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

Emissions of air pollutants

Emissions of transboundary air pollutants in the Netherlands 1990-2011

Informative Inventory Report 2013

Netherlands Informative Inventory Report 2013

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Rapport in het kort

Emissies Nederland in 2010 onder plafonds
De Nederlandse uitstoot van stikstofoxiden (NO_x) is in 2011 zodanig afgenomen dat het voor het eerst kwam onder het maximum dat de Europese Unie daaraan voor 2010 heeft gesteld. Hiermee voldoet Nederland aan alle vier de zogeheten nationale emissieplafonds (NEC). Voor ammoniak, zwaveldioxide en niet-methaan vluchtige organische stoffen (NMVOS) voldeed Nederland al in 2010 aan deze plafonds.

Dit blijkt uit de toelichting van het RIVM op de Nederlandse emissiecijfers van grootschalige luchtverontreinigende stoffen, het Informative Inventory Report (IIR) 2013. Deze cijfers betreffen de uitstoot van zwaveldioxide, stikstofoxiden, NMVOS, koolmonoxide, ammoniak, fijn stof (PM_{10}), zware metalen en persistente organische stoffen (POP's). De uitstoot van al deze stoffen is tussen 1990 en 2011 gedaald. Dit komt vooral door schonere auto's en brandstoffen en door emissiebeperkende maatregelen van industriële sectoren.

Lagere uitstoot van schadelijke stoffen door oude personenauto's
Door de jaren heen resulteren nieuwe methoden om de emissies te berekenen in nauwkeurigere uitkomsten. Zo blijkt onder andere uit dit verslagjaar dat de emissieberekening voor personenauto's in Nederland is verbeterd. Daaruit volgt dat de uitstoot van schadelijke stoffen door benzineauto's zonder katalysator lager is dan werd verondersteld. Dat komt vooral doordat deze auto's gemiddeld op jaarbasis minder kilometers rijden dan eerder werd gedacht. Het CBS heeft afgelopen jaar de gereden kilometers van personenauto's nauwkeuriger in beeld gebracht door ze specifieker dan voorheen uit te splitsen naar leeftijd en brandstoftype. Tussen 2005 en 2010 valt hierdoor de totale uitstoot van stikstofoxiden door personenauto's, zowel diesel als benzine, circa 15 procent lager uit dan vorig jaar was berekend. De uitstoot van NMVOS is dit jaar zelfs 25 procent lager berekend.

Jonge dieselauto's vervuilender dan gedacht
De uitstoot van stikstofoxiden door zogeheten Euro-5 dieselauto's blijkt hoger dan eerder werd aangenomen; in 2010 circa 6 procent. De Euro-5 aanduiding verwijst naar de Europese wetgeving voor de uitstoot van schadelijke stoffen door personenauto's en bestelauto's. Volgens deze wetgeving zou de stikstofoxidenuitstoot door dieselauto's met 28 procent moeten dalen ten opzichte van de Euro-4-norm. Euro-5 personenauto's zijn in 2008 op de Nederlandse markt gekomen, waarna TNO in 2012 van enkele Euro-5 auto's de emissies heeft gemeten. Hieruit blijkt dat de uitstoot van stikstofoxiden flink hoger ligt dan de Europese emissienormen voor deze auto's; de mate waarin hangt af van het rijgedrag (optrekken en remmen in steden of doorrijden op de snelweg). Auto's blijken in de praktijk minder zuinig te rijden dan tijdens condities waaronder fabrikanten testen. De stikstofoxidenuitstoot van Euro-5 dieselauto's is daarmee gemiddeld zelfs hoger dan de norm voor Euro-4 auto's.

Trefwoorden: emissies, grootschalige luchtverontreiniging, emissieregistratie

Abstract

Emissions the Netherlands in 2011 under national ceilings
Emissions of nitrogen oxides (NO_x) have decreased in 2011 to the level that for the first time they were below the cap the European Union has set for 2010. Herewith, the Netherlands comply with all four so-called emission ceilings (NEC). For ammonia, sulphur dioxide and non-methane volatile organic compounds (NMVOC) the Netherlands already complied with the ceilings in 2010.

This has become apparent from RIVM's explanation of Dutch emission data on transboundary air polluting substances, in the Informative Inventory Report (IIR) 2013. This concerns emissions of sulfur dioxide, nitrogen oxides, NMVOC, carbon monoxide, ammonia, particulate matter (PM_{10}), heavy metals and persistent organic pollutants (POPs) which have all decreased over the 1990–2011 period. The downward trend may in particular be attributed to cleaner fuels, cleaner car engines and to emission reductions in the industrial sectors.

Lower emissions of pollutants from old passenger cars
New methods of calculating emissions, over the years, have led to results that are ever more accurate. This year, the largest improvement was made in emission calculations for passenger cars in the Netherlands. Consequently, emissions from gasoline cars without catalytic converter appeared to be lower than previously calculated. In particular, this is because these cars on average drive fewer kilometres per year than previously assumed. Statistics Netherlands (CBS) have monitored the kilometres driven by passenger cars more accurately, by splitting them more specifically by age and fuel type. Between 2005 and 2010, the total NO_x emission by passenger cars, both diesel-fuelled, as gasoline fuelled, appeared to be about 15 per cent lower than calculated last year. The calculated NMVOC emission was even 25 per cent lower.

Young diesel cars more polluting than expected
Nitrogen oxides emissions from so-called Euro-5 diesel cars appear to be higher than previously assumed; About 6 per cent in 2010. The Euro-5 term refers to the European standard on emissions of pollutants from passenger cars and light-duty vehicles. According to this legislation, NO_x emissions by diesel cars should drop by 28 per cent compared to the Euro-4 standard. Euro-5 cars have penetrated the Dutch market in 2008 and ever since TNO has measured the on-road emissions by several Euro-5 cars. These measurements have shown that NO_x emissions are considerably higher than the standards; how much higher depends on driving behaviour (accelerating and braking in cities or continuous driving on highways). Cars appear to drive less economical on the road than during the car producers' testing conditions. Therefore, the on-road NO_x emissions from Euro-5 diesel cars are on average even higher than the Euro-4 standard.

Key words: emissions, transboundary air pollution, emission inventory

Contents

1 Introduction

The United Nations Economic Commission for Europe's' Geneva 1979 Convention on Long-Range Transboundary Air Pollution (CLRTAP) was accepted by the Netherlands in 1982. Under the Convention parties are obligated to report emission data to the Conventions' Executive Body in compliance with the implementation of the Protocols to the Convention (also accepted by the Netherlands). The annual Informative Inventory Report (IIR) on national emissions of SO_2, NO_x, NMVOC, CO, NH_3 and various heavy metals and POP is prepared using the Guidelines for Estimating and Reporting Emission Data under the CLRTAP (UNECE, 2009).
The Netherlands' IIR 2013 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 2011, including descriptions of methods, data sources, QA/QC activities carried out and a trend analysis. The inventory covers all anthropogenic emissions to be reported in the Nomenclature for Reporting (NFR), including individual polycyclic aromatic hydrocarbons (PAHs), which are to be reported under persistent organic pollutants (POP) in Annex IV.

1.1 National inventory background

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

Instead of using the defaults from the EMEP/EEA air pollutant emission inventory guidebook (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, 2012). 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:
PBL Netherlands Environmental Assessment Agency
- 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;
- 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), in 2011 about 1000 facilities are 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).

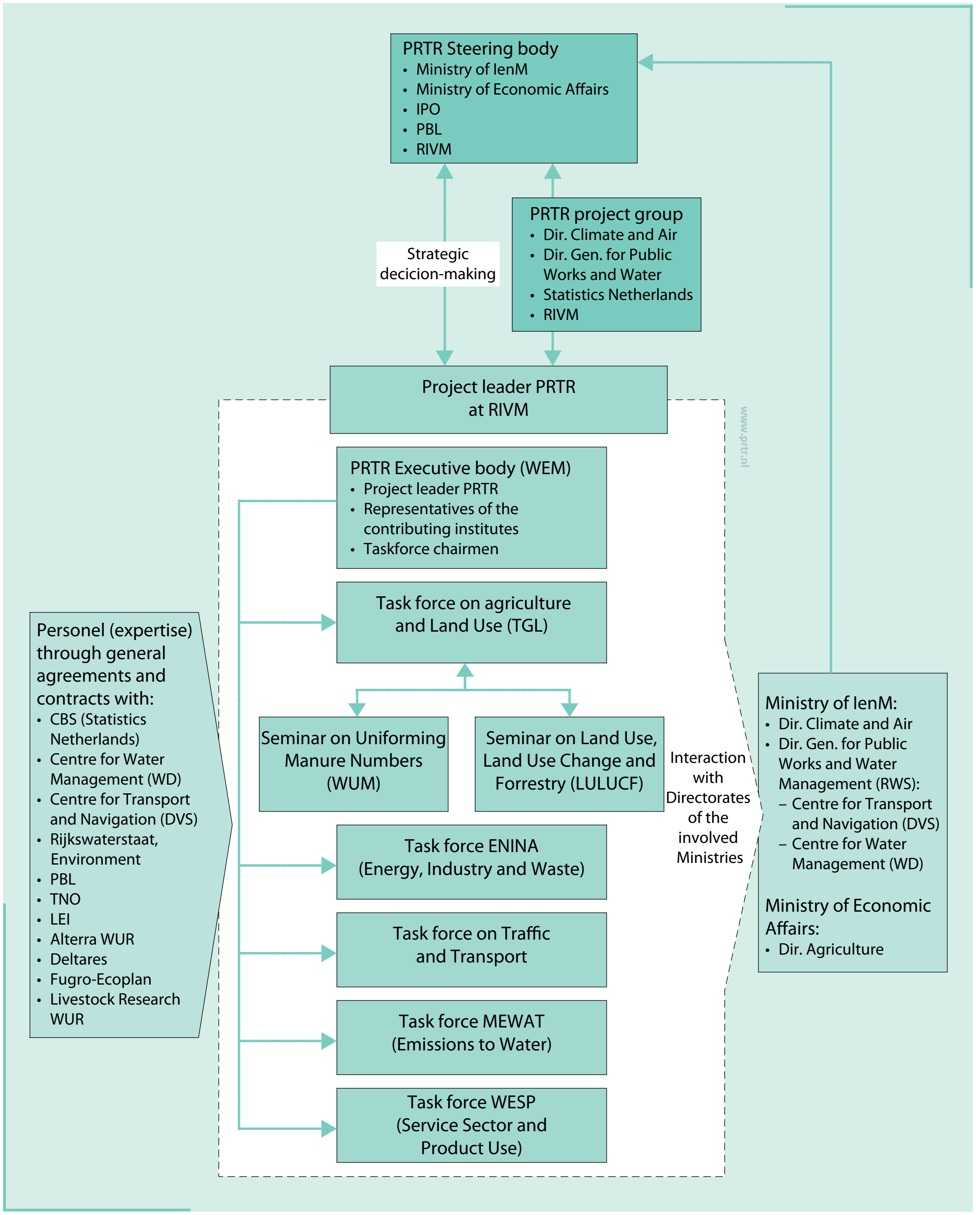
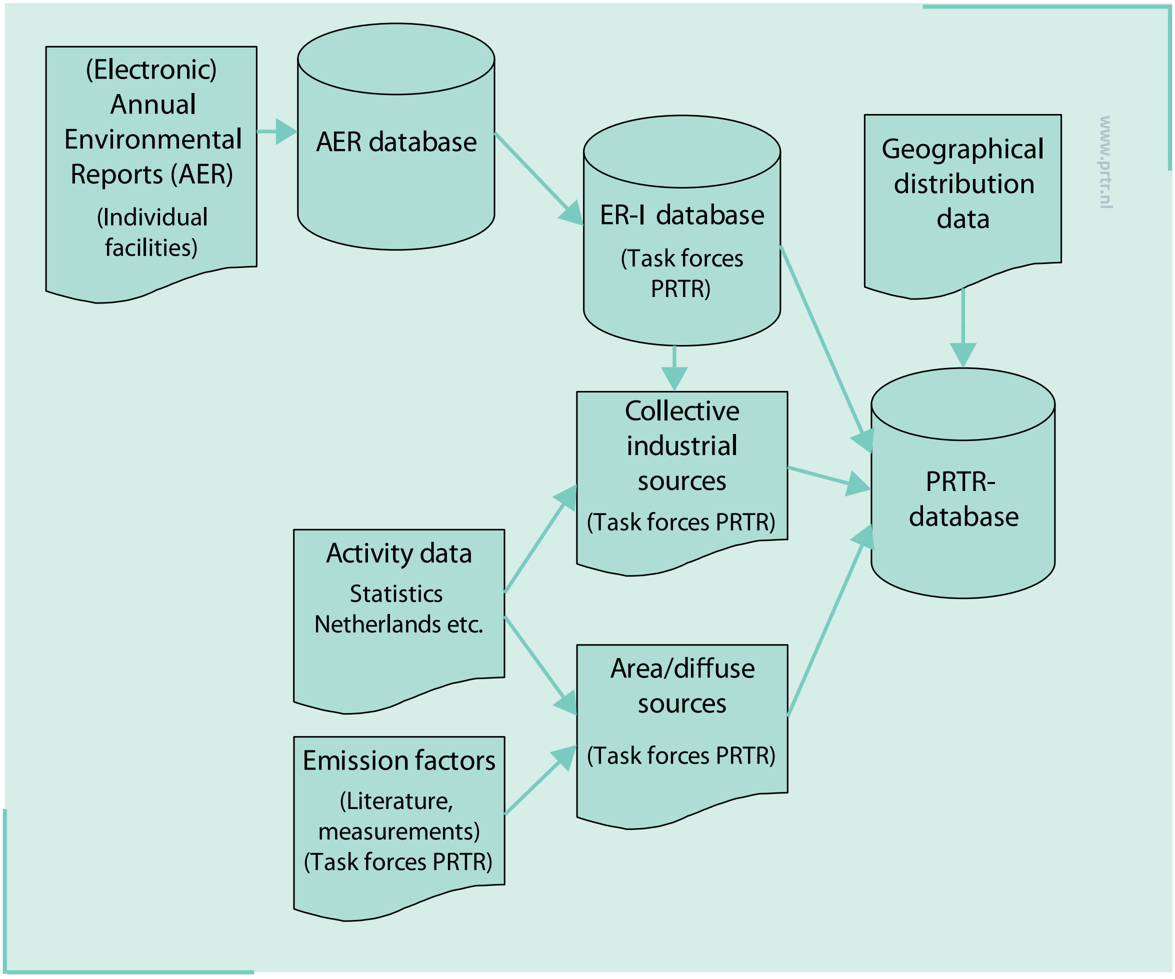


Figure 1.2 The data flow in the Netherlands Pollutant Release and Transfer Register.



