOC emissions decreased from 14.4 Gg in 1990 to 4.2 Gg in 2008. These reductions were mainly the result of the implementation of technical measures (e.g. afterburners). In 2012, the Dutch printing ink market continued to be confronted with declining sales and revenues. This could at least partly be attributed to the economic crisis. However, there is also an underlying development that is causing a structurally lower demand for ink: the continued increase in the digital exchange of information. Consequently, emissions from Printing decreased to 3.4 Gg in 2012.

Domestic solvent use, including fungicides (category 3D2)
In this category, the most important emission sources are those of cosmetics (and toiletries), cleaning agents and car products. Here, NMVOC emissions increased from 11 Gg in 1990 to 20 Gg in 2012. This was mainly the result of the increase in the consumption of cosmetics.

Other product use (category 3D3)
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 2012. 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 14 g I-TEQ in 2012.

6.3.4 Activity data and (implied) emission factors

Printing (category 3D1)
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 2008–2012 period, emissions were calculated using the annual sales figures of printing ink, which have been available since 2007.

Domestic solvent use, including fungicides (category 3D2) and other product use (category 3D3)
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.

Other product use (category 3D3)
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.

6.3.5 Methodological issues

Printing (category 3D1)
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

Domestic solvent use, including fungicides (category 3D2) and other product use (category 3D3)
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.

Other product use (category 3D3)
See Subsection 6.3.3.

7
Agriculture

7.1 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 categories:

- 4B Animal husbandry and manure management
- 4D Crop production and agricultural soils
- 4F Field burning of agricultural wastes
- 4G Agriculture other

In the Netherlands, no emissions have been allocated to category 4G and, as field burning of agricultural wastes is prohibited by law, emissions from activities belonging to category 4F are negligible, in actual practice. Emissions of the greenhouse gases nitrous oxide (N_2O) and methane (CH_4) are reported in annual National Inventory Reports (NIR). Therefore, the Informative Inventory Report (IIR) focuses on emissions of ammonia (NH_3), nitric oxide (NO) and particulate matter (PM) from the source categories of Animal husbandry and manure management (4B) and Crop production and agricultural soils (4D).

The agricultural sector is responsible for more than 85% of NH_3 emissions in the Netherlands. Agriculture is also a large source of particulates (TSP) and associated particulate matter fractions (PM_{10}, $PM_{2.5}$). Most agricultural emissions come from livestock, as manure is the primary source of NH_3 and animal housing contributes significantly to PM_{10}.

7.1.1 Key sources

Dairy cattle (category 4B1a) are the largest key source of NH_3, followed by swine (category 4B8), non-dairy cattle (category 4B1b) and synthetic N fertilisers (category 4D1a).

Laying hens (category 4B9a), broilers (category 4B9b) and swine (category 4B8) are the key sources of both PM_{10} and TSP emissions within the agricultural sector. Laying hens are the largest contributors to the national total in PM_{10} emissions.

7.1.2 Trends

NH_3 emissions have decreased sharply between 1990 and 2012, 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. Maximum application standards for manure and synthetic fertiliser, together with systems of production rights, have further decreased emissions. Livestock production per head has increased over the years, whereas animal numbers in general have shown a decreasing trend (although in recent years, animal numbers have rather stabilised). Ongoing improvement in nutritional management with a profound reduction of dietary crude protein in combination with increased animal productions, led to lower N excretions per animal, which also contributed significantly to lower NH_3 emissions. This leads to high trend contributions from these source categories and, since the national total is dominated by emissions from agriculture, to an overall decreasing trend in NH_3 emissions.

Although PM emissions for most animal categories decreased slightly over the 1990–2012 period with falling animal numbers, these emissions nearly doubled for laying hens. The reason for this is the almost complete transition from liquid manure systems to solid manure systems, with higher associated emission factors.

7.2 Animal husbandry and manure management

7.2.1 Source category description

This source comprises emissions from the handling and storage of animal manure. The category of Animal husbandry and manure management (4B) has the following subcategories:

- 4B1a Dairy cattle
- 4B1b Non-dairy cattle
- 4B2 Buffalo
- 4B3 Sheep
- 4B4 Goats
- 4B5 Camels and llamas
- 4B6 Horses
- 4B7 Mules and asses
- 4B8 Swine
- 4B9a Laying hens
- 4B9b Broilers
- 4B9c Turkeys
- 4B9d Other poultry
- 4B13 Other animals

Animals in the categories 4B2 (Buffalo), 4B5 (Camels and llamas) and 4B9d (Other poultry) do not occur in the Netherlands. Animal numbers in the category 4B7 (mules and asses) are small and, therefore, were not estimated. Rabbits and fur-bearing animals are being reported under category 4B13 (Other animals).

7.2.2 Key sources

Dairy cattle (category 4B1a) are the largest contributors to NH_3 emissions, at 29.9% of the national total. Swine (category 4B8) and non-dairy cattle (category 4B1b) are key sources that contribute 17.1% and 13.9%, respectively.

At 10.3%, laying hens (category 4B9a) are the largest source of PM_{10} emissions in the national total, and they also form an important source of TSP with a contribution of 8.7%. Broilers (category 4B9b) are responsible for 5.0% of PM_{10} emissions and 4.2% of TSP. Swine (category 4B8) form a key emission source as well, with PM_{10} and TSP contributions of 4.6% and 3.9%, respectively.

7.2.3 Overview of emission shares and trends

Table 7.1 presents an overview of emissions of the main pollutants NO and NH_3, together with the emission of particulate matter species TSP, PM_{10} and $PM_{2.5}$ that originate from this category.

Table 7.1 Emissions of main pollutants and particulate matter from category 4B Manure management.

	Main pollutants		Particulate Matter		
	NO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$
Year	Gg	Gg	Gg	Gg	Gg
1990	8.0	320	3.88	3.88	0.41
1995	7.9	175	3.94	3.94	0.41
2000	6.8	133	4.40	4.40	0.43
2005	6.2	112	4.69	4.69	0.42
2010	6.8	102	5.32	5.32	0.45
2011	7.1	98	5.78	5.78	0.47
2012	6.8	90	5.62	5.62	0.45
1990 - 2012 period [1]	-1.2	-230	1.74	1.74	0.04
1990 - 2012 period [2]	-15%	-72%	45%	45%	11%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

Between 1990 and 2012, NH_3 emissions were reduced by 72%, with an initial sharp decrease in the 1990-1995 period. Emissions resulting from the application of animal manure here are reported under the category of Animal husbandry and manure management (4B), which is different from the NIR where such emissions are reported under the category of Crop production and agricultural soils (4D). Therefore, the sharp decrease in emissions in 1995 was mainly the result of changes in application methods (i.e. incorporation of the manure into the soil instead of spreading it over the surface). Both a higher production rate per animal and quotas have resulted in a decreasing trend in animal numbers, although in recent

Table 7.2 Animal numbers over the 1990–2012 period (in 1,000 heads)

Animal type	1990	1995	2000	2005	2010	2011	2012
Cattle	4,926	4,654	4,069	3,797	3,975	3,885	3,879
- dairy cattle	1,878	1,708	1,504	1,433	1,479	1,470	1,484
- non-dairy cattle	3,048	2,946	2,565	2,364	2,497	2,416	2,395
Sheep	1,702	1,674	1,305	1,361	1,130	1,088	1,043
Goats	61	76	179	292	353	380	397
Horses[1]	370	400	417	433	441	436	431
Pigs (*1000)	13.9	14.4	13.1	11.3	12.3	12.4	12.2
Poultry (*1000)	94.9	91.6	106.5	95.2	103.4	98.9	97.0
- laying hens (*1,000)	44.3	38.2	44.0	42.6	49.2	45.7	44.1
- broilers (*1,000)[2]	50.6	53.5	62.5	52.6	54.2	53.3	53.0
Other animals	659	527	641	745	1,001	1,016	1,074

[1] including privately owned horses

[2] including turkeys; Source: CBS, 2012

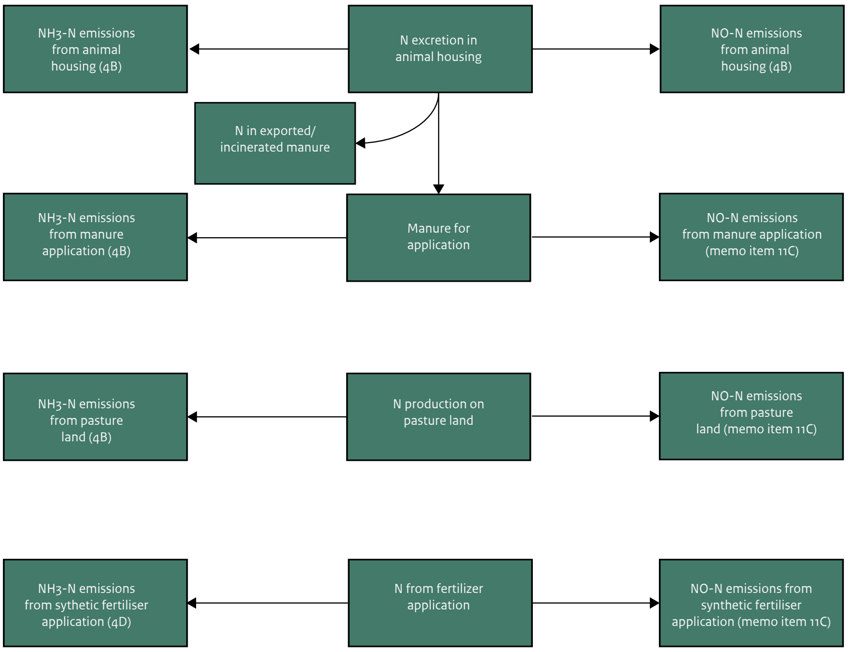
Table 7.3 Nitrogen flows related to NH_3 and NO_x emissions (in Gg N).

	1990	1995	2000	2005	2010	2011	2012	Change 2011 - 1990 (%)
4B Manure management								
Nitrogen excretion in animal housing	514.5	516.1	432.5	393.5	423.3	423.2	410.6	-20%
- of which in solid form	102.1	104.3	94.8	88.4	96.5	93.8	89.5	-12%
- of which in liquid form	412.4	411.8	337.7	305.1	326.8	329.4	321.2	-22%
NH_3-N emissions from animal housing	72.3	70.5	56.3	48.9	49.3	46.8	44.2	-39%
NO-N emissions from animal housing	2.4	2.4	2.1	1.9	2.1	2.2	2.1	-15%
N_2O-N emissions from animal housing	2.4	2.4	2.1	1.9	2.1	2.2	2.1	-15%
Other N losses from animal housing[1]	14.6	14.3	12.2	12.4	15.0	17.8	17.6	21%
Nitrogen in exported/incinerateded manure	12.5	26.9	23.5	32.8	54.8	54.1	61.0	388%
Available manure for application	410.3	399.8	336.3	295.7	300.0	300.2	283.8	-31%
(N excretion in animal housing - total N losses in animal housing - exported/incinerated manure)								
NH_3-N emissions from manure application	182.5	63.6	51.0	43.7	34.9	35.3	31.6	-83%
NO-N emissions from manure application	4.9	4.8	4.0	3.5	3.6	3.6	3.4	-31%
N_2O-N emissions from manure application	1.6	3.5	2.9	2.6	2.6	2.6	2.5	50%
Nitrogen excretion on pasture land	195.9	179.9	132.5	101.2	81.3	68.9	65.0	-67%
NH_3-N emissions excretion on pasture land	15.2	13.7	4.5	3.0	1.8	1.3	1.2	-92%
NO-N emissions excretion on pasture land	2.4	2.2	1.6	1.2	1.0	0.8	0.8	-67%
N_2O-N emissions excretion on pasture land	6.5	5.9	4.4	3.3	2.7	2.3	2.1	-67%
4D Agricultural soils								
Nitrogen from fertiliser application[2]	412.4	405.8	339.5	279.2	219.5	214.1	213.2	-48%
NH3-N emissions from fertiliser application	12.0	12.0	10.5	11.4	8.9	9.3	12.0	0%
NO-N emissions from fertiliser application	4.9	4.9	4.1	3.4	2.7	2.7	2.7	-46%
N2O-N emissions from fertiliser application	5.4	5.3	4.4	3.6	2.9	2.8	2.8	-47%

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

[2] including N in the rinsing liquid of air scrubbers

Figure 7.1 Nitrogen flows in relationship to NH_3 and NO_2 emissions.



years they rather stabilised. An ongoing decrease in N excretions per animal due to lower dietary crude protein, has added to the effect.