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.greenhousegases.nl), particulate matter (PM) and all emissions related to mobile sources, the documentation has been translated in English.
In general, two emission models are used in the Netherlands:

- A model for emissions from large *point sources* (e.g. large industrial and power plants), which are registered separately and supplemented with emission estimates for the remainder of the companies within a subsector (based mainly on IEFs from the individually registered companies). This is the so-called bottom up method.
- A model for emissions from *diffuse sources* (e.g. road transport, agriculture), which are calculated from activity data and emission factors from sectorial emission inventory studies in the Netherlands (e.g. SPIN documents produced by the 'Co-operation project on industrial emissions').

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 2010, 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 the annual project plan (RIVM, 2011). 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 1.2). 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 2012 inventory the PRTR task forces filled in a standard-format database with emission data from 1990 to 2011. 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 taskforces.

Table 1.2 Key items of the verification actions data processing 2012 and NFR/IIR 2013.

OC Item/action	Date	Who	Result	Documentation *
Automated initial check on internal and external data consistency.	During each upload	Data Exchange Module (DEX)	Acceptation or rejection of uploaded sector data	Upload event and result logging in the PRTR-database
Input of hanging issues for this inventory.	09-07-2012	RIVM-PRTR	List of remaining issues/ actions from last inventory	Actiepunten trendanalyse voorlopige emissiecijfers 2011 v 27 juni 2012.xls
Input for checking allocations from de PRTR-database to the NFR tables.	13-02-2012	RIVM-NIC	List of allocations	NFR-ER-Koppellijst 13febr2012_BJ.xls
Input for checking the integrity of the time series 1990-2010	26-11-2012	RIVM-PRTR	Comparison sheets to check for accidentally changed data in in the time series 1990-2010	historische reeksen luchtemissies vergeleken v26 november 2012.xls
Input for error checks	26-11-2012	RIVM-PRTR	Comparison sheets 2010-2011 data	Verschiltabel definitieve emissiecijfers 26 november 2012 LUCHT Actueel.xls
Input for trend analysis	02-12-2012	RIVM-PRTR	Updated list of required actions	Actiepunten definitieve emissiecijfers 1990-2011 v2 december 2012.xls
Input for trend analysis and checking of the result of resolved actions	02-12-2012	RIVM-PRTR	Comparison sheets 2010-2011 data	Verschiltabel definitieve emissiecijfers 30 november 2012 LUCHT Actueel.xls
Trend analysis workshops	04-12-2012	Sector specialists, RIVM-PRTR	Explanations for observed trends and actions to resolve before finalising the PRTR dataset	- Landbouw dataset 2012 definitief eo_ niveau JV.xls - Trendverklaring reeks 1990-2011 definitief_AFVAL.doc - Trendanalyse verkeer 1990-2011 definitief.ppt
Input for resolving the final actions before finalising the PRTR dataset	07-12-2012	RIVM-PRTR	Updated Action list	Actiepunten definitieve emissiecijfers 1990-2011 v 7 december 2012.xls
Request to the contributing institutes to endorse the PRTR database	14-12-2012 till 7-12-2012	PRTR project secretary, Representatives of the contributing institutes	Reactions of the contributing institutes to the PRTR-project leader	- Email with the request - Actiepunten definitieve emissiecijfers 1990-2011 v 13 december 2012.xls - Emails with consent from PBL, CBS and Deltares.
Input for compiling the NEC report (in NFR-format)	28-12-2012	RIVM-NIC	List of allocations for compiling from the PRTR-database to the NFR-tables	NFR-ER-Koppellijst 2012-12-10.xls
Final PRTR dataset	20-12-2012	PRTR project leader	Updated Action list	Actiepunten definitieve emissiecijfers 1990-2011 v 20 december 2012.xls
List of allocations for compiling from the PRTR-database to the NFR-tables	13-02-2013	RIVM	Input for compiling the EMEP/LRTAP report (NFR format)	NFR-ER-Koppellijst 2012-12-17-BL.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 sub sectors. The task forces examine these time series. During the trend analysis for this inventory the emission data were checked in two ways: 1) emissions from 1990 to 2010 from the new time series were compared with the time series of last years' inventory and 2) the data for 2011 were compared with the trend development per gas since 1990. The checks of outliers are performed on a more detailed level of the sub-sources in all sector background tables:

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

Exceptional trend changes and observed outliers are noted and discussed at the trend analysis workshop, resulting in an action list. Items on this list have to be processed within 2 weeks or be dealt with in next year's inventory.

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

1.7 Uncertainties

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

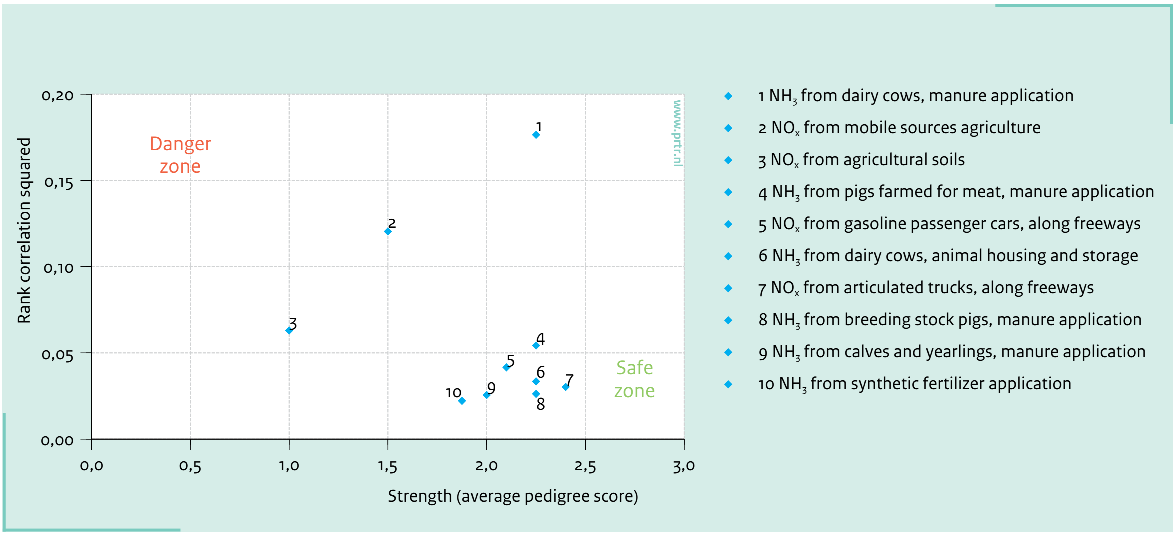
1.7.1 Quantitative uncertainty

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

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.



source category using Monte Carlo analysis). See Table 1.2 for results. A comparison was also made between the Tier-1 and Tier-2 methodologies. This was not straightforward, as the two studies used a different knowledge collection. The 2000 Tier-1 analysis used CLRTAP default uncertainties for several NO_x processes, which explains the difference with the 1999 Tier-1 results. For NH_3, the difference between the 2000 Tier 1 and Tier 2 can be explained by taking non-normal distributions and dependencies between individual emission sources per animal type into account (both are violations of the Tier-1 assumptions: effects encapsulated in the 1999 Tier-1 analysis). The differences for SO_2 and total acidifying equivalents are small. The conclusion drawn from this comparison is that focusing on the order of magnitude of the individual uncertainty estimates, as in the RIVM (2001) study, provides a reasonable first assessment of the uncertainty of source categories.

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.

NFR09 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

NFR09 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 furbearing 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 Netherlands emission inventory covers all important sources.

2 Trends in emissions

2.1 Trends in national emissions

In 2011, the Dutch NO_x emissions have further decreased and were below the national emission ceiling for the first time, be it one year later than agreed upon in the EU directive. For NH_3, SO_2 and NMVOC the Netherlands already complied to the respective ceilings in 2010. The emissions of all substances showed a downward trend in the 1990-2011 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, 57% for PM, 59% for NO_x and 98% for SO_2, despite a growth in road transport of 31%. 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 92% in PM emissions and 63% in NO_x emissions, since 1990. The drivers for the downward emission trend for specific substances will be elaborated in more detail in the next section.

Table 2.1 Total national emissions, 1990-2011.

	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	566	1124	477	192	355	90	68	44	336	2.1	3.5
1995	472	915	338	130	208	68	50	33	159	1.1	1.4
2000	394	744	233	73	161	46	39	24	33	0.9	1.0
2005	337	632	169	64	141	40	33	19	36	1.7	0.9
2010	274	551	145	34	122	34	29	15	44	2.5	0.6
2011	259	529	144	34	119	34	29	14	28	1.1	0.8
1990 - 2011 period [1]	-307	-595	-333	-158	-236	-56	-39	-30	-308	-1.0	-2.7
1990 - 2011 period [2]	-54%	-53%	-70%	-82%	-67%	-62%	-58%	-68%	-92%	-46%	-77%

[1] Absolute difference in Gg

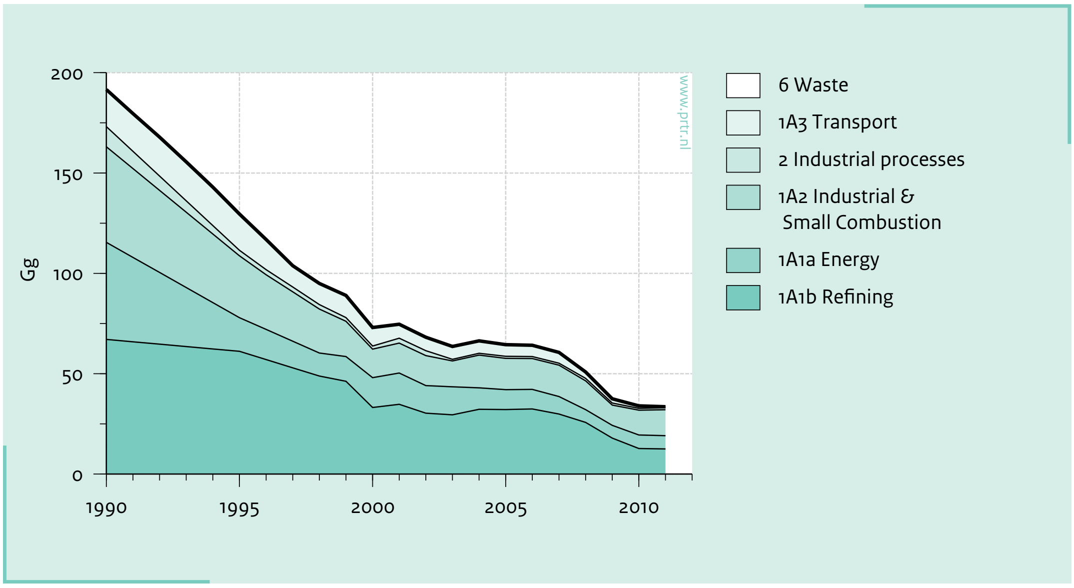
[2] Relative difference to 1990 in %

	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	20.0	1.5	9.9	69.2	75.3	0.4	220.7
1995	69	9.7	1.0	6.6	69.6	86.6	0.3	142.0
2000	30	3.8	1.1	3.1	70.7	18.7	0.5	91.0
2005	38	3.8	1.5	2.3	74.8	10.7	2.6	83.3
2010	30	3.7	0.8	1.7	81.8	1.8	1.5	105.4
2011	31	3.8	1.2	1.5	81.9	2.0	0.8	102.7
1990 - 2011 period [1]	-711	-16.2	-0.2	-8.4	12.7	-73.3	0.4	-118.0
1990 - 2011 period [2]	-96%	-81%	-16%	-85%	18%	-97%	106%	-53%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

Figure 2.1. SO_2 emission trend, 1990-2011.



2.2 Trends in sulphur dioxide (SO_2)

The Dutch SO_x emissions (reported as SO_2) decreased by 158 Gg in the 1990-2011 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 93% of the national SO_2 emissions.

2.3 Trends in nitrogen oxides (NO_x)

The Dutch emissions (NO and NO_2, expressed as $NO_{2)}$ decreased by 307 Gg in the 1990-2011 period, corresponding to 54% of the national total in 1990 (Figure 2.2). Main contributors to this decrease were the road-transport and energy sectors. The emissions per vehicle decreased significantly in this period, but the effect on total emissions was partially counterbalanced by an increase in number and mileages of vehicles. The shares of the different NFR categories in the national total did not change significantly.

Figure 2.2 NO_x emission trend, 1990–2011.