Since NO emissions from agriculture form a new emission source not accounted for under the National Emission Ceiling (NEC), most of these emissions are reported as memo items under the category of Other natural emissions (11C). Only emissions from animal housing and storage have been included under Animal husbandry and manure management, as they are deemed non-natural. NO resulting from the application of manure and synthetic fertiliser are considered to be related to land use and are not reported under Animal husbandry and manure management.

7.2.4 Activity data and (implied) emission factors

NH_3, NO and PM emissions from Animal husbandry and manure management were calculated using the National Emission Model for Agriculture (NEMA), managed by Statistics Netherlands (CBS). Input data included animal numbers as determined by the annual agricultural census (see the summary in Table 7.2, and Van Bruggen *et al.* (2014) for a full overview of subcategories and years). Furthermore, the N excretions per animal calculated annually by the working group on uniformity of calculations of manure and mineral data (WUM) were used as basic input. The data were recalculated in 2009 based on the latest insights (CBS, 2012a).

For horses, an estimated 300,000 additional animals were included in the inventory, to account for privately owned animals. The emissions of NH_3 and PM resulting from the Animal husbandry and manure management of these animals are reported under the category of Other (7A), but were included in the N flows presented here.

A distribution was made of animals over the various housing types, using information from the agricultural census and taking grazing into account. Corresponding emission factors were then applied for NH_3, N_2O, NO and N_2 (Van Bruggen *et al.*, 2011), using the gross total ammonia nitrogen (TAN) excreted in each housing type. For ammonia, these emission factors were based on measurements, and stipulated in the Dutch Ammonia and Livestock Farming Regulation (Rav). To calculate N_2O, default emission factors from the IPCC Guidelines 1996 and Good Practice Guidance 2001 were used. These were also used for NO, following research carried out by Oenema *et al.* (2000), who set the ratio to 1:1. Similarly, emissions from manure storage were calculated considering implementation grades.

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 Velthof *et al.*, 2009. NO emissions related to manure application were being calculated using the EMEP default factor.

Figure 7.1 presents a schematic overview of NH_3 and NO emissions in relationship to N flows, including their allocation to source categories. Table 7.3 provides a summary of associated N flows (in Gg N), over the 1990–2012 period.

Both synthetic fertiliser use and N excreted by animals decreased considerably, over the 1990–2012 period, while the manure exported or incinerated increased by a factor of four. These developments resulted in less nitrogen (N) being applied to soils and, therefore, to overall lower emissions of NH_3 and NO. For manure application, incorporation into the soil is mandatory since the early 1990s, leading to much lower NH_3 emission levels. However, N_2O emissions from manure application have increased, because the emission factor is higher, compared to surface spreading.

Particulate matter emissions from agriculture mainly originate from animal skin, manure, feed and bedding particles ventilated from animal housing. The previous emission factors were outdated and possibly inaccurate; therefore, Wageningen UR Livestock Research conducted a measurement programme between 2007 and 2009. For a range of livestock categories and animal housing types, PM_{10} and $PM_{2.5}$ emissions were determined, see the publication series 'Dust emission from animal houses' (available at www.asg.wur.nl). The animal housing types not included were given emission factors proportional to those used before. 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).

7.2.5 Methodological issues

Emissions of NH_3, N_2O and NO from animal manure in animal housing and storage, as well as during manure application, were calculated using model data from the National Emission Model for Agriculture (NEMA). The Total Ammonia Nitrogen (TAN) in manure was estimated, on the basis of the faecal digestibility of nitrogen in feed rations, taking into account organic N mineralisation/immobilisation and excretion on pasture land during grazing. From this, NH_3 emissions were calculated according to the method described in Velthof *et al.* (2009).

Input for the model was divided into general (activity data, i.e. animal numbers) and specific input; the latter concerned excretions of nitrogen and phosphate from animals in different categories. Also considered were the ammonia volatilisation rates from animal housing systems and from soil application systems for animal manure. The average annual nitrogen excretion per animal category was calculated as the difference between nitrogen absorbed from feed and that captured in animal products. In this 'balancing' method, annual changes were also taken into account, such as those in feed allowance, feed supply (e.g. roughages) and feed composition (nitrogen content).

The excreted nitrogen partly volatilises as ammonia within animal housing, on pasture land, during storage and application to soil, taking into account the share of housing and manure application systems with a low ammonia volatilisation rate. The volatilisation rate of ammonia from animal manure depends on such aspects as the nitrogen content of the manure, the chemical balance between ammonia and ammonium in the manure and, finally, on the surface area of the manure exposed to air and the duration of the exposure.

The main sources of PM emissions from agriculture are animal housing systems. The general input data used for calculating emissions from animal housing systems are animal numbers taken from the annual agricultural census. For several animal categories, country-specific emission factors are available (see Subsection 7.2.4).

7.2.6 Uncertainties and time-series consistency

The NEMA model was used, for the first time, for the 2011 inventory report. With insufficient data available to determine the level of uncertainty of the calculations, this analysis was scheduled for a later inventory report. Uncertainty estimates of source data were also outdated and needed to be reassessed. The reassessed figures have since been published (CBS, 2012). Although work has started on determining the level of uncertainty of the calculations, it has not yet been completed, as the uncertainty analysis of greenhouse gas emissions was given priority.

As annual censuses have been conducted in the same way for many years (even decades), and the same calculations were used for the whole series, the time-series consistency is very good.

7.2.7 Source-specific QA/QC and verification

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

7.2.8 Source-specific recalculations

Ammonia emission factors for the animal housing of dairy cattle were updated. New measurements over the 2007–2012 period indicate higher values; among other things because the living space per animal increased. Data were interpolated from 2002 onwards, as previous figures represented the situation in 2001. As a result, ammonia emissions from housing and storage increased by 1.4 Gg in 2002 to up to 3.5 Gg in 2011. In part, the increase in emissions is compensated for by lower emission levels following manure application.

Over recent years, the use of air scrubbers as an abatement technology for reducing ammonia emissions has seen a rapid increase. Inspection reports have shown that such air scrubbers were not always used where required. Furthermore, until now, the ammonia retained was considered to remain within the animal manure, but the rinsing liquid in actual practice is being used as a chemical fertiliser. Implementation grades have now been corrected for the reported deficiencies and the waste stream has been allocated correctly. The effect can be seen to have started in 1997, and to become clearly visible by 2005 with a 0.6 Gg increase in NH_3 emissions from housing and storage. In 2011, this increased to 1.8 Gg, although some would ultimately be compensated for by a decrease in the emissions from manure application.

Over 2010 and 2011, there appeared to have been a build-up of stored manure. However, on closer inspection, this was found not to have been the case as there was sufficient capacity available to dispose of all manure produced. The emissions from manure application thus were added to the inventory and amounted to around 3.5 Gg NH_3 for 2010 and 1.5 Gg for 2011.

7.2.9 Source-specific planned improvements

The current inventory report only includes NO emissions from housing and storage included in the reported national totals. NO emissions from the application of 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.

An uncertainty analysis of NH_3 emissions calculated by the NEMA model is foreseen for the next inventory report.

7.3 Crop production and agricultural soils

7.3.1 Source category description

This category consists of all emissions related to the agricultural use of land. For this inventory report, the following categories are relevant:

- 4D1a Synthetic N fertilisers
- 4D2a Farm-level agricultural operations including storage, handling and transport of agricultural products
- 4D2b Off-farm storage, handling and transport of bulk agricultural products
- 4D2c N excretion on pasture range and paddock unspecified

Within category 4D1a, NH_3 emissions from the application of synthetic fertilisers are included. Category 4D2a contains PM emissions from the use of synthetic fertilisers and pesticides, the supply of concentrate feed to farms, haymaking and crop harvesting. Emission levels from category 4D2b are low and, therefore, were not estimated. Other than in the NIR, emissions from the application of animal manure are not to be reported under category 4D, but under 4B Animal husbandry and manure management. Therefore, emissions from animal production during grazing (category 4D2c) have also been included there.

7.3.2 Key sources

Synthetic N fertilisers (4D1a) are one of the key sources of NH_3 emissions, at 11.3% of the national total.

7.3.3 Overview of shares and trends in emissions

Table 7.4 presents an overview of emissions of the main pollutant NH_3, together with the particulate matter species TSP, PM_{10} and $PM_{2.5}$ that originate from the category of Crop production and agricultural soils (4D).

Data on NH_3 solely reflect emissions caused by the use of synthetic fertiliser, which has been decreasing over the years, following policy measures aimed at reducing nutrient supply to soils. The use of pesticides, supply of concentrate feed to farms, haymaking and crop harvesting

Table 7.4 Emissions of main pollutants and particulate matter from the category of Crop production and agricultural soils (4D)

	Main Pollutants	Particulate Matter		
	NH_3	TSP	PM_{10}	$PM_{2.5}$
Year	Gg	Gg	Gg	Gg
1990	13.9	0.76	0.76	0.11
1995	14.0	0.75	0.75	0.11
2000	12.0	0.76	0.76	0.11
2005	13.0	0.77	0.77	0.11
2010	10.2	0.76	0.76	0.11
2011	10.6	0.75	0.75	0.11
2012	13.6	0.74	0.74	0.11
1990 - 2012 period [1]	-0.3	-0.02	-0.02	0.00
1990 - 2012 period [2]	-2%	-3%	-3%	-1%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

also contribute to the emissions of particulate matter reported within this category.

Since NO emissions from Crop production and agricultural soils are not accounted for under the NEC, they were reported as a memo item under the category of Other natural emissions (11C). NO emissions from synthetic fertiliser use is thus included in this category (see also Subsection 7.2.3).

7.3.4 Activity data and (implied) emission factors

Ammonia emissions from the use of synthetic fertilisers were calculated using data on the amount of nitrogen fertiliser sold, corrected for non-agricultural use. Several types of nitrogen fertiliser were distinguished – each with their own specific ammonia emission factor (Velthof *et al.*, 2009). These emission factors were used in NEMA model calculations of NH_3 emissions from synthetic fertilisers.

The NEMA calculations also included the associated NO 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.

7.3.5 Methodological issues

NH_3, NO and PM emissions from the use of synthetic fertiliser were calculated in the NEMA model (see Subsection 7.2.5 for a general description). Specific activity data and emission factors related to synthetic fertiliser use are discussed in the previous section.

Small sources of PM emissions to be reported under category 4D, include applications of synthetic fertilisers and pesticides, the supply of concentrate feed to farms, haymaking and crop harvesting.

7.3.6 Uncertainties and time-series consistency

There was insufficient data available to assess the uncertainty of the calculations (see also Subsection 7.2.6). An uncertainty analysis of NH_3 emissions, using the NEMA model, has been scheduled for the coming year.

As annual censuses have been performed in the same way for many years (even decades), and the same calculations were used for the whole series, the time-series consistency is very good.

7.3.7 QA/QC and verification

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

7.3.8 Recalculations

Over recent years, the use of air scrubbers as an abatement technology for reducing ammonia emissions has seen a rapid increase. Until now, the ammonia retained was considered to remain within the animal manure, but the rinsing liquid in actual practice is being used as a chemical fertiliser. The waste stream has now been allocated correctly and the effect can be seen from 1997 onwards, increasing to 0.2 Gg higher NH_3 emissions from fertiliser application in 2011.

7.3.9 Planned improvements

NO emissions from the application of synthetic fertiliser are currently reported under the category of Other natural emissions (11C). This categorisation will be reconsidered as soon as emission ceilings also include this new emission source.

An uncertainty analysis of NH_3 emissions, calculated by the NEMA model, is foreseen for the next inventory report.

8

Waste

8.1 Overview of the sector

Waste sector emissions include those from industrial activities. The waste sector (NFR 6) consists of the following source categories:

6A Solid waste disposal on land
6B Waste-water handling
6C Waste incineration
6D Other waste

Solid waste disposal on land (category 6A)

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)).

Waste-water handling (category 6B)

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 things. Around 80% of this methane is captured and is either used in energy production or is flared. For this reason, the WWPT emissions, therefore, are reported under the source category of Commercial and institutional services (1A4ai).