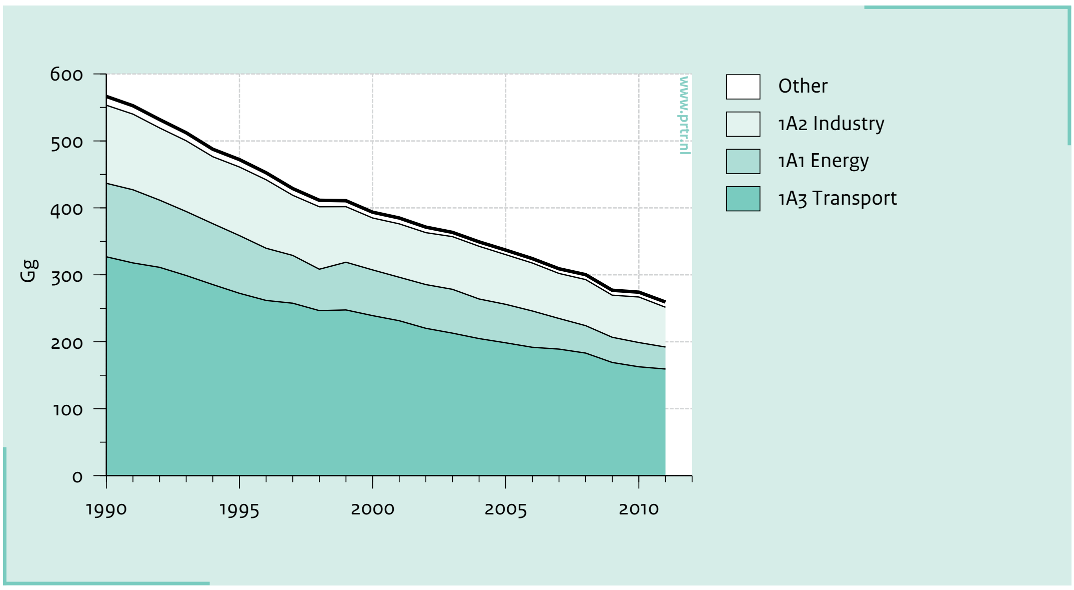
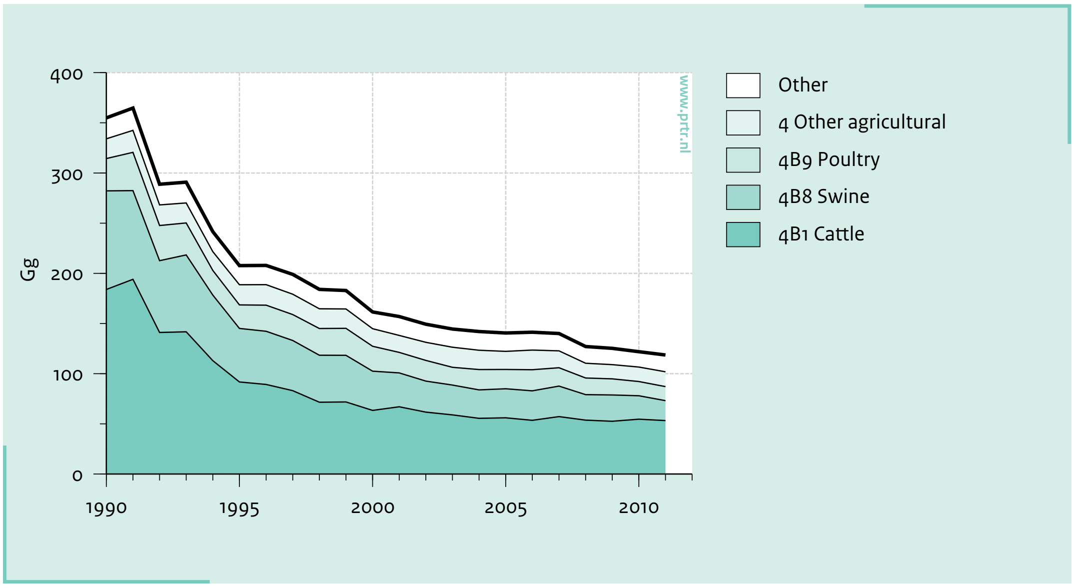


Figure 2.3 NH_3 emission trend, 1990 - 2011.



2.4 Trends in ammonia (NH_3)

The Dutch NH_3 emissions decreased by 236 Gg in the 1990-2011 period, corresponding to 67% 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 as a result 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 over 85% 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 333 Gg in the 1990-2011 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, 1990–2011.

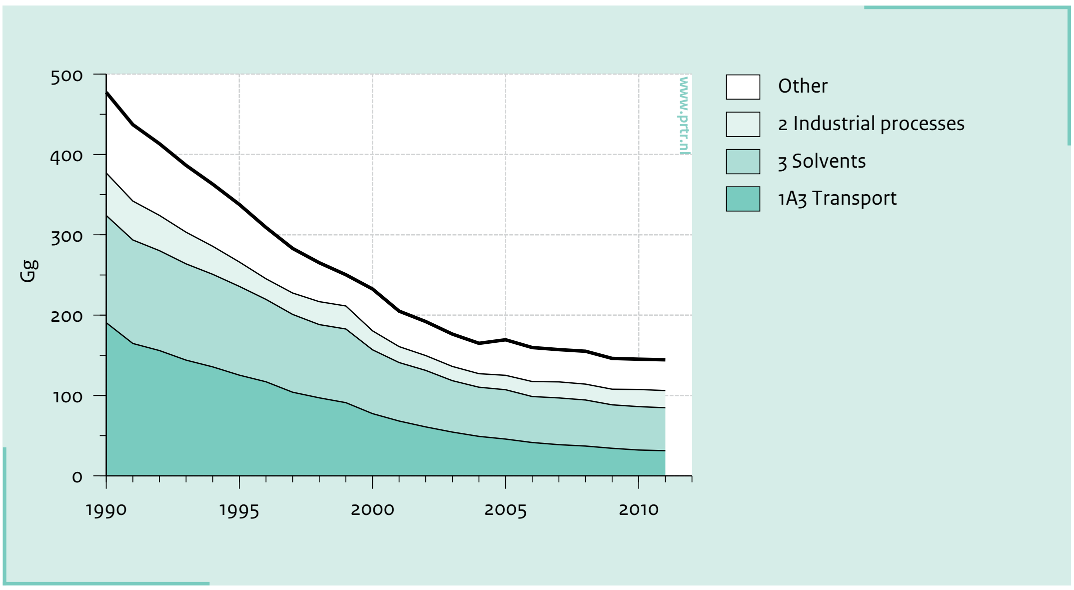
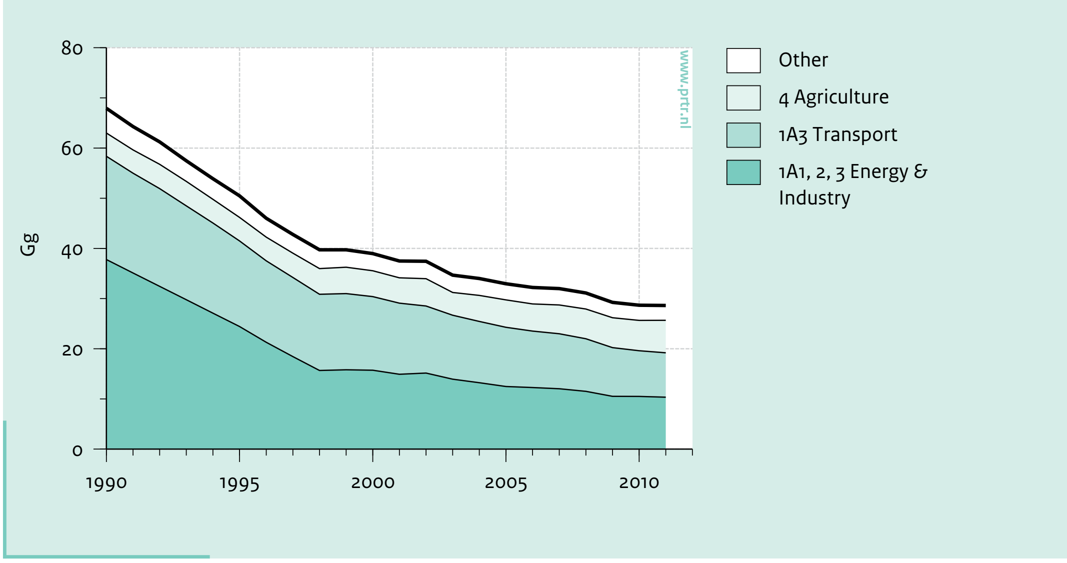


Figure 2.5 PM_{10}, emission trend, 1990–2011.



2.6 Trends in PM_{10}

Dutch PM_{10} emissions decreased by 39 Gg in the 1990-2011 period, corresponding with 57% 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 also included in the 2013 submission to UNECE. These emissions are calculated as a specific fraction of PM_{10} by sector (based on Visschedijk *et al.*, 1998). $PM_{2.5}$ emissions in the Netherlands decreased by 31 Gg in the 1990-2011 period, corresponding with 70% 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, 1990–2011.

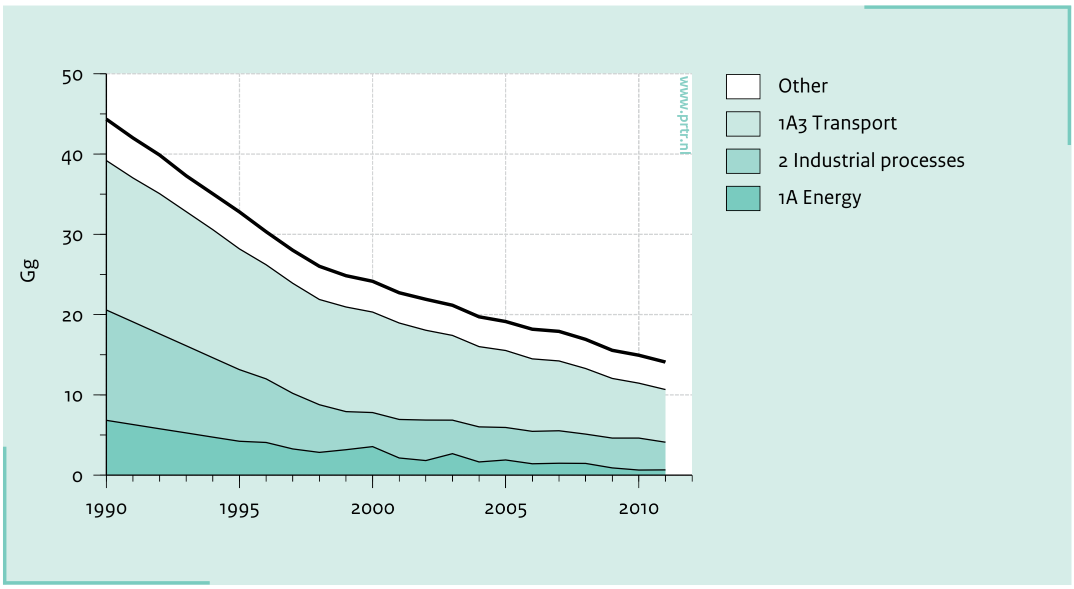
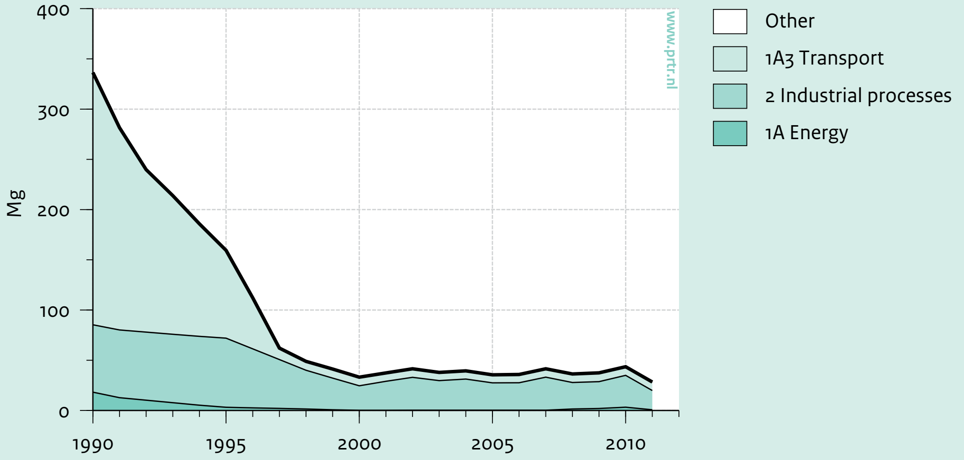


Figure 2.7 Pb, emission trend 1990-2011.



2.8 Trends in Pb

Lead (Pb) emissions in the Netherlands decreased by 308 Mg in the 1990-2011 period, corresponding with 92% 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. Because of the replacement of electrostatic filters and optimisation of other reduction technologies of Tata Steel the Pb emission in 2011 decreased considerably.