Waste incineration (category 6C)

Emissions from this category comprise those from urban and industrial waste incineration and crematoria. Since all waste incineration plants in the Netherlands produce electricity and/or heat that is used for energy purposes, emissions from this source category (6C) are included in the sector on energy (source category Public electricity and heat production (1A1a)).

NO_x and SO_x emissions from Cremations (category 6Cd) originate mainly from fuel use (natural gas). These emissions, therefore, are included in the source category Commercial and institutional services (1A4ai).

Other waste (category 6D)

The emissions from the Other waste source sector comprise those from the emission sources: Industrial composting, waste preparation for recycling and scrap fridges/freezers.

Table 8.1 Overview of emission totals in the Waste sector (NFR 6).

Year	Main Pollutants		Particulate Matter			Heavy Metals/POPs	
	NMVOC	NH_3*	TSP	PM_{10}	PM_{25}	Hg	DIOX
	Gg	Gg	Gg	Gg	Gg	Mg	g I-Teq
1990	1.5	0.00	0.006	0.006	0.006	0.06	0.00
1995	1.3	0.28	0.013	0.013	0.010	0.07	0.30
2000	1.0	0.30	0.007	0.007	0.007	0.10	0.27
2005	0.8	0.27	0.006	0.006	0.006	0.09	0.25
2010	0.6	0.21	0.003	0.003	0.003	0.05	0.09
2011	0.5	0.22	0.006	0.006	0.002	0.04	0.06
2012	0.5	0.21	0.002	0.002	0.001	0.03	0.02
1990 - 2012 period 1)	-1.0	0.21	-0.004	-0.004	-0.005	-0.03	0.02
1990 - 2012 period 2)	-67%	-	-73%	-73%	-85%	-55%	-

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

8.1.1 Key sources

There are no relevant key sources in the Waste sector.

8.1.2 Methodological issues

There are no specific methodological issues.

8.1.3 Uncertainties and time-series consistency

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

8.1.4 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.

8.1.5 Source-specific recalculations

There were no source-specific recalculations in this sector.

8.1.6 Source-specific planned improvements

There are no source-specific planned improvements.

8.2 Solid waste disposal on land

8.2.1 Source-category description

This category includes all waste landfill sites in the Netherlands that have been managed and monitored since 1945, and concerns both historical and current public dump sites, plus waste dumping sites on private land. These waste sites are considered to be responsible for most of the emissions from this source category.

The source category of Solid waste disposal on land (6A) comprises the direct emissions from landfills and from extracted landfill gas.
Extracted landfill gas is used as an energy source and as such the emissions from this source are included in those from the energy sector.

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. 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 with a model based on the IPCC guidelines on methane. Based on measurements of the composition of landfill gas, the model uses fractions to calculate the level of individual substances in NMVOC emissions.

8.2.2 Key sources

There are no keys sources of landfill gas emissions.

8.2.3 Overview of shares and trends in emissions

NMVOC emission levels related to this source category are relatively low (with 1.46 Gg and 0.43 Gg in 1990 and 2012, respectively). Therefore, shares and trends in these emissions are not elaborated here.

8.2.4 Emissions, activity data and (implied) emission factors

Emissions of the individual compounds of NMVOC were 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.

For each waste site, landfill site operators systematically monitor the amount of waste dumped (weight and composition). Since 1993[1], 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).

8.2.5 Methodological issues

There are no specific methodological issues.

8.3 Waste-water handling

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 Commercial and institutional services (1A4ai).

8.4 Waste incineration

8.4.1 Source-category description

The source category of Waste incineration (6C) comprises emissions from the following sources:
6Ca Clinical waste incineration
6Cb Industrial waste incineration
6Cc Municipal waste incineration
6Cd Cremations
6Ce Small-scale waste burning

Emissions from Clinical waste incineration (category 6Ca) and Industrial waste incineration (category 6Cb) are included in Municipal waste incineration (category 6Cc). In the Netherlands, the heat that is generated by waste incineration is used to produce electricity and heating. This source category, therefore, is reported under the energy sector (source category Public electricity and heat production (1A1a)). Emissions from Cremations (category 6Cd) originate from the incineration of human remains (process emissions) and from the incineration fuel (combustion emissions). The combustion emissions are reported under the energy sector (source category of Commercial and institutional services (1A4ai)).
Because of a ban on small-scale waste burning (category 6Ce), this emission source does not occur in the Netherlands.

8.4.2 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 emission source.

8.4.3 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.

8.4.4 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, 2013).

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[1] The obligation to weigh incoming waste at landfill sites started with the Dumping Decree coming into force in 1993.

Table 8.2 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	140,709	83,379	59	100

* Interpolation using year 2011
** Calculation based on an accurate list of crematoria under the NeR (LVC, 2012)

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 g Hg/cremation for 1995*;
- 1.37 g Hg/cremation for 2000*;
- 1.44 g Hg/cremation for 2002*;
- 1.73 g Hg/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 mg Hg/m^3 (Elzinga, 1996). Based on this result, an emission factor of 0.1 g Hg/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 100gTSP/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 gTSP/cremation or less (Elzenga, 1996). However, measurements carried out at the crematorium in the Dutch city of Geleen showed concentrations of <6 mgTSP/m^3 (~13 gTSP/cremation), and at the crematorium in Bilthoven concentrations of less than 0.7 mgTSP/m^3 were measured. For facilities with NeR measures in place, calculations were done under the assumption of an emission level of 10 gTSP/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 BImSchV)) for installations equipped with filters is 0.1 ng I-TEQ/m^3 (or 0.2 ug I-TEQ/cremation).
For installations with NeR measures in place, calculations were done with an emission factor of 0.2 ug I-TEQ/cremation.

8.4.5 Methodological issues

There are no specific methodological issues.

8.5 Other waste

8.5.1 Source-category description

The source sector Other waste (6D) comprises the following emission sources:

- Industrial composting;
- Waste preparation for recycling;
- Scrap fridges/freezers.

Industrial composting
In the Netherlands, domestic organic waste is collected separately from other domestic waste. The organic waste then is composted, on an industrial scale, and a small part is turned into biogas through anaerobic digestion.
The process of composting takes place in an enclosed environment, where ambient air is lead through a

bioreactor before being released into the open air. This results in emissions, the most relevant of which is NH_3. The domestic organic waste that is processed in an anaerobic digester results in biogas that is used in energy production. This emission source is included in the energy sector (source category of Public electricity and heat production (1A1a)).

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 appliances' insulating layer.

8.5.2 Key sources

There are no keys sources in the category of Other waste.

8.5.3 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.

8.5.4 Emissions, activity data and (implied) emission factors

Industrial composting
The data for the reporting year were supplied, on request, to the working group on waste registration (WAR) as part of its work to draw up the annual report containing figures on Dutch waste (Nederlands Afval in Cijfers). For NH_3 emissions from composting, an emission factor of 200 g NH_3/tonne organic waste was used.

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 implied emission factors and production data or those based on environmental reports in combination with specific emission factors (as described in Subsection 5.1.1 under Methodological issues).

Scrap fridges/freezers
When recycling scrapped fridges/freezers, from the insulation material, a small amount of NMVOC (as dichlorodifluoromethane (CFC12), used as blowing agent) will emit. In the calculations, an emission 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 onwards of 2009.

8.5.5 Methodological issues

There are no specific methodological issues.

9

Other

Emissions from burning candles, smoking cigarettes and lighting fireworks are reported in this category. This also includes the emissions of NH_3 from privately owned horses (stable and storage only), human transpiration and respiration, and from manure sold and applied to private properties or nature parks. 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.
Category 7A describes a key source for the following components: NH_3 (9.4%), TSP (4.1%), PM_{10} (4.8%) and $PM_{2.5}$ (9.7%) as percentages of national total in 2012.

10

Recalculations and other changes

10.1 Recalculations of certain elements of the 2013 inventory report

Compared to the 2013 inventory report (Jimmink et al., 2013), several methodological changes were implemented in the Pollutant Release and Transfer (PRTR) system:

- Fuel emissions in the road transport sector were recalculated (as happens every year) based on the updated VERSIT+ LD model (Ligterink and De Lange, 2009).
- PM emissions from tyre and brake wear were recalculated (yielding a decrease compared to the previous inventory report). On the basis of new emission factors, Cr, Zn and Ni emissions were found to have increased and Cu and Pb emissions to have decreased.
- The NH_3 emission levels changed, because a new model was used to calculate the N flows in agriculture
- Errors in the calculation of HCB emissions for the 1990–1995 period were corrected.

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

10.2 Improvements

10.2.1 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:

- $PM_{2.5}$ emissions were recalculated for all years and for many sources, partly as a result of new $PM_{2.5}$ fractions and partly due to error corrections.
- Emissions from fuel use and process emissions in energy and industrial production were recalculated from 2010 onwards, on the basis of improved emission data from individual companies.
- Applying the new data on diesel-fuel sales from the NEH (Netherlands Energy Statistics) led to an increase in emissions for the 2006–2009 period, compared to last year’s inventory report.
- Data on emissions related to inland navigation within the Netherlands were improved, using a new model as well as improved activity data on 2005 and onwards.

10.2.2 Planned improvements

During the compilation process of inventory reports, activities are initiated for future improvements. In next submission all missing HCB emission sources will be included, where possible.

Table 10.1 Differences in total national emission levels between current and previous inventory reports, for the years 1990, 2000, 2010 and 2011.

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	CO Gg
1990	IIR 2013	566.4	477.3	191.6	354.9	44.3	67.9	90.1	1124.4
	IIR 2014	575.2	481.5	191.6	354.9	46.5	69.3	91.5	1145.0
Difference	absolute	8.8	4.2	0.0	0.0	2.1	1.3	1.3	20.6
	%	1.6%	0.9%	0.0%	0.0%	4.8%	2.0%	1.5%	1.8%
2000	IIR 2013	393.5	232.5	73.0	161.5	24.1	39.0	45.8	743.8
	IIR 2014	394.9	238.1	73.0	161.5	24.5	39.3	46.1	791.9
Difference	absolute	1.3	5.6	-0.1	0.0	0.3	0.3	0.3	48.1
	%	0.3%	2.4%	-0.1%	0.0%	1.4%	0.8%	0.7%	6.5%
2010	IIR 2013	274.1	145.2	34.0	121.9	14.9	28.7	34.3	551.2
	IIR 2014	271.9	167.7	34.0	127.5	14.6	28.3	33.9	605.5
Difference	absolute	-2.2	22.5	0.0	5.6	-0.4	-0.3	-0.4	54.3
	%	-0.8%	15.5%	-0.1%	4.6%	-2.5%	-1.2%	-1.0%	9.8%
2011	IIR 2013	259.4	144.4	33.6	118.7	14.1	28.6	34.4	529.3
	IIR 2014	257.3	148.5	33.6	125.2	14.0	28.0	33.8	583.2
Difference	absolute	-2.1	4.2	0.1	6.6	-0.1	-0.6	-0.6	53.9
	%	-0.8%	2.9%	0.2%	5.5%	-0.8%	-2.1%	-1.8%	10.2%

10.3 Effects of recalculations and improvements

Tables 10.1 to 10.3 give the changes in total national emission levels for the various compounds, compared to the inventory report of 2012.

The larger part of the changes shown in Table 10.1 are largely due to improvements made in the estimation methods for the category of Off-farm storage, handling and transport of bulk agricultural products(4D2b). The changes in NH_3 emissions originate from the recalculations on the agricultural sector.
The relatively large change in the NMVOC emissions of 2010 is the result of the inclusion of a previously missing source in oil and gas production.
Changes in the 2011 figures are also the result of using improved activity data for that year.

The major cause of The changes in Pb, Cr , Cu, Ni and Zn emissions mainly are the result of improved emission factors for automobile brake wear, based on new measurements.

All changes shown in Table 10.3 are due to improvements made in the estimation methods for the transport sector. Changes in the 2011 figures are also the result of using improved activity data for that year.
The table does not present any recalculation results of HCB emissions for the years 1990 to 1995.
Estimates of the time series for HCB were only included in the Dutch inventory from 2010 onwards. In the 2011 inventory, it was erroneously assumed that, from 1990 onwards, all emission sources would have been equipped with BAT abatement techniques. This error has now been corrected by introducing a gradual implementation of BAT techniques over the 1990–1995 period. Emission results for that period, therefore, were increased, compared to the results presented in the previous inventory reports. The difference for 1990 is about 44 kg HCB.

Table 10.2 Differences in the total national emission level between the current and previous inventory reports for the years 1990, 2000, 2010 and 2011 (metals).

National total		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
		Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	IIR 2013	336.4	2.1	3.5	1.5	9.9	69.2	75.3	0.4	220.7
	IIR 2014	331.0	2.1	3.5	1.5	11.8	37.2	75.7	0.4	223.1
Difference	absolute	-5.4	0.0	0.0	0.0	1.9	-32.0	0.4	0.0	2.4
	%	-1.6%	0.0%	0.0%	0.0%	18.9%	-46.3%	0.6%	0.0%	1.1%
2000	IIR 2013	33.1	0.9	1.0	1.1	3.1	70.7	18.7	0.5	91.0
	IIR 2014	28.2	0.9	1.0	1.1	4.9	39.6	19.2	0.5	93.5
Difference	absolute	-4.9	0.0	0.0	0.0	1.8	-31.1	0.4	0.0	2.4
	%	-14.8%	0.0%	0.0%	0.0%	59.1%	-44.0%	2.2%	0.0%	2.7%
2010	IIR 2013	43.6	2.5	0.6	0.8	1.7	81.8	1.8	1.5	105.4
	IIR 2014	38.1	2.5	0.5	0.8	3.8	46.9	2.2	1.5	107.9
Difference	absolute	-5.5	0.0	-0.1	0.0	2.1	-34.9	0.4	0.0	2.5
	%	-12.6%	0.0%	-18.2%	0.0%	125.3%	-42.6%	25.3%	0.0%	2.4%
2011	IIR 2013	28.3	1.1	0.8	1.2	1.5	81.9	2.0	0.8	102.7
	IIR 2014	22.7	1.1	0.6	1.2	3.6	46.4	2.5	0.8	105.1
Difference	absolute	-5.6	0.0	-0.2	0.0	2.1	-35.5	0.4	0.0	2.3
	%	-19.7%	-1.7%	-23.8%	-0.4%	137.4%	-43.3%	22.2%	0.0%	2.3%

Table 10.3 Differences in the total national emission level between the current and previous inventory reports for the years 1990, 2000, 2010 and 2011 (PCDD/F and PAHs).

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 2013	742.5	5.2	8.0	4.0	2.8	20.0
	IIR 2014	742.6	5.2	8.0	4.0	2.8	20.1
Difference	absolute	0.1	0.0	0.0	0.0	0.0	0.1
	%	0.0%	0.3%	0.2%	0.3%	0.3%	0.3%
2000	IIR 2013	29.7	1.3	1.2	0.7	0.6	3.8
	IIR 2014	29.7	1.3	1.2	0.7	0.6	3.8
Difference	absolute	0.0	0.0	0.0	0.0	0.0	0.0
	%	0.0%	0.4%	0.3%	1.0%	1.4%	0.6%
2010	IIR 2013	30.2	1.2	1.2	0.6	0.6	3.7
	IIR 2014	30.2	1.2	1.2	0.6	0.6	3.7
Difference	absolute	0.0	0.0	0.0	0.0	0.0	0.0
	%	0.0%	0.0%	-0.1%	0.4%	0.8%	0.2%
2011	IIR 2013	31.3	1.2	1.3	0.6	0.7	3.8
	IIR 2014	30.2	1.2	1.3	0.6	0.7	3.8
Difference	absolute	-1.1	0.0	0.0	0.0	0.0	0.0
	%	-3.5%	0.0%	-0.1%	0.3%	0.6%	0.1%

11
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. Where available, references to detailed documentation were included in the IIR. An overview of the historical and projected total emissions for the Netherlands per pollutant is given in Table 11.1.

A study by Verdonk and Wetzels (2012) examines the future development of Dutch energy use, greenhouse gas emissions and air pollution, and was based on a consistent set of assumptions about economic, structural, technological and policy developments. The most important methods and principles are presented here.

Physical developments determine emissions

Starting from a macro-economic point-of-view, an estimation is made of the production and consumption of goods and services. 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.

Model system

A collection of models simulated the energy use in the Netherlands (Volkers, 2006). The assumptions, e.g. economic growth and policies, are input to the models. The model system also takes the import and export of electricity into account, ensuring the making of a complete national energy balance.

Table 11.1. Historical and projected emissions from the Netherlands (PBL, 2012; RIVM, 2014a).

		Historical (RIVM, 2014a)					NEC	Projected (Verdonk and Wetzels, 2012)	
Pollutant/year		**1990**	**2000**	**2005**	**2010**	**2012**	**2010**	**2020**	**2030**
SO_2	Gg	192	73	64	34	34	50	37	34
NO_x	Gg	575	395	337	272	248	260	187	165
NH_3	Gg	355	162	143	127	120	128	109	110
NMVOC	Gg	482	238	172	150	146	185	149	158
PM_{10}	Gg	69	39	33	28	27	*NA*	27	27
$PM_{2.5}$	Gg	46	24	19	15	13	*NA*	12	11

Table 11.2 Assumptions and activity data used for national emission projections.

Activity	2010	2011	2020	2030	Units (energy units are in NCV)
Assumptions for general economic parameters:					
1. Gross Domestic Product (GDP)	589	602	701	829	10^9 €
2. Population	16575	16656	17229	17688	Thousand People
3. International coal prices	74		80	85	€ per tonne or GJ (Gigajoule), Other please specify
4. International oil prices	60		91	105	€ per barrel or GJ
5. International gas prices	0.184		0.28	0.32	€ per m^3 or GJ
Assumptions for the energy sector:					
Total gross inland consumption					
1. - Oil (fossil)	725	748	803	774	Petajoule (PJ)
2. - Gas (fossil)	1526	1344	1115	1101	Petajoule (PJ)
3. - Coal	244	249	447	347	Petajoule (PJ)
4. - Biomass without liquid biofuels (e.g. wood)	98	81	48	90	In tonnes or %: Mton
5. - Liquid biofuels (e.g. bio-oils)	10	13	37	36	Petajoule (PJ)
6. - Solar	1	1	12	37	Petajoule (PJ)
7. - Other renewable (wind, geothermal etc.)	126	133	251	368	Petajoule (PJ)
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

Uncertainties

Future economic growth, energy price developments and policy efficacy are important uncertain factors, influencing the outcome of the models. In addition, there are monitoring uncertainties, because it is impossible to exactly measure or calculate the emissions of air pollutants. For the year 2020, Verdonk and Wetzels (2012) calculated uncertainty margins, giving a 90-percent confidence interval.

This year's projection data delivery is the same as last year's and only includes the policy variant with policies already implemented and instrumented (with measures; WM scenario). In this report, policies refer to Dutch, as well as European policies.

The emission projections scenario in the IIR includes the effects of the economic recession of 2008 to 2010, the implementation of the European climate and energy measures, as well as effects of the proposed Industrial Emissions Directive. Based on assumed CO_2 and energy prices, Verdonk and Wetzels (2012) estimated the number of additional power plants and CHP installations, planned for the coming decade, in industry and glasshouse horticulture, as well as the share of renewable energy in electricity production.

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

11.1 Energy

Emissions are linked to energy use, which, in turn, is connected to fuel and CO_2 prices. The ECN Reference projection assumes a climbing oil price from 78 USD per barrel in 2010 to 118 USD per barrel in 2020 and 135 USD in 2030. The exchange rate in the 2012-2030 period is assumed to be 1.29 US dollars per euro. The direct impact from higher energy and CO_2 prices on final and primary energy use is projected to be relatively low. In 2008 the Energy research Centre of the Netherlands (ECN), on the basis of an analysis of the electricity market, concluded that in the coming decade strong climate policies and high CO_2 prices would be likely to improve the internationally competitive position of Dutch electricity generation (See http://www.ecn.nl/docs/library/report/2008/e08026.pdf). Higher CO_2 prices, paradoxically, are thought to increase the share of coal in Dutch electricity generation and limit the share of renewable energy in electricity production. The capacity of wind power is assumed to increase from 2000 MW in 2005 to the government target of 15400 MW by 2020. This includes the introduction of a wind farm of

Table 11.3 GDP yearly growth rate in the 2007-2020 period (%).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016-2020
Reference Projection 2010	3.5	2.0	-3.5	-0.3	1.7	1.7	1.7	1.7	1.7	1.7
Reference Projection 2012	3.9	1.8	-3.5	1.7	1.2	-0.75	1.25	1.5	1.5	1.9

6000 MW in the North Sea. However, restricted available and appointed budgets, until now, have limited the growth in wind energy on land as expected for 2020 to 4000 MW, and at sea to 1750 MW.

After the economic dip in 2009 and 2010, a moderate growth rate of 1.7 % averaged per annum from 2011 to 2020 is assumed. As a consequence of this, total domestic energy demand will rise only from 120 TWh in 2008 to 131 TWh by 2020.

The electricity market is a European market. Therefore, the projection of production capacity in the north-western European electricity market is mostly based on the EU baseline scenario 'Trends to 2030', corrected for recent developments, such as the postponement of the phasing out of nuclear plants in Germany and Belgium. Table 11.4 provides an overview of the net additional capacity in the Netherlands and interconnected countries. Clearly, the trend for the Netherlands is going towards much more production capacity. Relatively speaking, this growth in capacity is greater than in other countries. In general, the GW increase will be greater than the TWh demand; average operating hours will reduce. Partly because renewable GW provides less TWh than conventional capacity and partly because a period in which relatively few new plants were developed in north-western Europe, has to be made up for ('boom and bust' cycle).

Apart from price differences, the physical interconnections to foreign electricity markets, determine the import and export of electricity. For some considerable time, electricity connections have existed to Belgium, France and Germany. The connection to Germany has been expanded (1000-2000 MW) in 2013. Connections to Norway (700 MW) and United Kingdom (1000 MW) have become operational since 2008 and 2011, respectively.

The Netherlands have a high and still increasing degree of interconnection with Germany as a neighbouring country. Although currently, the Netherlands are still a net importer of German electricity, in the near future a switch to becoming a net exporter of electricity is foreseen.

The Netherlands, from their geographical location, have several business advantages. The coast and rivers provide good cooling possibilities and relatively low supply costs for coal. This advantage is expressed in the present power plant development boom in the Netherlands, among others by producers from German origin (E.ON, RWE). In addition, German power plants have a higher average CO_2 emission factor and are consequently more vulnerable to fluctuations in the CO_2 price.
In this projection, the German Government decision to postpone the phasing out of nuclear power plants has been taken into account. Keeping the nuclear plants in operation and simultaneously investing less in new fossil-fuel generation capacity in Germany, provides a cushioning effect on Dutch export to Germany. New projections estimate the import for the year 2020 to be 16 TWh. If Germany would phase out their nuclear plants would substantially before 2020, this would lead to approximately 6 TWh in additional export to Germany.

Table 11.4 Growth of production capacity in place for north-western Europe. Both conventional and renewable extras were considered.

	extra after 2005			extra after 2005			growth demand after 2005	
	2020 [GW]	2025 [GW]	2030 [GW]	2020 [%]	2025 [%]	2030 [%]	2020 [%]	2030 [%]
Netherlands	12,2	14,2	16,1	61	72	81	34	41
Germany	28,1	32,7	29,2	23	27	24	13	16
Belgium	5,3	6,6	6,9	35	43	45	25	31
France	5	0,2	1,9	4	0	2	15	18
Norway	12,6	15,2	18	42	51	61		
United Kingdom	5,4	12,5	18	6	14	20	14	18
Denmark	-0,8	0	0,2	-6	0	1	13	16

Table 11.5 Development of the NO_x emission from Industry, Energy and Refineries.

NO_x emission in [Gg]	1990	2000	2005	2010	2012	2020	2030
Industry	79.0	35.0	35.1	30.1	29.6	30.4	32.5
Refineries	18.8	10.3	9.1	5.6	5.3	5.1	4.9
Energy sector	82.7	52.1	43.1	26.1	21.4	27.8	24.3

11.1.1 NO_x

In 2005 the NO_x trading system entered into operation for installations with a capacity of more than 20 MWth (unless exempted) and installations with high process emissions. Since its implementation, there has been a surplus of emission allowances (NEA, 2011). In 2010, the surplus was 1.5 Gg. The allowed amounts will be lowered step by step, over the course of time. For incineration installations the maximum emission level (Performance Standard Rate; PSR) will be gradually tightened. This will reduce the permitted NO_x emission in the trading system by a further 2.5 Gg in 2013. Process emissions carry a reduction target. The recent closure of several companies with NO_x process emissions and a further reduction in emissions from small combustion sources, accounts for the (permitted) emissions in 2020 superseding the 2011 level.