3 Energy

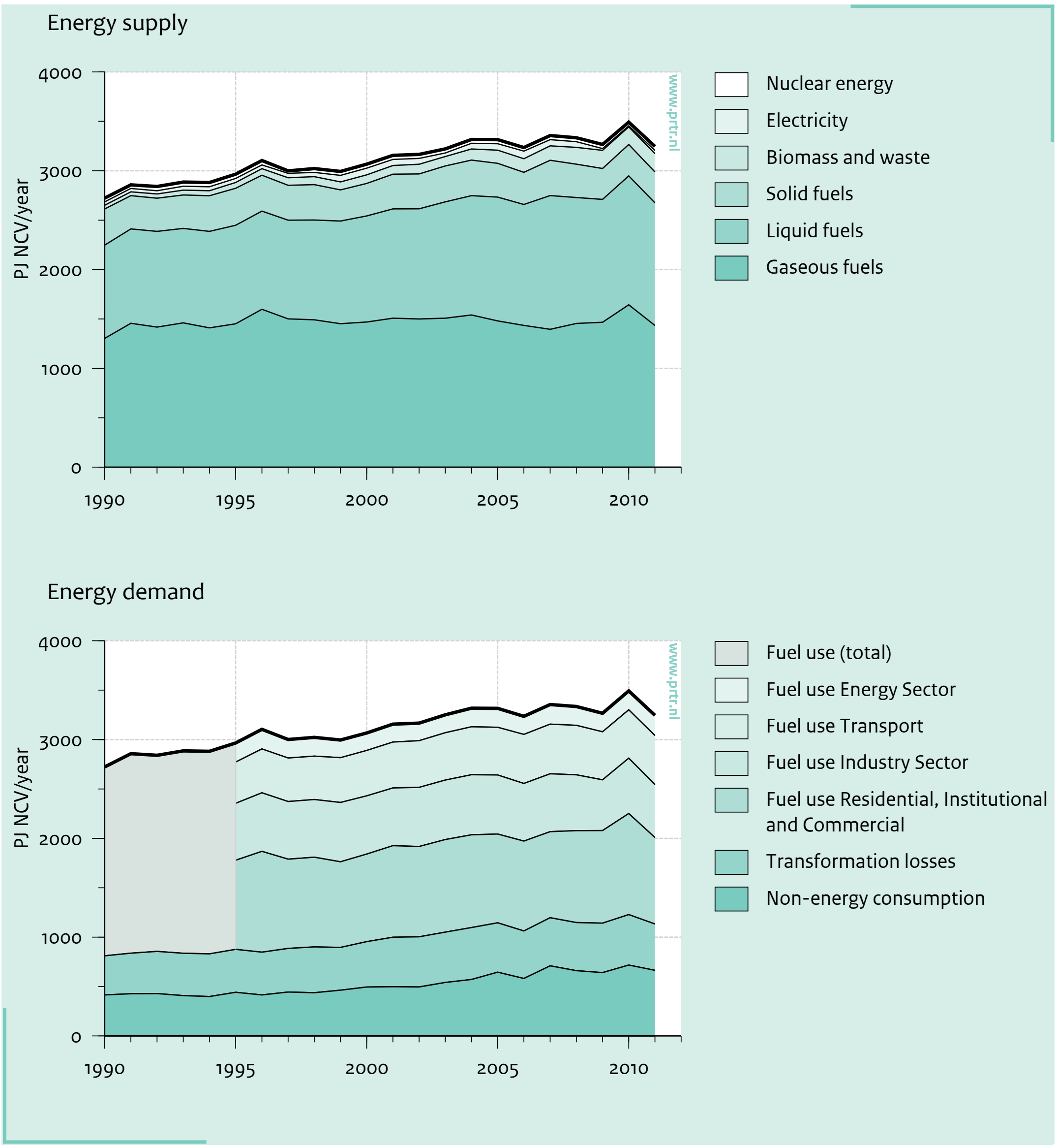
3.1 Overview of sector

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_{10} and NH_3 emissions from stationary combustion (categories 1A1, 1A2, 1A4 and 1A5) are based on environmental reports by large industrial companies. The emission data in the Annual Environmental Reports (AERs) are from direct emission measurements or calculations based on 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 2011, natural gas supplied about 44% of the total primary fuels used in the Netherlands, followed by liquid fuels (38%) and solid fossil fuels (10%). The contribution of non-fossil fuels, including renewables and waste streams, is rather limited (6%). Figure 3.1 shows the energy supply and energy demand in the Netherlands.

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



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.

Category / Sub-category	Pollutant	Contribution to national total in 2011 (%)
1A1a Public electricity and heat production	SO_x	19.8
	NO_x	8.7
	Hg	26.9
	Dioxins	24.2
	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.

	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
1990 - 2011 period [1]	-60	-4	-0.4	-42	0.08	-1.77	-2.00	-1.76	-15.97	-0.86	-1.70
1990 - 2011 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
1990 -2 011 period [1]	-560.4	-0.16	-0.34	-0.50	-1.90	-2.32	0.69	-27.85
1990 - 2011 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 except, emissions decreased between 1990 and 2011, while fuel consumption increased by 38% over the same period. The emissions from the main pollutants that were lower than in 1990, decreased by 45% to 86%. Emissions from other pollutants, lower than in 1990, decreased by 68% to 99%. The decrease in emissions has partly been caused by a shift from coal to gas consumption. Furthermore, the decrease in emissions has been caused by technological improvements. The only pollutants for which the emissions have increased are dioxins, NH_3, Se and HCB. The increase in HCB emission is solely due to the increase in the amount of incinerated waste over the years. Emissions are calculated using a fixed emission factor multiplied by the amount of waste.

3.2.4 Activity data and (implied) emission factors

Emission data are based on Annual Environmental Reports and collectively estimated industrial sources. For this source category, 80% to 100% of the emissions are based on Annual Environmental Reports. For estimation of emissions from collectively estimated industrial sources, National Energy Statistics (from Statistics Netherlands) are combined with implied emission factors from the Environmental Reports.

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. 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) and the emission factor ER-I. These emission factors are fuel and sector dependent.

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

where:

EF = emission factor

ER-I = Emission Registration database for individual companies

Next, total combustion emissions in this NACE category are calculated from the energy use according to the NEH (Netherlands Energy Statistics), multiplied by the implied emission factor.

$$ER\text{-}I\ Emission_{\ (NACE\ category)} = Emission\ factor\ ER\text{-}I_{\ (NACE\ category)} * Energy\ use_{\ (NACE\ category)}$$

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

There were no source-specific recalculations in this submission.

3.2.9 Source-specific planned improvements

There are no source-specific planned improvements.

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

3.3.1 Source category description

This source category consists of the following categories:

- 1A1b 'Petroleum refining'
- 1A1c 'Manufacture of solid fuels and other energy industries'
- 1A2a 'Iron and Steel'
- 1A2b 'Non-ferrous Metals'
- 1A2c 'Chemicals'
- 1A2d 'Pulp, Paper and Print'
- 1A2e 'Food Processing, Beverages and Tobacco'
- 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-c, 1A2a-e and 1A2fi are key sources for the pollutants mentioned in Table 3.3.

Table 3.3 Pollutants for which the Industrial Combustion (NFR 1A1b, 1A1c and 1A2) sector is a key source.

Category / Sub-category	Pollutant	Contribution to total in 2011 (%)
1A1b Petroleum refining	SO_x	37.2
1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	SO_x CO	8.7 12.4
1A2b Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	SO_x	10.4
1A2c Stationary combustion in manufacturing industries and construction: Chemicals	NO_x NMVOC Cd	4.6 3.2 8.5
1A2fi Stationary combustion in manufacturing industries and construction: Other	SO_x	8.0

3.3.3 Overview of shares and trends in emissions

An overview of the trends in emissions is shown in Table 3.4. Emissions have reduced since 1990 for most pollutants, except for dioxins. Reduction in emissions of main pollutants has been caused by improvement in used techniques. Fluctuation in dioxin emission have been caused by differences in fuels used and/or incidental emissions. Emission reduction of SO_2 and PM_{10} is mainly caused by a shift in fuel use by refineries from oil to natural gas.

Table 3.4 Overview of trends in emissions.

	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	101	267	34.7	110	0.58	8.76	7.93	4.89	1.88	0.14	0.18
1995	78	215	20.0	90	0.32	6.18	5.89	3.81	1.59	0.15	0.08
2000	49	161	7.4	46	0.05	4.83	4.72	3.30	0.04	0.01	0.11
2005	49	154	9.8	46	0.06	2.09	1.88	1.43	0.01	0.00	0.00
2010	40	124	8.5	24	0.45	0.75	0.51	0.37	2.95	1.28	0.02
2011	39	111	8.3	25	0.78	0.84	0.65	0.47	0.36	0.10	0.03
1990 - 2011 period [1)]	-62	-156	-26.4	-86	0.20	-7.92	-7.28	-4.41	-1.53	-0.04	-0.15
1990 - 2011 period [2)]	-61%	-58%	-76%	-78%	35%	-90%	-92%	-90%	-81%	-28%	-85%

[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	0.87	0.17	2.48	1.39	64.48	0.04	2.94
1995	0.02	0.09	0.14	2.73	2.19	79.34	0.05	2.65
2000	0.00	0.00	0.00	0.51	0.15	17.40	0.00	0.84
2005	0.87	0.10	0.78	0.08	0.09	6.50	0.08	0.51
2010	5.69	0.12	0.01	0.14	1.13	0.02	0.12	6.93
2011	0.78	0.09	0.01	0.08	0.46	0.04	0.02	2.08
1990 - 2011 period [1)]	0.77	-0.78	-0.16	-2.41	-0.93	-64.44	-0.03	-0.86
1990 - 2011 period [2)]	8033%	-90%	-92%	-97%	-67%	-100%	-59%	-29%

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

3.3.4 Activity data and (implied) emission factors

Petroleum refining (1A1b)
All emission data have been based on Annual Environmental Reports.

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

Iron and steel (1A2a)
All emission data have been based on Annual Environmental Reports and registered in the ER-I database.

Non-ferrous metals (1A2b)
Emission data have been based on Annual Environmental Reports and collectively estimated industrial sources. For this source category, the percentage of SO_2 emissions, based on annual reports, is 100%.

Chemicals (1A2c)
Emission data have been based on Annual Environmental Reports and collectively estimated industrial sources. For this source category, the percentages of emissions based on annual reports are about 100% for SO_2, 90% for NO_x, 75% for CO and 100% for Pb, Cd and dioxins.

Pulp, paper and print (1A2d)
All emission data have been based on Annual Environmental Reports and registered in the ER-I database.

Food processing, beverages and tobacco (1A2e)
Emission data have been based on Annual Environmental Reports 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 Annual Environmental Reports 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

For all sectors, emissions have been based on data in AERs from individual facilities (Tier-3 methodology). The emissions and fuel consumption data in AERs were systematically examined for inaccuracies by checking the resulting implied emission factors. If environmental reports provided data of high enough quality, the information was used for calculating an 'implied emission factor' for a cluster of reporting companies (aggregated by NACE code) and the emission factor ER-I. These emission factors are fuel and sector dependent.

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

where:

EF = emission factor

ER-I = Emission Registration database for individual companies

Total combustion emissions in this NACE category have been calculated from the energy use in the NEH (Netherlands Energy Statistics), multiplied by the implied emission factor.

$$\text{ER-I Emission}_{\text{(NACE category)}} = \text{Emission factor ER-I}_{\text{(NACE category)}} * \text{Energy use}_{\text{(NACE category)}}$$

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

There were no source-specific recalculations in this submission.

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 sector's 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

Key sources in this sector are presented in Table 3.5.

Table 3.5 Pollutants for which the Small Combustion (NFR 1A4 and 1A5) sector is a key source sector.

Category / Subcategory	Pollutant	Contribution to total of 2011 (%)
1A4ai Commercial/ institutional, stationary	NO_x	3.7
1A4bi Residential, stationary	NO_x	3.9
	NMVOC	6.3
	CO	10.8
	TSP	9.9
	PM_{10}	5.6
	$PM_{2.5}$	10.8
	Dioxins	17.8
	PAH	75.8
1A4ci Agriculture/forestry/ fishing, stationary	NO_x	4.2

Table 3.6 Overview of trends in emissions from Small Combustion.

	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	0.07	0.01	0.00	0.00
2010	13	4	1.4	0	0.05	0.05	0.05	0.00	0.00	0.00
2011	10	3	1.1	0	0.06	0.05	0.05	0.00	0.00	0.00
1990–2011 period [1]	-4	0	-0.1	-2	-0.31	-0.29	-0.26	-0.63	-0.03	-0.09
1990–2011 period [2]	-30%	-5%	-7%	-93%	-83%	-84%	-85%	-100%	-100%	-100%

	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
1990–2011 period [1]	100.01	-0.46	-0.01	-3.53	-0.39	-2.95	-1.14
1990–2011 period [2]	-100%	-97%	-90%	-100%	-100%	-99%	-99%

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

3.4.3 Overview of shares and trends in emissions

An overview of the trends in emissions is shown in Table 3.6. Emissions of all pollutants have decreased since 1990, while fuel use increased only slightly (0.4%).

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 3.7).

Table 3.7 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
Carbon black		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 3.8 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	1500
Carbon black	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)

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 3.8). The fuel mostly used in this category is natural gas. The use of wood in stoves and fireplaces for heating is almost negligible.
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 house (Hulskotte *et al.*, 1999).

Agriculture/forestry / fishing (1A4ci)
Stationary combustion emissions have been based on fuel consumption obtained from Statistics Netherlands, which in turn has been based on data from the Agricultural Economics Research Institute, and emission factors (Table 3.7).

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

Activity data and emission factors for the use of charcoal have been revised, as a result of the UNFCCC in-country review in September 2011. Activity data is now based on the statistics from Statistics Netherlands, and emission factors are based on the IPCC Guidelines. This new methodology causes an increase in charcoal use of 200%, but since this is a minor source, emissions only increased slightly.

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 3.9.

Table 3.9 Pollutants for which the Small Combustion (NFR 1B) sector is a key source sector.

Category / Sub-category	Pollutant	Contribution to total in 2011 (%)
1B2ai Oil and gas production	NMVOC	5.0
1B2a.v Refining	NMVOC	5.8

3.5.3 Overview of shares and trends in emissions

An overview of the trends in emissions is shown in Table 3.10. The emissions from NMVOC decreased between 1990 and 2011.