11.1.2 SO_2

SO_2 emissions in the Netherlands are expected to increase from 34 to 37 Gg between 2011 and 2020 and subsequently decrease to 34 Gg in 2030. Companies in the industry, energy and refineries are responsible for almost all of the emissions (96% in 2011).

Development of emission of sulphur dioxides (SO_2) stationary sources

SO_2 emissions from stationary sources decreased significantly up to 2000, but there has been little change in these emission levels since then. In recent years, emissions have decreased again, due to measures in coal-fired plants, the transition of refineries to gas-firing instead of (a part of) oil, and a decreasing sulphur content of oil products. For government policy, the SO_2 covenant with the electricity sector plays an important role, as does the agreement to enter a maximum emission level of 16 Gg in the permits for refineries, divided over various companies.
Relevant developments in SO_2 emissions in the various sectors include:

- The development of process emissions in industry is assumed to equal the physical growth of the sector. However, the emission developments in this sector have been examined over the past years. For example, emissions in the base metal industry, in the last few years, were 0.4 Gg lower. Moreover, for several situations it is assumed that emissions will increase less rapidly than a linear relation with the physical production would imply.
- Refineries have agreed to switch from burning heavy fuel oil to burning gas. Furthermore, they agreed to limit the maximum emission amount to 16 Gg in 2010 and subsequent years, and establish a permitted emission level per company. If refineries would stop burning oil and keep their installations in the BAT (Best Available Technique) range of the IPCC guideline, then emissions would be significantly lower than in 2005. To comply with the new sulphur demands for sea-going vessels, Dutch refineries will have to make large investments in additional secondary production capacity and desulphurisation installations before 2020. As this will lead to higher energy use and additional desulphurisation capacity (with corresponding process emissions) this might put pressure on the 16 Gg agreement.
- The electricity sector agreed to reduce SO_2 emissions, over the period from 2010 to 2019, down to 13.5 Gg. The agreement does not include the year 2020 because future European agreements could possibly demand a further emission reduction. According to these scenario calculations, emissions in 2010 were well below the agreed ceiling, as the sector, over the years, already has taken various measures years to reduce SO_2 emissions. On balance, this leaves ample space for new construction plans while remaining below the emission ceiling for 2019.
- In households and the services sector (TSG), emission levels have decreased, due to a decreasing sulphur content of domestic fuel oil, from 0.2% to 0.1%.

11.1.3 Policy measures

For NO_x trading in industry, the performance standard rate of 40 g/GJ has been sharpened to 37 g/GJ. Moreover, emission standards for medium-sized heating systems have been sharpened under BEMS legislation. The refinery sector has agreed to an SO_2 emission cap of 16 Gg. Additional policies envisage a sharpening of this cap to 14.5 Gg.

11.2 Transport

Emission projections for the transport sector were updated based on new assumptions on future oil prices and economic and demographic developments. Since economic growth is expected to be lower on the short term and oil prices are higher than previously expected, transport volumes in general are lower in the updated Reference projections. Fleet renewal is also slower though, resulting in higher emissions per unit of transport volume (vehicle kilometre, MJ, etc.).

11.2.1 Projected transport volumes

The projected growth in passenger transport in the Netherlands was derived from the Dutch National Model System for Traffic and Transport (LMS). The LMS is regularly used in The Netherlands to forecast national transport volumes taking into account the impact of transport infrastructure projects (i.e. new roads, wider roads, new railway connections), transport policies, demographic and economic trends, car ownership and transport cost. Passenger car use (vehicle kilometres) is expected to increase by approximately 1% annually between 2011 and 2020. This is slightly lower than pre-crisis growth rates and slightly lower than in the 2010 Reference projections, reflecting slower economic recovery combined with higher future oil prices.

The future composition of the Dutch passenger car fleet was derived from Dynamo, the Dutch dynamic automobile market model (Meurs *et al*., 2006; MuConsult, 2010). Dynamo models the impact of trends in demographics, household incomes, car prices and government policies on the size, composition and usage of the Dutch passenger car fleet up to 2040. Car ownership is expected to increase from 7.9 million cars in 2012 to 8.7 million cars in 2020, resulting mainly from an expected increase in the number of households in The Netherlands. The share of diesel cars in the car fleet is expected to increase from 17% in 2012 to 21% in 2020. This is still well below EU average, with passenger car taxation in The Netherlands still favoring gasoline over diesel.

Projections of future freight transport in the Netherlands, by road, rail and inland shipping were derived by TNO using the TRANS-TOOLS model (TNO, 2009). TRANS-TOOLS is a European transport network model that covers both passenger and freight transport, although for the Reference projections the model was only used for freight transport projections. To take into account the lower economic growth projections and higher oil prices in the new Reference projections, transport volumes were adjusted downwards using elasticities of demand which reflect the effect of changes in economy (GDP) and transport prices on transport volumes (PBL, 2012).

Freight transport in the Netherlands (expressed in ton kilometres) is expected to increase by 17% between 2011 and 2020 in the new Reference projections. Rail transport shows the largest growth in this time span with transport volumes increasing by 39%. Freight transport by road and by inland ship is expected to increase by 19% and 12% respectively between 2011 and 2020. Even though rail transport shows the highest growth rates, most freight is still being transported by road (51% of tonne-kilometres) or by ship (42%) in 2020, with rail transport only being responsible for 7% of total freight transport. Electrification of rail transport is also expected to continue in future years, therefore diesel fuel consumption by rail transport is expected to stabilize at current rates even though transport volumes continue to grow.

The future composition of the light- and heavy-duty truck fleet in The Netherlands was derived from trend extrapolation, taking into account the lower expected growth in total transport volumes as well as policy measures related to different vehicle types (e.g. subsidy programmes for light-duty trucks with diesel particulate filters and Euro-VI heavy-duty trucks).

Transport growth in other transport related categories has been derived from existing studies or by extrapolating the historical trends of the 2000–2011 period. The projected growth in air travel was derived from a study by Significance (2008), for the Dutch Ministry of Transport, on growth projections for Schiphol Amsterdam Airport. The results from this study were corrected for differences in assumptions on future economic growth in the Reference projections, using price elasticities of demand derived from international literature (Hoen *et al*., 2010). The number of flights to and from Schiphol Amsterdam Airport is expected to increase by approximately 19%, between 2008 and 2020. Projections on the composition of the future aircraft fleet were also derived from the study by Significance (2008).

The projected use of non-road mobile machinery in the Netherlands is coupled to projected economic growth in the various, related economic sectors. Total energy use by non-road mobile machinery is expected to grow by 14%, between 2010 and 2020. Energy use by fisheries is expected to further decrease up to 2020, in line with historic trends.

11.2.2 Policy measures and emission projections

Relevant policy measures that were agreed upon at the start of 2012 in the EU or in the Netherlands were taken into account in the Reference projections. For road traffic, emissions of NO_x PM and NMVOC are expected to decrease further between 2011 and 2020 reflecting fleet renewal in combination with more stringent emission standards for new vehicles, e.g. the Euro-5 and Euro-6 emission standards for light duty vehicles and the Euro-VI standards for heavy-duty vehicles. Euro-5 emission standards for light duty vehicles require all new diesel cars to be equipped with a diesel particulate filter (DPFs), resulting in substantial reductions in PM_{10} and $PM_{2.5}$ exhaust emissions as more DPFs enter the Dutch vehicle fleet in coming years. PM_{10} exhaust emissions from passenger cars and light duty trucks are expected to decrease from 3.2 Gg in 2010 to 0.9 Gg in 2020.

Euro-6 and Euro-VI emission standards should result in major reductions of NO_x emissions from light- and heavy-duty vehicles, although real-world effectiveness of the new emission standards is still uncertain. In the Reference projections, it is assumed that Euro-6 and Euro-VI will indeed result in major (real-world) emission reductions. As a consequence, total NO_x emissions from road transport are expected to decrease from 99 Gg in 2011 to 44 Gg in 2020.

PM_{10} emissions due to brake and tyre wear and road abrasion are expected to increase due to the projected growth in road traffic. By 2020, non-exhaust PM_{10} emissions will be responsible for 69% of total PM_{10} emissions by road traffic (currently this share is below 50%). The share of non-exhaust emissions in $PM_{2.5}$ emissions from road transport is much smaller, therefore the decrease in $PM_{2.5}$ emissions from road transport is larger than for PM_{10}. $PM_{2.5}$ emissions from road transport are projected to decrease by 56%, between 2011 and 2020.

NO_x and PM emissions from inland shipping are expected to remain fairly stable, with the expected growth in transport volumes being compensated by the EU emission standards for diesel engines used in inland shipping. NMVOC emissions are expected to decrease slightly due to the same emissions standards. NO_x and PM emissions from NRMM are expected to decrease significantly, resulting from increasingly stringent emission standards for new diesel engines.

11.3 Industry

In 2011, industry, energy and refineries (IER) emitted 10.4 Gg PM_{10}, which is a share of 36% in total PM_{10} emissions in the Netherlands. Nearly all industrial sectors have PM_{10} emissions. PM_{10} is emitted during various industrial processes, such as combustion emission from fuel burning. PM and NMVOC emissions from industry are dominated by process emissions.

Industry has been more severely affected by the credit crisis than other sectors, so industrial production has decreased. This is especially true for the chemical industry, the metal industry and refineries. For 2010 to 2020, industrial growth is expected to be more or less equal to the growth of the economy. For the chemical industry, growth is expected to be considerably higher, whereas for the food and stimulants industry and the refineries it is thought to be lower.

11.3.1 PM_{10}

Successful emission curbing policy has lowered PM_{10} emissions in industry with about 70%, between 1990 and 2011. Agreements with the refinery sector about switching to gas-firing instead of oil-firing will further decrease the PM_{10} emissions in this sector.

11.3.2 NMVOC

The NMVOC emissions from industry and energy have decreased between 2000 and 2010 from 86 Gg to 50 Gg. Most of the reduction is due to lower NMVOC content in industrial coating application and general reducing measures in industry, energy and refineries. In 2020 and 2030 the emissions are expected to be 50 and 49, respectively. Whereas some sector show a light growth, other sectors are expected to show a slight reduction, so on average the emission is expected to remain at about the 2010 level.

11.4 Solvents and Product use

NMVOC emissions from households mostly come from use of luxury products, such as cosmetics and other toiletries and paints. Expenditure on luxury products is increasing more rapidly than the average household expenditure. The use of fireplaces and wood-burning stoves is also increasing, however, at a slower pace. The solvents in luxury products are not reduced like in the painting products. Therefore the NMVOC emissions from consumers increases by 5 Gg between 2010 and 2020, to about 37 Gg. After 2020 an increase to about 46 Gg is expected.

11.5 Agriculture

The NH_3 emissions are expected to decrease from 122 Gg in 2010 to 109 Gg in 2020, and 110 Gg in 2030. The agricultural sector has by far the greatest share (86% in 2011) in the national total NH_3 emissions. This mostly comes from animal manure.

Between 2010 and 2020, ammonia emissions from agriculture are expected to go down by about 13 Gg from 105 Gg to 92 Gg (Verdonk and Wetzels, 2012). This decline is mostly due to the implementation of low emission housing for pigs and poultry (-8 Gg) and due to a further reduction in the use of animal manure (-6 Gg).
NH3 emissions are expected to increase slightly between

Table 11.6 Projected animal numbers in the Netherlands (in 1000 heads).

Activity	2000	2010	2012	2020	2030
Beef Cattle	2,565	2,497	2,395	2,236	2,181
Dairy Cows	1,504	1,479	1,484	1,475	1,418
Sheep	1,305	1,130	1,043	1,483	1,491
Goats	179	353	397	1,483	1,491
Swine	13,118	12,255	12,234	10,273	9,423
Laying hens	53,078	56,500	51,427	59,099	61,610
Broilers	53,439	46,871	45,589	47,378	48,231
Horses	417	441	431	428	432
Rabbits and mink	641	1,001	1,061	1,001	911

2020 and 2030, by 0.3 Gg. This is the combined effect of a reduction in housing emissions, mostly by lower pig numbers (-1.6 Gg), a reduction in grazing emissions by further permanent housing of dairy cattle (-0.2 Gg) and an increase of ammonia emissions from manure application (+2.1 Gg).

As a consequence of further manure and ammonia policies (in order to comply with the EU Nitrate Directive), more manure will become available on the market for processing. It is unlikely that unprocessed manure will be exported, because transport costs are high (Hoogeveen *et al.*, 2011).

Although it is assumed that the costs of manure processing will be lower than the present level, some farmers will face high costs and consequently run out of business. Scaling in the agricultural sector is anticipated to continue.

As dairy cattle farmers typically own lands to put manure on, they have possibilities to adapt to future manure policies, albeit at slightly higher costs. The sector is expected to remain competitive on the world market through higher productivity and scaling. As a rule, swine farmers have a less competitive position compared to dairy cattle farmers, since they do not own any or enough land to spread their manure on. In addition, the value added per unit of manure production is relatively low. Poultry farmers often also do not own any land to unload manure on. However, their competitiveness is relatively less dependent on the costs of manure processing, since combustion in this sector is a very cheap technique.

11.5.1 Policy measures

The introduction of air scrubbers has been assumed for NH_3 and $PM_{2.5}$ emissions from very large animal houses.

12 Spatial distributions

12.1 Background for reporting

In 2012 the Netherlands has reported geographically distributed emissions and LPS data to the UNECE LRTAP Convention for the years 1990, 1995, 2000, 2005 and 2010. Emission data are disaggregated to the standard EMEP grid with a resolution of 50km x 50km. Reporting is mandatory for the following air pollutants: SO_x, NO_x, NH_3, NMVOC, CO, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, DIOX, PAH and HCB. Guidelines for reporting air emissions on grid level are given in UNECE (2009). Gridded emission data are used in integrated European air pollution models, e.g. RAINS/GAINS and EMEP's chemical transport models. The aggregated sectors, 'gridded NFR' (GNFR), for reporting are defined in Table I of Annex IV to the Guidelines for reporting emission data under the Convention on Long-range Transboundary Air Pollution (UNECE, 2009). These aggregations can be achieved through the aggregation of the spatially resolved (mapped) detailed NFR sectors.

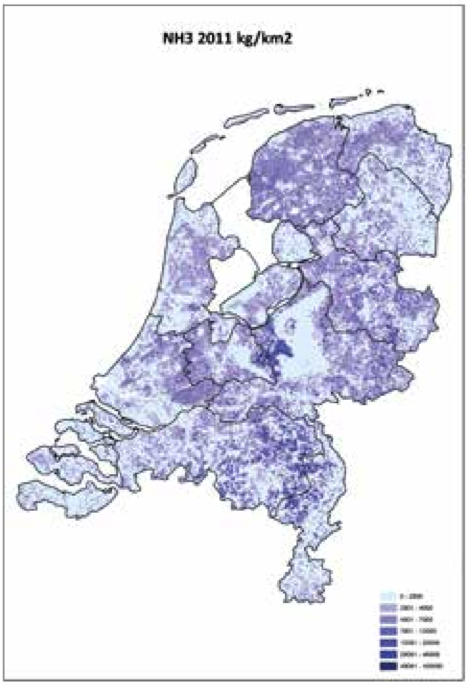
The gridded emission data of the 2012 reporting is available at the Central Data Repository (CDR) at the EIONET website.

12.2 Methodology for disaggregation of emission data

All emissions in the Dutch PRTR are linked with a spatial allocation. For every spatial allocation category, a factsheet is available: http://www.emissieregistratie.nl/ERPUBLIEK/misc/Documenten.aspx?ROOT=\Algemeen%20%28General%29\Ruimtelijke%20toedeling%20%28Spatial%20allocation%29.
Such a factsheet contains a brief description of the methods used, an example of the relevant distribution map, references to background documents and a list of the institutes concerned. Furthermore an Excel sheet is available which can be used to link emission, emission source, allocation and factsheet.
There are three methods used for spatial allocation of emission sources:
1. direct linkage to location;
2. model calculation;
3. estimation through 'proxy data'.

The first category applies only to large point sources of which both the location and the emissions are known. This concerns all companies that are required by Dutch law to report their air and water emissions by means of Annual Environmental Reports (AER), combined with data concerning waste water treatment plants (RWZIs).

Figure 12.1 Geographical distribution of NH_3 emissions in the Netherlands in 2011.



The agricultural sector is the major contributor to the national total NH_3 emission. Emissions of NH_3 are mainly related to livestock farming and especially to the handling of manure from the animals. Emissions of NH_3 are therefore related to storage and spreading of manure as well as emissions from stables (Luesink *et al.*, 2008).

Altogether, this category encloses almost three thousand sources.

Some examples of the second method, spatial distributions based on model calculations are:

- Ammonia from agriculture
- Particulate matter (PM10) from agriculture
- Deposition on surface water
- Leaching and run-off to surface water (heavy metals and nutrients)
- Emissions of crop protection chemicals to air and surface water

Finally, the third and largest group of emissions is spatially allocated by proxy data. Examples of these allocation keys are population and housing density, vehicle kilometres (roads, shipping routes, railways), land cover and number of employees per facility.

12.3 Maps with geographically distributed emission data

Examples of combinations of the three methods can be seen in the maps below, based on the latest reporting data from the Netherlands Pollutants Release and Transfer Register (2011, http://www.emissieregistratie.nl/ERPUBLIEK/bumper.en.aspx). The selected air pollutants are ammonia (NH_3), sulphur dioxide (SO_2), nitrogen dioxide (NO_x) and fine particulates ($PM_{2.5}$). Figures 12.1-12.4 show the geographically distributed emissions for these air pollutants. Even from the national distributed totals, spatial patterns from the major sectors are recognizable.

Figure 12.2 Geographical distribution of SO_2 emissions in the Netherlands in 2011.

Figure 12.3 Geographical distribution of NO_x emissions in the Netherlands in 2011.

Both SO_2 and NO_x are predominantly emitted by the (road) transport sector: cities, main roads and shipping routes are clearly visible. Inland shipping routes are more visible in SO_2 emissions as more reduction measures were taken in other sectors compared to inland shipping.

Figure 12.4 Geographical distribution of $PM_{2.5}$ emissions in the Netherlands in 2011.

Finally, the map of fine particulate matter shows a pattern in which cities, agriculture, main roads and shipping routes can be recognized. This is due to emissions of residential heating, agricultural animal housing, road traffic and shipping, all known as important sources of PM.

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Appendix 1 Key source analysis results

Results from the key source analysis have been calculated and sorted for every component. In addition to a 2012 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 2012 level assessment (Emissions in Gg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
1A1b	1A1b Petroleum refining	13.95	41.13%	41.13%
1A1a	1A1a Public electricity and heat production	8.12	23.94%	65.06%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	3.04	8.96%	74.02%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	2.51	7.40%	81.42%

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

NFR Code	Long name	1990	Contribution	Cumulative contribution
1A1b	1A1b Petroleum refining	67.09	35.02%	35.02%
1A1a	1A1a Public electricity and heat production	48.37	25.25%	60.27%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	19.95	10.41%	70.68%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	9.14	4.77%	75.45%
2A7d	2A7d Other Mineral products	7.47	3.90%	79.35%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	6.24	3.26%	82.61%

Table 1.1.c SO_x key source categories identified by 1990 - 2012 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative Trend contribution
1A1b	1A1b Petroleum refining	67.09	13.95	1.08%	16.83%	16.83%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	5.91	2.67	0.83%	12.93%	29.76%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	9.14	3.04	0.74%	11.54%	41.30%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	19.95	2.13	0.73%	11.38%	52.67%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	6.24	0.03	0.56%	8.71%	61.38%
1A3bi	1A3bi Road transport: Passenger cars	4.51	0.20	0.31%	4.87%	66.25%
2A7d	2A7d Other Mineral products	7.47	0.83	0.26%	4.04%	70.29%
1A2b	1A2b Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	4.97	1.33	0.23%	3.63%	73.93%
1A1a	1A1a Public electricity and heat production	48.37	8.12	0.23%	3.63%	77.55%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	2.55	0.04	0.22%	3.36%	80.92%

Table 1.2.a NO_x key source categories identified by 2012 level assessment (Emissions in Gg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
1A3biii	1A3biii Road transport:, Heavy duty vehicles	47.42	19.13%	19.13%
1A3bi	1A3bi Road transport: Passenger cars	27.05	10.91%	30.03%
1A1a	1A1a Public electricity and heat production	21.40	8.63%	38.67%
1A3di(ii)	1A3di(ii) International inland waterways	17.74	7.15%	45.82%
1A3bii	1A3bii Road transport:Light duty vehicles	13.68	5.52%	51.34%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	11.32	4.57%	55.91%
1A4ci	1A4ci Agriculture/Forestry/Fishing: Stationary	11.04	4.45%	60.36%
1A4ai	1A4ai Commercial / institutional: Stationary	11.00	4.44%	64.80%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	9.96	4.02%	68.81%
1A3dii	1A3dii National navigation (Shipping)	9.63	3.89%	72.70%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	9.23	3.72%	76.42%
1A4bi	1A4bi Residential: Stationary plants	9.21	3.72%	80.14%

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

NFR Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	1A3bi Road transport: Passenger cars	140.89	24.50%	24.50%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	90.12	15.67%	40.16%
1A1a	1A1a Public electricity and heat production	82.71	14.38%	54.54%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	35.89	6.24%	60.78%
1A3di(ii)	1A3di(ii) International inland waterways	22.34	3.88%	64.67%
1A3bi i	1A3bi Road transport: Light duty vehicles	20.54	3.57%	68.24%
1A4bi	1A4bi Residential: Stationary plants	20.23	3.53%	71.77%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	19.99	3.48%	75.24%
1A1b	1A1b Petroleum refining	18.85	3.28%	78.52%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	18.83	3.27%	81.79%

Table 1.2.c NO_x key source categories identified by 1990 - 2012 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	140.89	27.05	5.86%	28.17%	28.17%
1A1a	1A1a Public electricity and heat production	82.71	21.40	2.48%	11.92%	40.09%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	90.12	47.42	1.49%	7.17%	47.26%
1A3di(ii)	1A3di(ii) International inland waterways	22.34	17.74	1.41%	6.78%	54.04%
1A4ci	1A4ci Agriculture/Forestry/Fishing: Stationary	8.73	11.04	1.27%	6.09%	60.13%
1A3dii	1A3dii National navigation (Shipping)	6.44	9.63	1.19%	5.73%	65.86%
1A4ai	1A4ai Commercial / institutional: Stationary	13.65	11.00	0.89%	4.28%	70.14%
1A3bii	1A3bii Road transport:Light duty vehicles	20.54	13.68	0.84%	4.04%	74.18%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	35.89	11.32	0.72%	3.47%	77.65%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	7.01	6.01	0.52%	2.50%	80.15%

Table 1.3.a NH_x key source categories identified by 2012 level assessment (Emissions in Gg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
4B1a	4B1a Cattle dairy	35.93	29.89%	29.89%
4B8	4B8 Swine	20.58	17.12%	47.01%
4B1b	4B1b Cattle non-dairy	16.70	13.90%	60.91%
4D1a	4D1a Synthetic N-fertilizers	13.64	11.35%	72.25%
7A	7A Other	11.25	9.36%	81.62%

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

NFR Code	Long name	1990	Contribution	Cumulative contribution
4B1a	4B1a Cattle dairy	120.90	34.06%	34.06%
4B8	4B8 Swine	98.28	27.69%	61.75%
4B1b	4B1b Cattle non-dairy	62.99	17.75%	79.50%
4B9a	4B9a Laying hens	21.23	5.98%	85.48%

Table 1.3.c NH_x key source categories identified by 1990 - 2012 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
4B8	4B8 Swine	98.28	20.58	3.58%	26.80%	26.80%
4D1a	4D1a Synthetic N-fertilizers	13.91	13.64	2.52%	18.84%	45.64%
7A	7A Other	14.30	11.25	1.81%	13.52%	59.16%
4B1a	4B1a Cattle dairy	120.90	35.93	1.41%	10.57%	69.74%
4B1b	4B1b Cattle non-dairy	62.99	16.70	1.30%	9.77%	79.51%
1A3bi	1A3bi Road transport: Passenger cars	0.84	2.42	0.60%	4.51%	84.02%

Table 1.4.a NMVOC key source categories identified by 2012 level assessment (Emissions in Gg).