Table 3.10 Overview of trends in emissions

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
1990 - 2011 period [1]	- 30.3	- 0.01
1990 - 2011 period [2]	- 64%	- 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 have been 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 have been 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

There were no source-specific recalculations in this submission.

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 the 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*. (2013).

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 2011 level and the trend (in italics) assessment. Some source categories are key sources for both the trend and the 2011 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	1 A 5 b 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 1A3 Transport. 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
1A3bi	Passenger cars	4.2%	27.8%	4.9%	17.5%	39.1%	4.2%	5.0%	10.2%	44.2%
1A3bii	Light duty trucks		5.5%			6.1%	4.9%	5.9%	12.0%	
1A3biii	Heavy duty vehicles	7.6%	21.9%			3.1%	5.6%	7.6%	10.2%	
1A3biv	Motorcycles and mopeds				3.9%	5.6%				
1A3bv	Gasoline evaporation				10.1%					
1A3bvi	Tyre and break wear						4.4%	5.0%	2.2%	20.0%
1A3bvii	Road abrasion						3.7%	4.2%		
1A3di(ii)	International inland waterways		6.5%						3.6%	
1A3dii	National navigation		5.1%						2.8%	
1A2fii	Mobile Combustion in manufacturing industries and construction		3.7%						2.6%	
1A4aii	Commercial/ institutional mobile					4.6%				
1A4bii	Residential household gardening (mobile)					10.3%				
1A4cii	Agriculture/forestry/ fishing: off-road vehicles and other machinery		3.9%							
1A5b	Other, Mobile (including military, land based and recreational boats)					6.5%				

4.2 Civil Aviation

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	4.24	0.40	0.11	0.035	0.035	0.030	3.63	0.0098	0.0012
1995	1.80	4.67	0.37	0.15	0.043	0.043	0.036	3.88	0.0088	0.0011
2000	2.44	4.26	0.27	0.21	0.051	0.051	0.041	3.05	0.0064	0.0008
2005	2.81	3.79	0.24	0.10	0.053	0.053	0.041	2.21	0.0059	0.0007
2010	2.76	4.09	0.24	0.09	0.052	0.052	0.040	2.53	0.0057	0.0007
2011	2.92	3.91	0.25	0.10	0.056	0.056	0.042	2.25	0.0061	0.0007
1990 -2011 period [1)]	1.56	-0.33	-0.15	-0.01	0.021	0.021	0.013	-1.38	-0.0041	-0.0004
1990 -2011 period [2)]	115%	-8%	-38%	-11%	61%	61%	42%	-38%	-42%	-38%

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

4.2.2 Key sources

Civil aviation is not a key source 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 2011, increasing from 4.9 to 9.9 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 by 2% in 2010 and by 7% in 2011. This is roughly in line with the trends in the number of air passengers (+14% between 2009 and 2011) and the number of flights (+7% between 2009 and 2011) at Schiphol.

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 0.7 PJ in 2011. 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 74% since 2003 to 1.1 million in 2011, whereas the number of air passengers at Eindhoven Airport increased from 0.4 million to 2.7 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 fuel consumption in the last 20 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 2011, 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 2011 total PM exhaust emissions also increased throughout the time series. PM_{10} emissions due to tyre and brake wear increased by 175% between 1990 and 2011, 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 break wear emissions in total PM_{10} emissions from civil aviation increased from 14% to 24% between 1990 and 2011.

Civil aviation is a small emission source in The Netherlands and is not a key source for any pollutant. Civil aviation was responsibly though for 8% of total Pb emissions in 2011. The share in total NO_x emissions was 1%, whereas the share in emissions of all other substances was less than 1%.

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 so-called EMASA model from TNO to calculate fuel consumption and resulting emissions (see also Klein *et al.*, 2013). 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*. (2013).

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 reasonably good.

4.2.8 Source-specific recalculations

There were no source-specific recalculations for civil aviation'.

4.2.9 Source-specific planned improvements

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

4.3 Road Transport

4.3.1 Source category description

The source category 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.

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 2011 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 38% of total NO_x emissions (national totals), 23% of PM_{10}, 32% of $PM_{2.5}$, 16% of NMVOC, 49% of CO and 20% of Pb in The Netherlands in 2011. 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

Table 4.4 Key source analysis for road transport subcategories.

Source category		1990 level	2011 level	1990 - 2011 trend
1A3b i	Passenger cars	NO_x, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Pb	NO_x, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$	NO_x, NMVOC, CO, PM_{10}, $PM_{2.5}$, Pb, SO_2, NH_3
1A3b ii	Light duty vehicles	CO, TSP, PM_{10}, $PM_{2.5}$	NO_x, TSP, PM_{10}, $PM_{2.5}$	NO_x, CO, TSP, PM_{10}, $PM_{2.5}$
1A3b iii	Heavy duty vehicles	SO_2, NO_x, TSP, PM_{10}, $PM_{2.5}$	NO_x, CO, PM_{10}, $PM_{2.5}$	SO_2, NO_x, TSP, PM_{10}, $PM_{2.5}$
1A3b iv	Mopeds & motorcycles	NMVOC, CO	NMVOC, CO	NMVOC, CO
1A3b v	Gasoline evaporation	NMVOC		NMVOC
1A3b vi	Tyre and brake wear		TSP, PM_{10}, Pb	TSP, PM_{10}, Pb
1A3b vii	Road abrasion		TSP, PM_{10}	TSP, PM_{10}, $PM_{2.5}$

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

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	243	697	176.4	13	0.90	15.5	15.5	13.8	246.2	0.03
1995	187	523	109.9	12	1.89	12.3	12.3	10.5	83.0	0.03
2000	150	413	62.5	3	2.57	10.3	10.3	8.4	5.1	0.04
2005	123	317	33.7	0	2.55	8.6	8.6	6.5	5.4	0.04
2010	102	265	23.3	0	2.54	6.8	6.8	4.7	5.6	0.04
2011	99	258	22.9	0	2.57	6.6	6.6	4.5	5.7	0.04
1990 -2011 period [1]	-144	-439	-153.5	-12	1.67	-8.8	-8.8	-9.3	-240.5	0.01
1990 -2011 period [2]	-59%	-63%	-87%	-98%	187%	-57%	-57%	-68%	-98%	32%

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

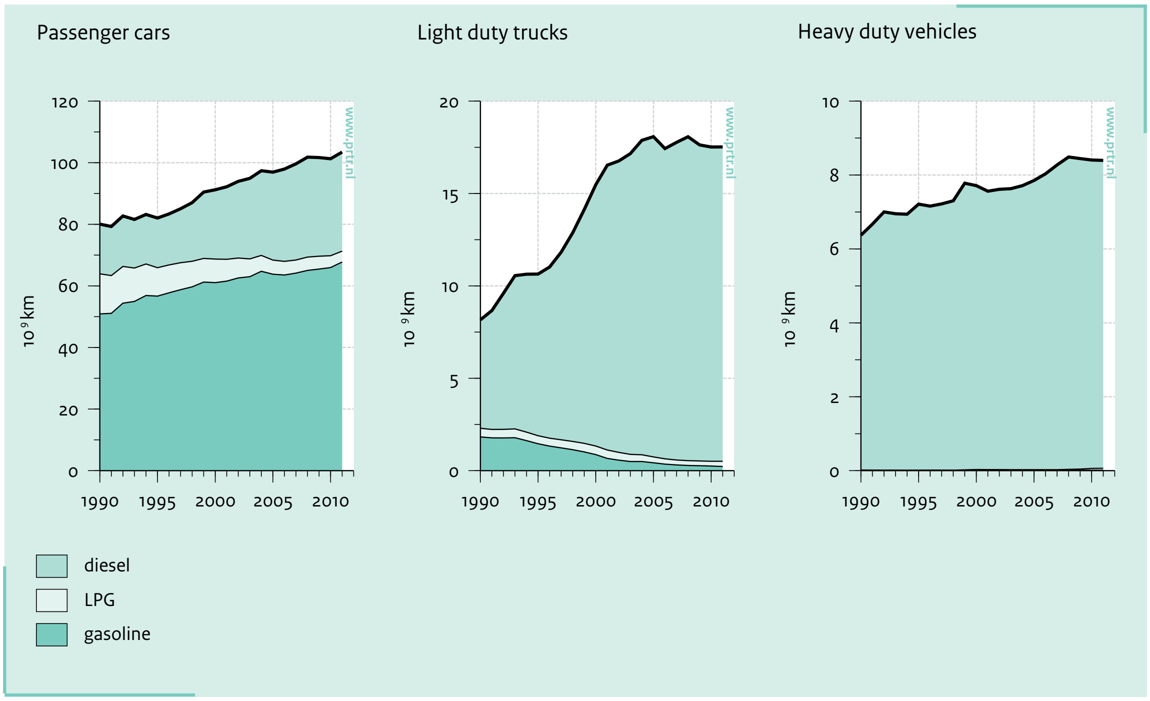
	POPs		Other Heavy Metals					
	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	
1990	2.19	1.49	0.16	0.17	51.9	0.24	0.01	29.6
1995	1.29	1.03	0.17	0.18	50.5	0.26	0.01	31.0
2000	0.69	0.66	0.20	0.21	50.4	0.28	0.01	34.4
2005	0.48	0.40	0.21	0.23	53.8	0.30	0.01	36.7
2010	0.33	0.29	0.22	0.24	56.2	0.31	0.01	38.1
2011	0.33	0.28	0.22	0.24	57.0	0.32	0.01	38.6
1990-2011 period [1]	-1.87	-1.21	0.06	0.07	5.1	0.08	0.00	9.1
1990-2011 period [2]	-85%	-81%	37%	38%	10%	33%	32%	31%

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

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, TSP, PM_{10} and $PM_{2.5}$ did not change significantly between 1990 and 2011 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 2011), CO (62% to 49%) and Pb (73% to 20%).

Emissions of SO_2 decreased by 98% between 1990 and 2011 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 2011.

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



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. Within road transport categories, there was no key source for NH_3 in the 2011 level assessment, although passenger cars were a key source in the trend assessment.

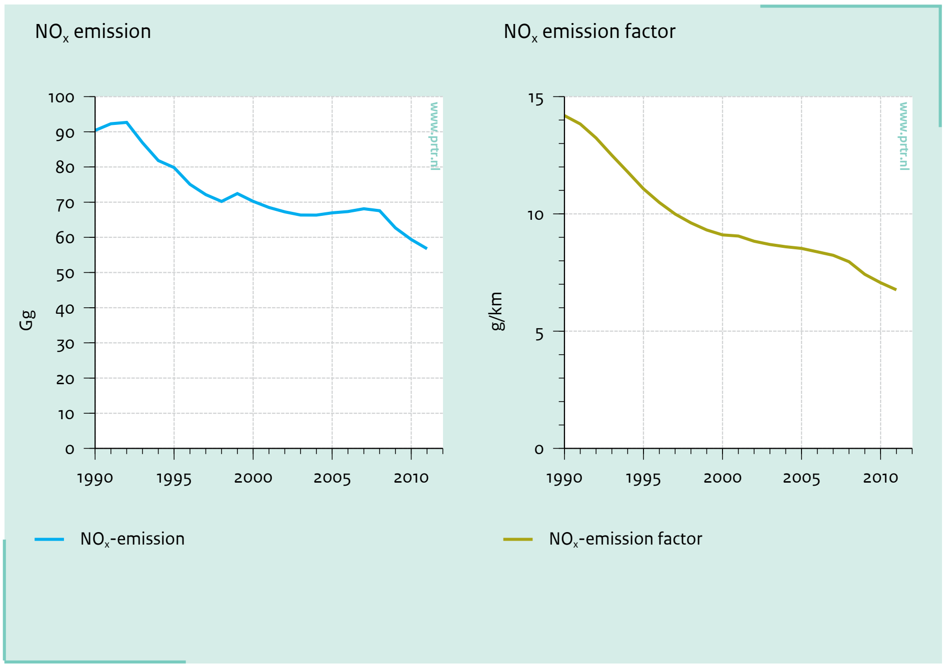
Emissions from heavy metals have increased, with the exception of Pb. Road transport, however, is not a key source for emissions of heavy metals. Again, Pb emissions from passenger cars are the only exception, as a key source in the 1990 level assessment and the 1990-2011 trend assessment.