NFR Code	Long name	2012	Contribution	Cumulative Contribution
3D2	3D2Domestic solvent use including fungicides	20.31	13.94%	13.94%
3A2	3A2 Industrial coating application	15.46	10.61%	24.55%
1A3bi	1A3bi Road transport: Passenger cars	13.68	9.39%	33.95%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	11.85	8.13%	42.08%
3D3	3D3 Other product use	10.30	7.07%	49.15%
1A4bi	1A4bi Residential: Stationary plants	9.02	6.19%	55.33%
1B2a iv	1B2a iv Refining / storage	8.65	5.94%	61.28%
2B5a	2B5a Other chemical industry	7.20	4.94%	66.22%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	6.11	4.19%	70.41%
1B2a i	1B2a i Exploration, production, transport	6.03	4.14%	74.55%
2D2	2D2 Food and drink	4.58	3.15%	77.70%
3D1	3D1 Printing	3.36	2.31%	80.00%

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

NFR Code	Longname	1990	Contribution	Cumulative
1A3bi	1A3bi Road transport: Passenger cars	99.51	20.67%	20.67%
3A2	3A2 Industrial coating application	70.97	14.74%	35.41%
1A3bv	1A3bv Road transport: Gasoline evaporation	35.45	7.36%	42.77%
2B5a	2B5a Other chemical industry	33.36	6.93%	49.70%
1B2aiv	1B2aiv Refining / storage	31.67	6.58%	56.28%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	30.48	6.33%	62.61%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	25.19	5.23%	67.84%
3D3	3D3 Other product use	15.31	3.18%	71.02%
1B2ai	1B2ai Exploration, production, transport	14.39	2.99%	74.01%
3D1	3D1 Printing	14.36	2.98%	76.99%
3A1	3A1 Decorative coating application	13.52	2.81%	79.80%
1A4bi	1A4bi Residential: Stationary plants	13.22	2.75%	82.54%

Table 1.4.c NMVOC source categories identified by 1990 - 2012 trend assessment (Emissions in Gg).

NFR Code	Longname	1990	2012	Trend	Trend contribution	Cumulative trend contribution
3D2	3D2Domestic solvent use including fungicides	11.31	20.31	3.51%	18.12%	18.12%
1A3bi	1A3bi Road transport: Passenger cars	99.51	13.68	3.41%	17.63%	35.75%
1A3bv	1A3bv Road transport: Gasoline evaporation	35.45	1.65	1.88%	9.74%	45.49%
3A2	3A2 Industrial coating application	70.97	15.46	1.25%	6.46%	51.95%
3D3	3D3 Other product use	15.31	10.30	1.18%	6.08%	58.03%
1A4bi	1A4bi Residential: Stationary plants	13.22	9.02	1.04%	5.38%	63.41%
3A1	3A1 Decorative coating application	13.52	0.96	0.65%	3.36%	66.77%
2B5a	2B5a Other chemical industry	33.36	7.20	0.60%	3.11%	69.88%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	30.48	11.85	0.54%	2.82%	72.70%
2D2	2D2 Food and drink	7.06	4.58	0.49%	2.63%	75.32%
1A3bii	1A3bii Road transport: Light duty vehicles	10.28	0.73	0.49%	2.55%	77.88%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	0.86	2.00	0.36%	1.87%	79.75%
1B2ai	1B2ai Exploration, production, transport	14.39	6.03	0.35%	1.80%	81.55%

Table 1.5.a CO key source categories identified by 2012 level assessment (Emissions in Gg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
1A3bi	1A3bi Road transport: Passenger cars	246.15	43.89%	39.14%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	63.30	11.29%	55.17%
1A4bi	1A4bi Residential: Stationary plants	57.57	10.26%	65.44%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	29.81	5.31%	70.75%
1A4bii	1A4bii Residential: Household and gardening (mobile)	29.72	5.30%	76.05%
1A5b	1A5b Other, Mobile (including military, land based and recreational boats)	21.02	3.75%	79.80%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	15.87	2.83%	82.63%

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

NFR Code	Long name	1990	Contribution	Cumulative Contribution
1A3bi	1A3bi Road transport: Passenger cars	600.95	52.49%	52.49%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	187.38	16.37%	68.85%
1A4bi	1A4bi Residential: Stationary plants	71.88	6.28%	75.13%
1A3bii	1A3bii Road transport:Light duty vehicles	46.87	4.09%	79.22%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	44.72	3.91%	83.13%

Table 1.5.c CO key source categories identified by 1990 - 2012 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	600.95	246.15	4.21%	22.98%	22.98%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	187.38	63.30	2.49%	13.57%	36.56%
1A4bii	1A4bii Residential: Household and gardening (mobile)	14.99	29.72	1.95%	10.66%	47.22%
1A4bi	1A4bi Residential: Stationary plants	71.88	57.57	1.95%	10.65%	57.87%
1A3bii	1A3bii Road transport:Light duty vehicles	46.87	3.90	1.66%	9.08%	66.95%
1A5b	1A5b Other, Mobile (including military, land based and recreational boats)	14.12	21.02	1.23%	6.72%	73.67%
1A4aii	1A4aii Commercial / institutional: Mobile	7.71	14.05	0.90%	4.89%	78.57%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	44.72	29.81	0.69%	3.76%	82.33%

Table 1.6.a TSP key source categories identified by 2012 level assessment (Emissions in Gg).

NFR Code	Long name	2012	Contribution	Cumulative Contribution
1A4bi	1A4bi Residential: Stationary plants	3.39	10.79%	10.79%
4B9a	4B9a Laying hens	2.74	8.72%	19.51%
2C1	2C1 Iron and steel production	2.31	7.35%	26.85%
2D2	2D2 Food and drink	2.08	6.64%	33.49%
2B5a	2B5a Other chemical industry	1.91	6.09%	39.58%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.87	5.97%	45.55%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.40	4.45%	50.00%
4B9b	4B9b Broilers	1.32	4.19%	54.19%
7A	7A Other	1.27	4.06%	58.25%
1A3bi	1A3bi Road transport: Passenger cars	1.23	3.93%	62.18%
4B8	4B8 Swine	1.22	3.90%	66.08%
2A7d	2A7d Other Mineral products	1.21	3.87%	69.95%
1A3bii	1A3bii Road transport:Light duty vehicles	1.19	3.78%	73.73%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	1.13	3.61%	77.34%
3D3	3D3 Other product use	1.00	3.18%	80.52%

Table 1.6.b TSP key source categories identified by 1990 level assessment (Emissions in Gg).

NFR Code	Long name	1990	Contribution	Cumulative Contribution
2G	2G Other production, consumption, storage, transportation or handling of bulk products	17.54	19.18%	19.18%
2C1	2C1 Iron and steel production	9.78	10.70%	29.87%
1A1b	1A1b Petroleum refining	6.47	7.07%	36.95%
2B5a	2B5a Other chemical industry	6.01	6.57%	43.51%
2D2	2D2 Food and drink	5.84	6.39%	49.90%
1A3bi	1A3bi Road transport: Passenger cars	5.50	6.01%	55.92%
1A4bi	1A4bi Residential: Stationary plants	5.33	5.82%	61.74%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.24	5.72%	67.46%
1A3bii	1A3bii Road transport:Light duty vehicles	3.67	4.02%	71.48%
2A7d	2A7d Other Mineral products	3.40	3.72%	75.20%
1A1a	1A1a Public electricity and heat production	2.46	2.69%	77.89%
7A	7A Other	1.86	2.03%	79.92%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.72	1.88%	81.80%

Table 1.6.c TSP key source categories identified by 1990 - 2012 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
2G	2G Other production, consumption, storage, transportation or handling of bulk products	17.54	1.87	4.53%	19.78%	19.78%
4B9a	4B9a Laying hens	0.45	2.75	2.82%	12.31%	32.09%
1A1b	1A1b Petroleum refining	6.47	0.31	2.09%	9.31%	41.23%
1A4bi	1A4bi Residential: Stationary plants	5.33	3.39	1.70%	7.43%	48.66%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.24	0.62	1.29%	5.62%	54.27%
2C1	2C1 Iron and steel production	9.78	2.31	1.15%	5.02%	59.29%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.17	1.40	1.09%	4.75%	64.05%
4B9b	4B9b Broilers	1.30	1.32	0.95%	4.14%	68.19%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.87	1.13	0.91%	3.99%	72.18%
1A3bi	1A3bi Road transport: Passenger cars	5.50	1.23	0.71%	3.12%	75.29%
4B8	4B8 Swine	1.68	1.22	0.71%	3.09%	78.39%
3D3	3D3 Other product use	1.05	1.00	0.70%	3.04%	81.42%

Table 1.7.a PM_{10} key source categories identified by 2012 level assessment (Emissions in Gg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
4B9a	4B9a Laying hens	2.74	10.30%	10.30%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.86	6.98%	17.28%
2D2	2D2 Food and drink	1.73	6.51%	23.80%
1A4bi	1A4bi Residential: Stationary plants	1.59	6.00%	29.79%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.40	5.26%	35.05%
4B9b	4B9b Broilers	1.32	4.95%	40.01%
2C1	2C1 Iron and steel production	1.30	4.88%	44.89%
7A	7A Other	1.27	4.79%	49.68%
1A3bi	1A3bi Road transport: Passenger cars	1.23	4.64%	54.33%
4B8	4B8 Swine	1.22	4.61%	58.94%
2B5a	2B5a Other chemical industry	1.21	4.54%	63.48%
1A3bii	1A3bii Road transport:Light duty vehicles	1.19	4.46%	67.94%
2A7d	2A7d Other Mineral products	1.16	4.35%	72.29%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	1.13	4.27%	76.56%
3D3	3D3 Other product use	1.00	3.75%	80.32%

Table 1.7.b PM_{10} key source categories identified by 1990 level assessment (Emissions in Gg).

NFR Code	Long name	1990	Contribution	Cumulative Contribution
2C1	2C1 Iron and steel production	9.13	13.18%	13.18%
1A1b	1A1b Petroleum refining	6.46	9.32%	22.51%
1A3bi	1A3bi Road transport: Passenger cars	5.50	7.94%	30.45%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.24	7.56%	38.01%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	4.92	7.10%	45.11%
2B5a	2B5a Other chemical industry	4.11	5.93%	51.04%
2D2	2D2 Food and drink	3.85	5.56%	56.60%
1A3bii	1A3bii Road transport:Light duty vehicles	3.67	5.30%	61.90%
2A7d	2A7d Other Mineral products	2.64	3.81%	65.71%
1A4bi	1A4bi Residential: Stationary plants	2.53	3.65%	69.36%
1A1a	1A1a Public electricity and heat production	2.21	3.19%	72.55%
7A	7A Other	1.86	2.68%	75.23%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.72	2.48%	77.72%
4B8	4B8 Swine	1.68	2.42%	80.14%

Table 1.7.c PM_{10} key source categories identified by 1990 - 2012 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
4B9a	4B9a Laying hens	0.45	2.74	3.70%	13.93%	13.93%
1A1b	1A1b Petroleum refining	6.46	0.21	3.27%	12.31%	26.24%
2C1	2C1 Iron and steel production	9.13	1.30	3.18%	11.98%	38.22%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.24	0.62	2.01%	7.55%	45.77%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.17	1.40	1.37%	5.16%	50.93%
1A3bi	1A3bi Road transport: Passenger cars	5.50	1.23	1.26%	4.76%	55.69%
4B9b	4B9b Broilers	1.30	1.32	1.18%	4.43%	60.12%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.87	1.13	1.16%	4.35%	64.47%
1A1a	1A1a Public electricity and heat production	2.21	0.20	0.93%	3.52%	67.99%
1A4bi	1A4bi Residential: Stationary plants	2.53	1.59	0.90%	3.39%	71.38%
3D3	3D3 Other product use	1.05	1.00	1.13%	3.22%	74.60%
4B8	4B8 Swine	1.68	1.22	0.84%	3.16%	77.75%
7A	7A Other	1.86	1.27	0.81%	3.05%	80.80%

Table 1.8.a $PM_{2.5}$ key source categories identified by 2012 level assessment (Emissions in Gg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
1A4bi	1A4bi Residential: Stationary plants	1.51	11.72%	11.72%
7A	7A Other	1.26	9.27%	21.45%
1A3bi	1A3bi Road transport: Passenger cars	1.23	9.56%	31.01%
1A3bii	1A3bii Road transport: Light duty vehicles	1.19	9.18%	40.19%
2C1	2C1: Iron and steel production	0.83	6.41%	46.60%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	0.64	4.92%	51.53%
2B5a	2B5a Other chemical industry	0.63	4.91%	56.43%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	0.62	4.80%	61.23%
1A3di(ii)	1A3di(ii) International inland waterways	0.52	4.03%	65.26%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.42	3.24%	68.50%
2A7d	2A7d Other Mineral products	0.41	3.20%	71.70%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	0.37	2.89%	74.59%
1A3dii	1A3dii National navigation (Shipping)	0.36	2.80%	77.39%
3D3	3D3 Other product use	0.33	2.58%	79.97%
2D2	2D2 Food and drink	0.28	2.10%	82.10%

Table 1.8.b $PM_{2.5}$ key source categories identified by 1990 level assessment (Emissions in Gg).