1A3bi Passenger cars

The total number of kilometres driven by passenger cars in the Netherlands has steadily increased from approximately 80 billion in 1990 to 103 billion in 2011 (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 99% between 1995 and 2011. In comparison: gasoline mileages have increased by 20% 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 73% between 1990 and 2011. 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 2011, 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 2011. NO_x emissions of passenger cars have decreased significantly though throughout the time series: from 138 Gg in 1990 (24% of total NO_x) to 28 Gg in 2011. 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 (91% reduction between 1990 and 2011 even though traffic volumes increased by 20%). NO_x emissions from diesel-powered passenger cars increased from 10 Gg in 1995 to 17 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 17 Gg. Due to the decrease of NO_x emissions from gasoline passenger cars, NO_x has become mostly a

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



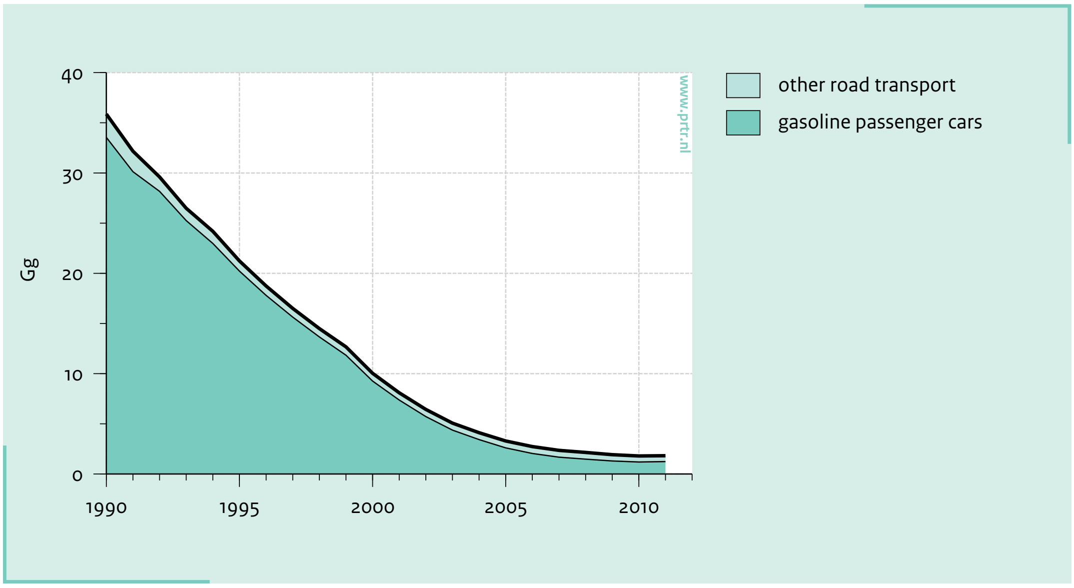
diesel related issue. The share of gasoline in total NO_x emissions from passenger cars has decreased from 79% in 1990 to 34% in 2011, whereas the share of diesel has increased from 9% to 61% between 1990 and 2011.

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 82 Gg in 1990 to 12 Gg in 2011, whereas CO emissions decreased from 545 to 195 Gg. NMVOC and CO emissions from diesel and LPG-powered passenger cars have also decreased significantly, but both are minor sources of NMVOC of 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 2011, passenger cars (source category 1A3bi, not including evaporative NMVOC emissions) were responsible for 10% of total NMVOC emissions (down from 20% in 1990) and 40% of total CO emissions (down from 52% in 1990) in The Netherlands.

PM_{10} exhaust emissions from passenger cars have decreased by 72% between 1990 and 2011. 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 2011 were 1.4 Gg, down 0.1 Gg (5%) from 2010. 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}. 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.

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.

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



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, the tax scheme for light-duty trucks was altered, making private ownership of a light-duty truck less attractive. 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 increased between 1995 and 2001, but have slowly decreased since. NO_x emissions in 2011 were slightly lower than in 1990 (13.8 Gg vs. 14.9 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 1995 and 2001, remained fairly constant between 2001 and 2005 and have since shown a minor decrease. This is caused by 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. Because of the poor NO_x-emission performance of recent euro-5 trucks (see also paragraph 4.3.8), the fleet average NO_x emission factor for diesel light duty trucks only decreased by 1% in 2011 compared to 2010. Between 2000 and 2010, the fleet average NO_x emission factor decreased by more than 3% annually. The share of light duty trucks in total NO_x emissions in The Netherlands was approximately 5% in 2011.

The exhaust emissions of NMVOC and CO from light-duty trucks have shown a major decrease throughout the time series. NMVOC emissions decreased from 8 Gg in 1990 to 1 Gg in 2011, whereas CO emissions decreased from 40 to 5 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 2011. 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 an NMVOC emissions, accounting for less than 1% of the national totals for both substances.

The exhaust emissions of PM_{10} (and subsequently also of $PM_{2.5}$) from light-duty trucks have started to decrease 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 98%. The average PM_{10} exhaust emission factor for diesel-powered light-duty trucks decreased by approximately 3% annually between 2005 and 2011, 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 18% between 2005 and 2011. In 2011, light duty trucks were responsible for 6% of total PM_{10} and 12% 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 22% in total NO_x in 2011. The number of vehicle kilometres driven by heavy-duty vehicles (trucks and buses) in the Netherlands increased by approximately 33% between 1990 and 2008 (see Figure 4.1). The economic crisis has since led to a slight decrease in traffic volumes. 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 57 Gg in 2011 (see Figure 4.2). The fleet average NO_x emission factor decreased by 52% in this period, from 14 g/km to 7 g/km. This decrease has mainly been caused by the tightening of EU emission standards for new heavy-duty engines. NMVOC exhaust emissions decreased by 82%, from 10 Gg in 1990 to 2 Gg in 2011, whereas PM_{10} and $Pm_{2.5}$ exhaust emissions decreased by 85%, from 5 Gg to less than 1 Gg. These decreases have also been caused by EU emission legislation.

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 2011 level assessment and the trend assessment. Even though vehicle kilometres increased by 39% between 1990 and 2011, 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 24 to 4 Gg between 1990 and 2011, whereas CO emissions decreased from 45 to 30 Gg. Motorcycles and mopeds were responsible for 3% of NMVOC and 6% of CO emissions in The Netherlands in 2011. NO_x emissions increased from 0.3 to 1.1 Gg, but the share of motorcycles and mopeds in total NO_x emissions in The Netherlands is less than 1%.

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 2011 (see Figure 4.3). Evaporative emissions from motorcycles and mopeds have increased slightly from 0.4 Gg in 1990 to 0.5 Gg in 2011.

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 27% between 1990 and 2011, 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.

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*. (2013).

Annual mileages by motorcycles in the Netherlands were derived from the survey on the use of motorcycles in the Netherlands. Data from this survey were used to estimate the total vehicle kilometres driven by motorcycles in the Netherlands. The survey was last conducted in 1993, since then the average annual mileages for motorcycles have been kept constant. Changes in the total vehicle kilometres driven have been caused only by changes in the national motorcycle fleet.

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*. (2013). 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*. (2013).

Total fuel consumption per vehicle and fuel type 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 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*. (2013). 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 therefore 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 0.6 PJ in 2011 (0.1% 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 for road transport.

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

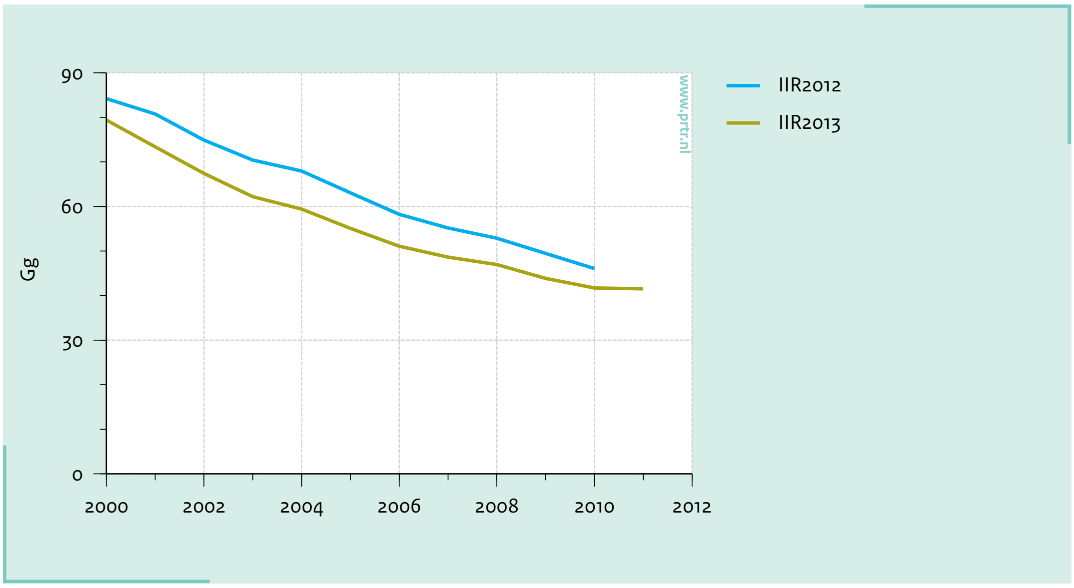
In this year's submission, several recalculations have been done compared to last year's submission.

NO_x emissions of Euro-5 light duty vehicles
The NO_x emissions of diesel passenger cars and light duty trucks in the 2008-2010 period have been recalculated in this year's submission using adjusted emission factors for Euro-5 vehicles. In 2012, measurements on Dutch Euro-5 diesel passenger cars showed that real-world NO_x emissions are higher than initially estimated, particularly on urban roads and on highways (Ligterink *et al*., 2012). The Euro-5 NO_x emission standard for diesel passenger cars is 28% lower than the Euro-4 standard. Previously is was estimated that real-world NO_x emissions of Euro-5 diesel passenger cars and light duty trucks would also be approximately 28% lower than real-world Euro-4 emissions. The real-world measurement showed though that real-world NO_x emissions of Euro-5 cars are actually higher than Euro 4 emissions. Similar conclusions were drawn for Euro-5 light duty trucks. Real-world emission measurements in other countries show similar results for Euro-5 diesel cars (e.g. Weiss *et al*., 2011 & Kousoulidou *et al*., 2013). TNO has used their measurement results to derive new Euro-5 NO_x emissions factor for diesel passenger cars and light duty trucks (Ligterink *et al*., 2012).

Euro-5 diesel passenger cars entered the Dutch market in 2008, although the market share in new vehicle sales was still minimal (1%). In 2009 and 2010, the market share of Euro-5 in new diesel passenger car sales increased to 29% and 71% respectively. Since Euro-5 emission standards for light duty vehicles (class II en III) enter into force a year later than for passenger cars, market penetration of Euro-5 light duty trucks started even later. As a consequence, the share of Euro-5 in the current passenger car and light duty truck fleet is still small. The impact of the adjustments of the Euro 5 NO_x emissions factors therefore was also still relatively small, with NO_x emissions increasing by 1.5 Gg in 2010 compared to last year's submission.

More detailed annual mileages for passenger cars
In this year's submission, emissions from passenger cars were recalculated using more detailed annual mileages derived by Statistics Netherlands. Average annual mileages for passenger cars are estimated by Statistics Netherlands based on odometer readings derived from the NAP database (as described in paragraph 4.3.4). Average annual mileages are reported per fuel type and per age category. In previous years, only one average annual mileage was estimated by Statistics Netherlands for all passenger cars older than 8 years. Since annual mileages decrease with vehicle age, this average was subsequently differentiated further within the Dutch E-PRTR for the different age groups within the 8 years and older group based on expert judgment.
The share of passenger cars 8 years and older in the total number of vehicle kilometres driven by passenger cars in the Netherlands has increased significantly throughout the time series: in early years the share varied between 15 and 20%, whereas in recent years the share in total vehicle kilometres driven was approximately 35 to 40%. The share in emissions is even larger with emissions from new

Figure 4.4 Emissions of NO_x from light duty vehicles (i.e. passenger cars and light duty trucks) in last year's and this year's submission.



vehicle categories dropping significantly due to further tightening of EU emission standard (especially for gasoline and LPG). For recent years of the time series, the age group of 9 years and older contains passenger cars from pre-Euro up until Euro-3. Emissions per vehicle kilometre vary significantly among these vehicles, therefore a more detailed specification of average annual mileages was required.

In 2012 Statistics Netherlands derived detailed average annual mileages for passenger cars. Specific mileages were reported for all ages up until 19 years old (95% of total passenger cars in 2010). For older cars, mileages were reported for 5 year age groups (e.g. 20-24, 25-29 years). The results show a relatively steep drop-off in annual mileages for older passenger cars, especially for gasoline. The average annual mileage of all gasoline passenger cars 8 years and older was 9.300 kilometres in 2010. In previous years, this was the only figure reported by Statistics Netherlands. The more detailed results however show that the average annual mileage decreases from 11.100 kilometres for 9 nine year old cars to 7.000 kilometre for 19 year old cars. After that, annual mileages decrease significantly: the 20-24 year age group has an average annual mileage of 5.700 kilometres and passenger cars 25 years and older drive less than 3.000 kilometres per year.

In previous years, the drop-off in the average annual mileages for older passenger cars was underestimated. As a consequence, the mileages of this age group were overestimated. Even though the share of passenger cars 25 years and older in total vehicle kilometres is small, all gasoline cars in this age group are pre-Euro cars and therefore are not equipped with a three-way-catalyst (TWC). Emissions of NO_x, CO and VOC per vehicle kilometre therefore are substantially higher than for newer passenger cars equipped with a TWC. As a consequence, applying the new detailed mileages for the different age groups led to a decrease in NO_x, CO and VOC emissions from passenger cars. Emission factors for pre-Euro passenger cars were unchanged and are reported in Klein *et al*. (2013).

Figure 4.4 shows the combined NO_x emissions from passenger cars and light duty trucks in the current submission and in last year's submission. NO_x emissions are approximately 10% lower in the current submission compared to last year, except for recent years. In 2009 and 2010 the decrease in NO_x emissions due to the lower annual mileages for older passenger cars is partially compensated by the increase in NO_x emission factors for euro-5 vehicles. NMVOC emissions by light duty vehicles decreased by approximately 20% in recent years of the time series, whereas CO emissions decreased by approximately 10%.