NFR Code	Long name	1990	Contribution	Cumulative Contribution
2C1	2C1 Iron and steel production	5.88	12.65%	12.65%
1A3bi	1A3bi Road transport: Passenger cars	5.50	11.84%	24.49%
1A1b	1A1b Petroleum refining	5.48	11.80%	36.29%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.24	11.27%	47.56%
1A3bii	1A3bii Road transport:Light duty vehicles	3.67	7.91%	55.47%
1A4bi	1A4bi Residential: Stationary plants	2.39	5.11%	60.60%
2B5a	2B5a Other chemical industry	2.12	4.56%	65.16%
1A1a	1A1a Public electricity and heat production	1.87	4.02%	69.18%
7A	7A Other	1.84	3.96%	73.14%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.64	3.52%	76.66%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.43	3.08%	79.74%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.26	2.71%	82.44%

Table 1.8.c $PM_{2.5}$ key source categories identified by 1990 - 2012 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
1A1b	1A1b Petroleum refining	5.48	0.18	2.90%	16.34%	16.34%
1A4bi	1A4bi Residential: Stationary plants	2.39	1.51	1.83%	10.32%	26.67%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.24	0.62	1.80%	10.14%	36.81%
2C1	2C1 Iron and steel production	5.88	0.83	1.73%	9.78%	46.59%
7A	7A Other	1.84	1.26	1.60%	9.03%	55.62%
1A1a	1A1a Public electricity and heat production	1.87	0.16	0.77%	4.32%	59.94%
1A3bi	1A3bi Road transport Passenger cars	5.50	1.23	0.63%	3.57%	63.51%
1A3di(ii)	1A3di(ii) International inland waterways	0.90	0.52	0.58%	3.27%	66.78%
1A3dii	1A3dii National navigation (Shipping)	0.34	0.36	0.57%	3.24%	70.01%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.43	0.64	0.51%	2.89%	72.91%
3D3	3D3 Other product use	0.42	0.33	0.47%	2.63%	75.54%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	0.21	0.25	0.42%	2.38%	77.92%
1A3bii	1A3bii Road transport:Light duty vehicles	3.67	1.19	0.35%	2.00%	79.92%
2C3	2C3 Aluminum production	0.71	0.04	0.33%	1.85%	81.76%

Table 1.9.a. Pb key source categories identified by 2012 level assessment (Emissions in Mg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
2C1	2C1: Iron and steel production	11.29	69.74%	69.74%
1A3ai(i)	1A3ai(i) International aviation (LTO)	1.73	10.69%	80.43%

Table 1.9.b Pb key source categories identified by 1990 level assessment.

NFR Code	Long name	1990	Contribution	Cumulative Contribution
1A3bi	1A3bi Road transport: Passenger cars	224.91	67.95%	67.95%
2C1	2C1 Iron and steel production	55.74	11.29%	84.79%

Table 1.9.c Pb key source categories identified by 1990 - 2012 trend assessment (Emissions in Mg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	224.91	0.04	3.31%	44.96%	44.96%
2C1	2C1 Iron and steel production	55.74	11.29	2.59%	35.13%	80.09%

Table 1.10.a Hg key source categories identified by 2012 level assessment (Emissions in Mg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
1A1a	1A1a Public electricity and heat production	0.196	35.74%	35.74%
2C1	2C1 Iron and steel production	0.188	34.23%	34.23%
2C5b	2C5b Lead production	0.062	11.31%	81.29%

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

NFR Code	Long name	1990	Contribution	Cumulative Contribution
1A1a	1A1a Public electricity and heat production	1.923	54.73%	54.73%
2B5a	2B5a Other chemical industry	0.702	19.98%	74.71%
2C1	2C1 Iron and steel production	0.388	11.05%	85.76%

Table 1.10.c Hg key source categories identified by 1990 - 2012 trend assessment (Emissions in Mg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
2C1	2C1 Iron and steel production	0.388	0.188	3.63%	28.74%	28.74%
2B5a	2B5a Other chemical industry	0.702	0.000	3.12%	24.77%	53.51%
1A1a	1A1a Public electricity and heat production	1.923	0.196	2.97%	23.54%	77.05%
1A4bi	1A4bi Residential: Stationary plants	0.025	0.025	0.59%	4.65%	81.70%

Table 1.11.a Cd key source categories identified by 2012 trend level assessment (Emissions in Mg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	0.427	53.85%	53.85%
2B5a	2B5a Other chemical industry	0.123	15.51%	69.36%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	0.071	8.95%	78.32%
1A1a	1A1a Public electricity and heat production	0.043	5.48%	83.80%

Table 1.11.b Cd key source source categories identified by 1990 level assessment (Emissions in Mg).

NFR Code	Long name	1990	Contribution	Cumulative Contribution
1A1a	1A1a Public electricity and heat production	0.949	45.45%	45.45%
2C1	2C1 Iron and steel production	0.687	32.87%	78.32%
1A1b	1A1b Petroleum refining	0.110	5.26%	83.58%

Table 1.11.c Cd key source categories identified by 1990 - 2012 trend assessment (Emissions in Mg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
1A1a	1A1a Public electricity and heat production	0.949	0.043	15.17%	42.83%	42.83%
2C1	2C1 Iron and steel production	0.687	0.427	7.96%	22.48%	65.31%
2B5a	2B5a Other chemical industry	0.000	0.123	5.89%	16.62%	81.93%

Table 1.12.a Dioxine key source categories identified by 2012 level assessment (Emissions in g I-Teq).

NFR Code	Long name	2012	Contribution	Cumulative contribution
3D3	3D3 Other product use	14.000	60.09%	60.09%
1A4bi	1A4bi Residential: Stationary plants	5.465	23.46%	83.55%

Table 1.12.b Dioxine key source categories identified by 1990 level assessment (Emissions in g I-Teq).

NF R Code	Long name	1990	Contribution	Cumulative Contribution
1A1a	1A1a Public electricity and heat production	568.009	76.49%	76.49%
1A4ai	1A4ai Commercial / institutional: Stationary	100.018	13.47%	89.96%

Table 1.12.c Dioxine key source categories identified by 1990 - 2012 trend assessment (Emissions in g I-Teq).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
1A1a	1A1a Public electricity and heat production	568.01	1.23	2.23%	41.62%	41.62%
3D3	3D3 Other product use	25.00	14.00	1.78%	33.16%	74.79%
1A4bi	1A4bi Residential: Stationary plants	8.61	5.47	0.70%	13.04%	87.82%

Table 1.13.a PAH key source categories identified by 2012 level assessment (Emissions in Mg).

NFR Code	Long name	2012	Contribution	Cumulative contribution
1A4bi	1A4bi Residential: Stationary plants	2.909	82.59%	82.59%

Table 1.13.b PAH key source categories identified by 1990 level assessment.

NFR Code	Long name	1990	Contribution	Cumulative Contribution
2C3	2C3Aluminum production	6.909	34.40%	34.40%
1A4bi	1A4bi Residential: Stationary plants	3.550	17.67%	52.07%
3A2	3A2 Industrial coating application	2.417	12.03%	64.10%
2C1	2C1 Iron and steel production	1.642	8.17%	72.28%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.370	6.82%	79.10%
1A3bi	1A3bi Road transport: Passenger cars	0.814	4.05%	83.15%

Table 1.13.c PAH key source categories identified by 1990 - 2012 trend assessment (Emissions in Mg).

NFR Code	Long name	1990	2012	Trend	Trend contribution	Cumulative trend contribution
1A4bi	1A4bi Residential: Stationary plants	3.550	2.909	11.38%	56.56%	56.56%
2C3	2C3Aluminum production	6.909	0.001	6.03%	29.95%	86.51%

B.A. Jimmink | H.M. ten Broeke | P.W.H.G. Coenen | R. Dröge | G.P. Geilenkirchen | A.J. Leekstra | C.W.M. van der Maas | R.A.B. te Molder | C.J. Peek | J. Vonk | D. Wever

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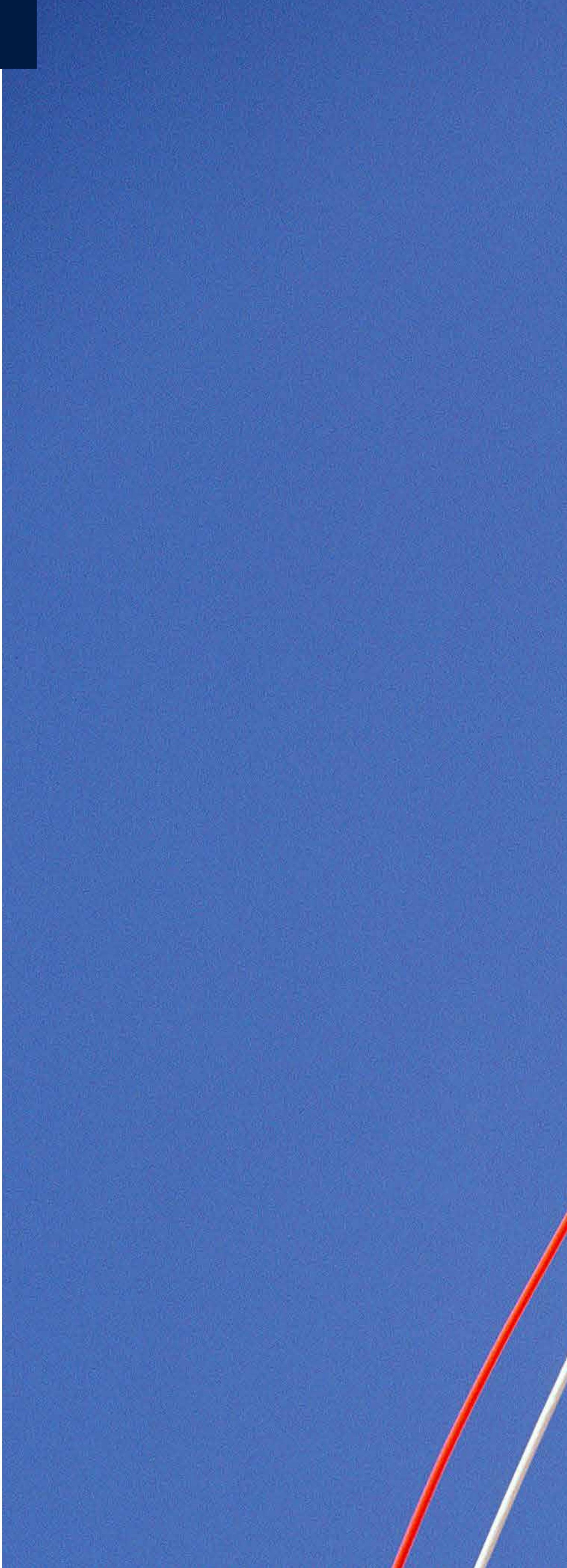
Emissions the Netherlands in 2012 remain under national ceilings

Emissions of nitrogen oxides (NO_x), ammonia, sulphur dioxide and non-methane volatile organic compounds (NMVOC) in the Netherlands have slightly decreased in 2012. Consequently, the emissions stayed below the caps the European Union has set from 2010. Herewith, the Netherlands comply with all four so-called emission ceilings (NEC).

This has become apparent from the emission data on air pollutants from the Netherlands. RIVM collects and reports these data. Besides above-mentioned substances, emissions of carbon monoxide, particulate matter (PM_{10}), heavy metals and persistent organic pollutants (POPs) have been reported. The emissions of all substances have decreased in the 1990-2012 period. The downward trend may in particular be attributed to cleaner fuels, cleaner car engines and to emission reductions in the industrial sectors.



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