4.3.9 Source-specific planned improvements

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

- Statistics Netherlands will derive new average annual mileages for so-called 'special vehicles', using odometer readings from the NAP register (the same method that is currently applied for passenger cars, light-duty and heavy-duty trucks and buses). Special vehicles are a separate group in the Dutch vehicle fleet statistics that

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
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg
1990	1.61	0.26	0.07	0.10	0.0003	0.06	0.06	0.05	0.22
1995	1.67	0.27	0.08	0.10	0.0003	0.06	0.06	0.06	0.26
2000	2.05	0.32	0.09	0.12	0.0004	0.07	0.07	0.06	0.28
2005	1.93	0.29	0.08	0.11	0.0003	0.07	0.06	0.06	0.27
2010	1.94	0.29	0.08	0.02	0.0003	0.07	0.06	0.06	0.29
2011	1.87	0.28	0.08	0.00	0.0003	0.07	0.06	0.06	0.29
1990 -2011 period [1]	0.25	0.02	0.00	-0.10	0.0000	0.01	0.01	0.01	0.07
1990 -2011 period [2]	16%	7%	5%	-99%	13%	11%	9%	10%	33%

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

contains e.g. garbage trucks, camper vans, tow trucks and fire trucks. Results should be available for next year's submission. Current mileages for special purpose vehicles were estimated in the nineties and have since been unchanged.

- New average annual mileages are also derived for motorcycles and mopeds by Statistics Netherlands, as was announced in last year's IIR. Unfortunately, the NAP register did not contain enough odometer readings to estimate average annual mileages for motorcycles. Therefore it was decided that a survey will be held among motorcycle and moped owners to complement the NAP-data.
- TNO will perform a study on the average load factors for heavy-duty trucks, using data from the Dutch 'Weighing-in-Motion' project. The load factors affect data on fuel consumption and resulting emissions of heavy-duty vehicles.
- 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 that are 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 therefore should also help improve fuel sold estimates of road transport emissions.

4.4 Railways

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 Dutch 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 2011. 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 2011, diesel fuel consumption decreased by 4% (0.06 PJ) to 1.37 PJ compared to 2010.

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, whereas PM_{10} emissions have fluctuated around 0.06 Gg. Pb emissions

have increased by 33% between 1990 and 2011. Pb emissions from railways result from wear of carbon brushes, which are estimated based on total electricity use by railways (in kWh). Trends in Pb emissions therefore follow trends in electricity use.
Emissions of other heavy metals are very low and therefore not shown in the table. SO_2 emissions from railways have decreased by 99% between 2007 and 2011 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. Fuel sales to the railways sector in the Netherlands are reported by Statistics Netherlands 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. In this year's submission, the time series for fuel sales to the railways sector was corrected for the 2006-2009 period, see also paragraph 4.4.8.

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 to be identical to railways. The wear of current collectors has not been included, because no information was available on this topic. Carbon brushes, besides copper, contain 10% lead and 65% carbon. Based on the NS-CTO study, the percentage of particulate matter in the total quantity of wear debris was estimated at 20%. Because of their low weight, these particles probably remain airborne. It is estimated that approximately 65% of the wear debris ends up in the immediate vicinity of the railway, while 5% enters the ditches alongside the railway line (Coenen and Hulskotte, 1998). According to the NS-CTO study, the remainder of the wear debris (10%) does not enter the environment, but attaches itself to the train surface and is captured in the train washing facilities.

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

Since 2010, Statistics Netherlands derives the fuel sales data for railways from Vivens, a recently founded co-operation of rail transport companies that purchases diesel fuel for the railway sector in the Netherlands. Vivens only has fuel sales data available from 2010 onwards. Applying these figures led to an inconsistency in the time-series: diesel fuel sales to the railway sector in the Netherlands in 2010, as reported by Vivens, was 60% (0.5 PJ) higher than diesel fuel sales in 2009, as reported by NS. This increase could only partially be explained by the increase in transport volumes of approximately 15% between 2009 and 2010. It was therefore concluded that fuel sales data to railways had been underestimated between 2006 and 2009. This led to a correction of the fuel sales data to railways in the 2012 Energy Balance. Based on transport volumes for freight and passenger transport by diesel trains, it was assumed that energy use was more or less constant between 2005 and 2008. In 2009, transport volumes decreased by approximately 15% due to the economic crisis. It was assumed that fuel consumption decreased accordingly. From 2010 onwards data from Vivens were used.

Applying the new diesel fuel sales data from the Energy Balance led to an increase of emissions in the 2006-2009 period compared to last year's submission. Fuel sales data increased by 9% in 2006, 12% in 2007, 19% in 2008 and 44% in 2009. Since emission factors are kept constant throughout the time series, emissions increased accordingly.

4.4.9 Source-specific planned improvements

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

4.5 Waterborne navigation and recreational craft

4.5.1 Source-category description

The source category 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 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 10% of total NO_x emissions and 6% of $PM_{2.5}$ emissions in The Netherlands in 2011. 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} (3%), NMVOC (1%), CO (1%) and SO_2 (0.1%) 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 regions. Total NO_x emissions of international maritime shipping on Dutch territory (including the Dutch Continental Shelf) amounted to 112 Gg in 2011, 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 2011.

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

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

	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			
1990	29	8	2.0	2	0.01	1.31	1.31	1.25	0.00	0.00	0.00
1995	25	7	1.8	2	0.01	1.32	1.32	1.25	0.00	0.00	0.00
2000	28	7	1.7	2	0.01	1.31	1.31	1.24	0.00	0.00	0.00
2005	26	6	1.5	2	0.01	1.13	1.13	1.07	0.00	0.00	0.00
2010	25	5	1.3	1	0.01	0.92	0.92	0.87	0.00	0.00	0.00
2011	26	6	1.3	0	0.01	0.91	0.91	0.86	0.00	0.00	0.00
1990 -2011 period 1)	-3	-2	-0.7	-2	0.00	-0.40	-0.40	-0.39	0.00	0.00	0.00
1990 -2011 period 2)	-9%	-29%	-35%	-98%		-30%	-30%	-31%			

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

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 24 PJ in 2010 and 26 PJ in 2011 (see Figure 4.5). 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 25 Gg in 2010 and 26 Gg in 2011. The introduction of emission standards for new ship engines (CCR stage I and II) has led to a 2% decrease in the fleet average NO_x emission factor (per kilogram of fuel) in 2011, but since fuel consumption increased by 8%, total NO_x emissions still increased compared to 2010.

SO_2 emissions from waterborne navigation have decreased by 95% between 2009 and 2011 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 & Hulskotte, 2010). Fleet average PM emission factors decreased by 9% in 2011 compared to 2010. As a consequence, the increase in fuel consumption in 2011 did not lead to increasing $PM_{2.5}$ and PM_{10} emissions in 2011, with emissions remaining at 2010 levels (0.9 Gg).

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 2010 to 2011, resulting in small decreases in emissions. PM_{10}, $PM_{2.5}$ and CO emissions decreased by less than 1%. NMVOC emissions decreased by 8%, whereas NO_x emissions showed a minor increase (0.5%) from 2010 to 2011.

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 2011 transport volumes increased again. The number of GT nautical miles (gross tonnage of the ships times nautical miles travelled) on Dutch territory, including the Dutch part of the North Sea, increased by 13% in 2011 compared to 2010. The number of ships that travelled the Dutch part of the North Sea increased by 9%, but average sailing speeds decreased further by 2% compared to 2010. As a consequence, energy use and resulting CO_2 emissions by maritime shipping in the Netherlands increased by 7% in 2011 compared to 2010 (MARIN & TNO, 2013). NO_x emissions increased by only 2% though due to the IMO emission standards resulting in lower fleet average NO_x emission factors. SO_2 emissions on the Dutch Continental Shelf (DCS) and during manoeuvring in port areas decreased by 26% in 2011 due to the Sulphur Emission Control Area on the North Sea. The maximum sulphur content on the North Sea decreased from 1.5% to 1% in July 2010. SO_2 emissions from ships at berth increased by 4%. The maximum sulphur content for ships at berth in EU ports decreased to 0.1% at the start of 2010. The decrease in sulphur content of the fuels used on the North Sea also led to a 15% decrease in PM emissions from maritime navigation on the DCS in 2011.

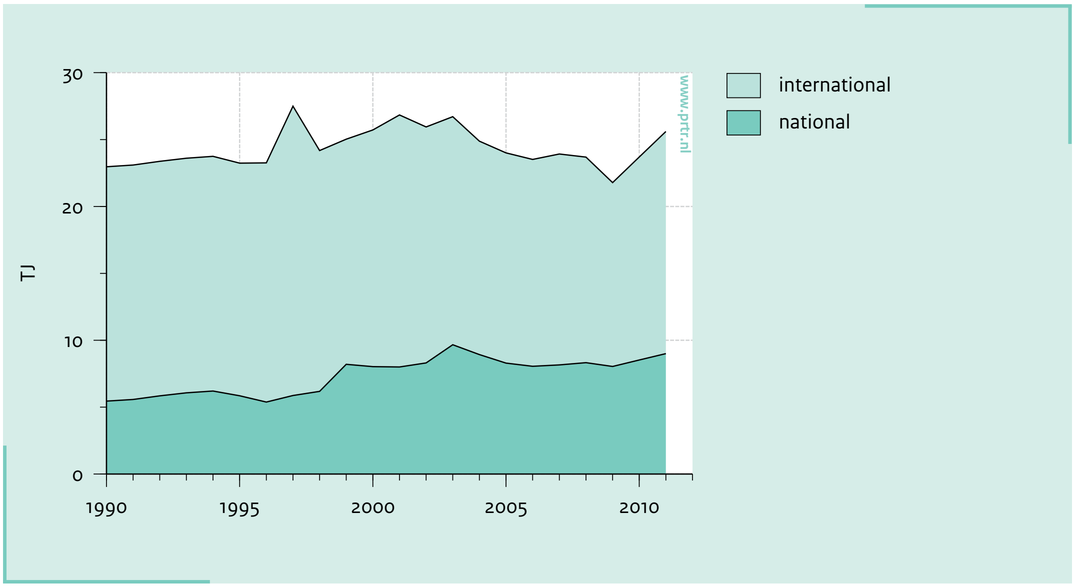
4.5.4 Activity data and (implied) emission factors

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 * 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

Figure 4.5 Fuel consumption in national and international inland shipping in the Netherlands.



year of construction and are reported in Hulskotte & Bolt (2013). Fleet average emission factors are estimated using the distribution of engines in the fleet over the various year-of-construction classes. Due to a lack of data on the actual age distribution of the engines in the inland waterway fleet, a Weibull function is used to estimate the age distribution of the engines. The values of the Weibull parameters (κ and λ) have been derived from a survey, carried out by TNO among 146 vessels. The median age of the engines in the survey was 9.6 years and the average age was 14.9 years. Resulting fleet average emission factors for different years of the time series are reported in Klein *et al*. (2013). The formula used to estimate the effect of lower sulphur content on PM emissions is described in Hulskotte & Bolt (2013).

In the emission calculation for inland shipping, a distinction is made between primary engines intended for propelling the vessel, and auxiliary engines required for manoeuvring the vessel (bow propeller engines) and

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

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*. (2013).

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 & TNO (2013).

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

Emissions of inland navigation in The Netherlands are estimated separately per waterway, taking into account the depth of the waterway and the sailing speeds in relation to the water. The distribution of vessel movements over the Dutch inland waterway network was re-estimated in 2012 using a new model from DVS (Hulskotte & Bolt, 2013). This Bivas model uses vessels passages at different sluices along the waterway network, collected in the IVS90 network, to model the distribution of vessel kilometres over the different waterways in The Netherlands. A modeling approach is required because the IVS90 network does not cover the entire waterway network.
The previous distribution of vessel kilometres over the waterway network was estimated in 2003 during the development of the EMS methodology and has been used for all subsequent years of the time series. The Bivas model was developed for the RWS Centre for Transport and Navigation (DVS) of the Dutch Ministry of Infrastructure and the Environment and became available in 2011. After reviewing the model, TNO concluded that differences between the model results and the old EMS distribution were minor. Since the distribution from the Bivas model uses more up to date data, it was advised to use the Bivas model results for emission calculations for inland navigation from 2005 onwards.

Applying the new distribution led to minor changes in the emission time series. Fuel consumption and resulting emissions decreased by approximately 2-3% for the 2005-2008 period compared to last year's submission. Fuel consumption and associated emissions in 2009 and 2010 actually increased by approximately 7-8% compared to last year's submission. This increase results from using Bivas data combined with new vessel kilometres data from Statistics Netherlands for both years. In last year's submission, preliminary data were used to estimate emissions in 2009 and 2010.

Emissions of maritime navigation have also been recalculated in this year's submission. To estimate fuel consumption and resulting emissions, the installed engine power of the ship is derived from the ship characteristics database of LLI. Until last year, it was assumed that the field containing the installed engine power related to the total installed engine power on the ship. However, last year it was found that in most cases this field contains the power of only one engine. Roughly 20% of ships have multiple engines, especially passenger/roro ships and working vessels (MARIN & TNO, 2013). Emissions from these ships have been underestimated in the past. In the current submission, multi-engine ships are properly taken into account in the emission estimates. This resulted in an increase in energy use by 7% (4 PJ) in 2009 and 2010. Emissions of most substances increased accordingly. NO_x emissions in 2009 and 2010 are 7% (7 Gg) higher than reported last year.

4.5.9 Source-specific planned improvements

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

4.6 Non-road mobile machinery

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 mobile machinery is the use in agriculture and construction. The largest volumes of fuel are used in tillage, harvesting and earthmoving. Furthermore, mobile machinery is used in nature and green maintenance, such as in lawn mowers, aerator machines, forest mowers and leaf blowers.
Emissions from non-road mobile machinery 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 non-road mobile machinery 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 2011 level assessment. The source category 1A4cii 'Agriculture/forestry/fishing: off-road vehicles and other machinery' is a key source for NO_x in both the 2011 level and the trend assessment. The source category 1A4bii 'Residential: household and gardening (mobile)' is a key sources of emissions of CO in both the 2011 level and the trend assessment, whereas the source category 1A4aii 'Commercial/institutional mobile' is a key source of CO in the 1990-2011 trend assessment.

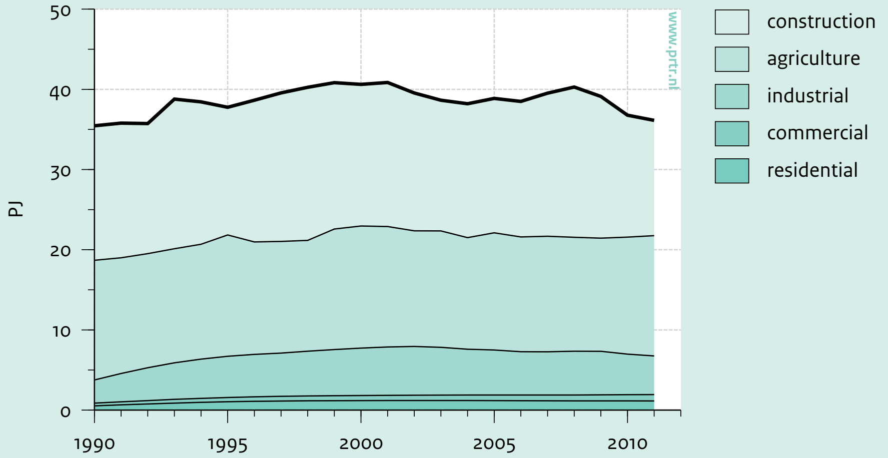
4.6.3 Overview of shares and trends in emissions

Non Road Mobile machinery was responsible for 11% of CO emissions, 8% of NO_x, 7% of $PM_{2.5}$ and 4% of PM_{10} emissions in The Netherlands in 2011. 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 2011.

Total energy use in non-road mobile machinery has fluctuated between 35 PJ and 40 PJ throughout the time series. Energy use in 2011 decreased by 2% compared to 2010, mainly due to the ongoing 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 14.4 in 2011. Figure 4.6 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, with 87% of energy use in 2011 coming from diesel fuel. Gasoline and LPG have a share of 5% and 8% 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 non-road mobile machinery in the Netherlands are shown in Table 4.8. With the introduction of EU emissions standards for non-road mobile machinery in 1999 and the subsequent tightening of the emission standards in later years, NO_x emissions of non-road mobile machinery have steadily decreased, as is shown in Figure 4.7. Since 1999, NO_x emissions have decreased by 48%, whereas fuel consumption has only decreased by 12%. NO_x emissions of gasoline and LPG

Figure 4.6 Fuel consumption in non-road mobile machinery in different sectors in the Netherlands.



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 2011, 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 emissions 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. As a consequence SO_2 emissions have reduced significantly.

4.6.4 Activity data and (implied) emission factors

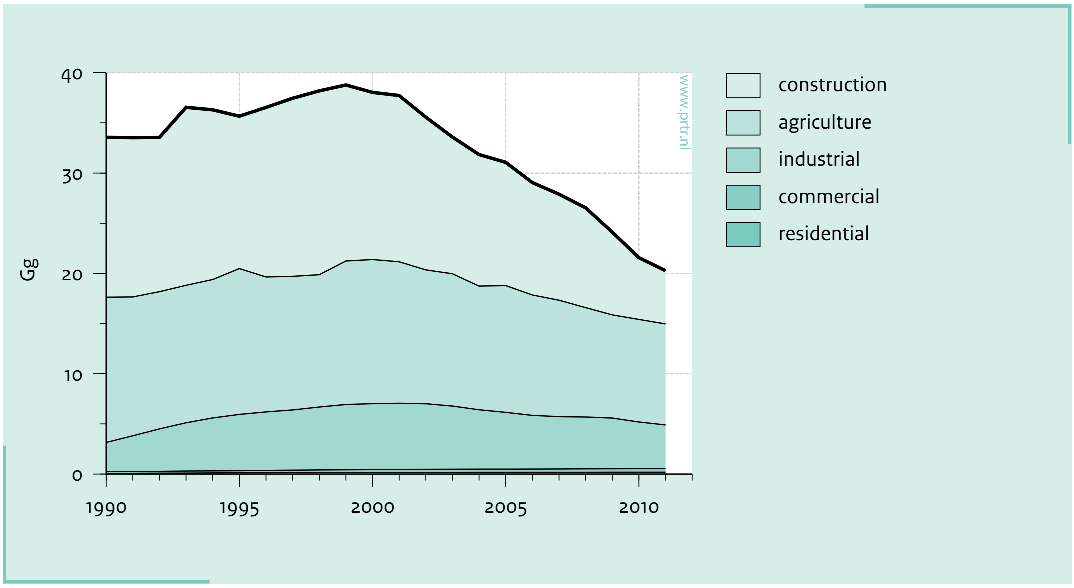
Fuel consumption and emissions from non-road mobile machinery were calculated using a Tier-3 methodology. Energy use and emissions were derived from the EMMA-model (Hulskotte and Verbeek, 2009). This model is based on sales data for different types of mobile machinery and assumptions on the average use (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:

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	20	57	3.8	0	0.01	1.00	1.00	0.95
1990 -2011 period [1]	-13	19	-3.6	-3	0.00	-2.27	-2.27	-2.16
1990 -20101period [2]	-40%	51%	-49%	-99%	-5%	-70%	-70%	-69%

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

Figure 4.7 NO_x emissions in non-road mobile machinery in different sectors in the Netherlands.



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

In which:

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

The TNO report on the EMMA model (Hulskotte and Verbeek, 2009) provides the emission factors of the various technologies and the different stages in the European emission standards. The emission factors are linked to the different machine types per sales year. 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 non-road mobile machinery are therefore rather uncertain.

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

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 2011, 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% in 2011. Fuel consumption by national fishing has been decreasing since 1995, as is shown in Figure 4.8. 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).

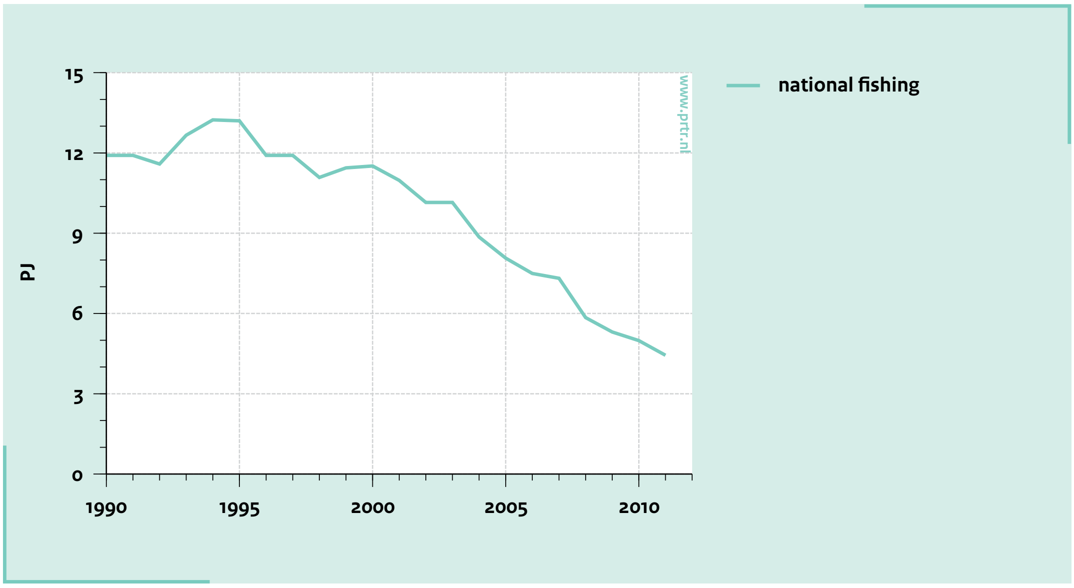
The trends in emissions from national fishing are shown in Table 4.9. Since the same emission factors were used for the entire time series, emissions from national fishing show similar trends to fuel consumption. NO_x emissions decreased from 16.5 to 6.1 Gg between 1990 and 2011, whereas PM_{10} emissions decreased from 0.39 to 0.15 Gg.

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
1990 -2011 period [1]	-10.3	-1.4	-0.5	-1.0	-0.25	-0.25	-0.23
1990 -2011 period [2]	-63%	-63%	-63%	-100%	-63%	-63%	-63%

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

Figure 4.8 Fuel consumption by the fishing fleet in the Netherlands.



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. It is further assumed that the vessels always refuel after completing 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.

5 Industry

5.1 Overview of the sector

Emissions from this sector include all non-energy-related emissions from industrial activities. Emissions from fuel combustion in industrial activities are included in data on the energy sector. Fugitive emissions in the energy sector (i.e. not relating to fuel combustion) are included in NFR sector 1B Fugitive emissions.

The Industrial Processes (NFR 2) sector consists of the following categories:

2A Mineral Industry;
2B Chemical Industry;
2C Metal Industry;
2D Other Production Industry;
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 production and consumption of POPs have been banned in the Netherlands. Emissions from the consumption of heavy metals are considered to be insignificant.

Table 5.1 gives an overview from the emissions from the Industrial Processes (NFR 2) sector.

Table 5.1 Overview of total emissions 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	5.0	52.9	10.0	4.1	44.4	26.2	13.3
1995	3.1	30.4	2.8	3.9	30.0	15.9	8.1
2000	1.8	23.6	1.5	2.7	12.5	7.7	2.9
2005	0.5	17.9	1.0	2.3	13.4	9.1	3.8
2010	0.5	21.4	0.9	1.2	11.6	8.5	3.6
2011	0.7	21.4	1.0	1.1	11.5	8.3	3.0
1990 - 2011 period [2)]	- 4.3	- 31.5	- 9.0	- 3.0	- 33.9	- 18.3	- 10.4
1990 - 2011 period [3)]	- 86%	- 60%	- 90%	- 73%	- 74%	- 69%	- 77%

	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	10.84
1995	66.20	0.62	0.85	29.21	3.76
2000	24.39	0.77	0.39	1.80	0.36
2005	27.22	1.50	0.36	3.91	0.29
2010	31.64 [1)]	0.29	1.81	0.19	0.50
2011	19.17 [1)]	0.33	2.06	0.38	0.19
1990 - 2011 period [2)]	- 47.94	0.05	- 0.72	- 35.92	-10.46
1990 - 2011 period [3)]	- 71%	5%	- 59%	-95%	- 97%

[1)] This is the correct value; value in the NFR is not correct (see also Table 5.3)

[2)] Absolute difference in Gg [3)] Relative difference to 1990 in %

5.1.1 Key sources

Because of increased emission levels of (sub)categories within the Industrial Processes sector or decreased emission levels of (sub)categories in other sectors, the following (sub)categories are from now on a key source in the industrial processes sector:

2B5a Other Chemical Industry for Cd (decreased emission level in other sectors)

2C3 Aluminium Production for PAH (increased emission level)

2C5b Lead Production for Hg (increased emission level)

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

The key sources are discussed in Sections 5.2 to 5.6. Because TSP and Cd time series of most key sources are incomplete they will not be discussed in Sections 5.2 to 5.6. In subsequent submissions, incomplete time series will be repaired, as far as possible.

Methodological issues

Industrial process emissions were based on environmental reports by large industries and if necessary extrapolations to total emissions per NACE category were made, using implied emission factors and production data (method 1) or they were based on environmental reports in combination with specific [emission]factors (method 2).

Method 1 Extrapolation from emission data of individual companies

$$\text{Emission factor ER-I}_{\text{(NACE category)}} = \text{Emissions ER-I}_{\text{(NACE category)}} / \text{Production ER-I}_{\text{(NACE category)}})$$

where

ER-I = Emission Registration database for individual companies

Production ER-I = activity data or proxy for the production process

Subsequently, total process emissions in this NACE

Table 5.2 Key sources of emissions from the Industrial Processes (NFR 2) sector.

Category / Sub-category		Pollutant	Contribution to total in 2011 (%)
2A7d	Other, specified in categories a-c and d further specified	TSP / PM_{10} / $PM_{2.5}$	3.5 / 4.2 / 3.1
2B5a	Other Chemical Industry	NMVOC TSP / PM_{10} / $PM_{2.5}$ Cd	1.8 5.4/3.9/4.1 11.5
2C11	Iron and Steel Production	TSP / PM_{10} / $PM_{2.5}$ Pb Cd Hg	9.2/5.2/6.3 62.2 60.2 52.7
2C3	Aluminium Production	PAH	7.5
2C5b	Lead Production	Hg	6.6
2D2	Food and Drink	NMVOC TSP / PM_{10}	3.5 6.3 / 6.2
2.G	Other production, Consumption, storage, transportation or handling of bulk products	NMVOC TSP / PM_{10} / $PM_{2.5}$	8.3 5.7 / 6.9 / 4.5

category were calculated from the production data, as provided in the Production Statistics (Statistics Netherlands). multiplied by the implied emission factor.

$$\text{ER-I Emission}_{\text{(NACE category)}} = \text{Emission factor ER-I}_{\text{(NACE category)}} * \text{Production}_{\text{(NACE category)}}$$

Note: Companies do not provide specific information to the PRTR on their measurement systems or emission model, or on which emission factors were used in the calculation model. Therefore, in some cases, the PRTR could not use the data from the environmental reports in the extrapolation to the total emissions from a sector.

Method 2 Sources without (complete) individual registration

Besides the data from the environmental reports a set of specific [emission] factors was used for the calculation of emissions, such as PAHs from 2C1 and 2C3. These [emission] factors were obtained from specific studies.

5.1.2 Uncertainties and time-series consistency

No accurate information was available for assessing the uncertainties about the emissions from the sources of this sector. Consistent methodologies – except for TSP and Cd – were used throughout the time series for the sources in this sector.

5.1.3 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.

5.1.4 Source-specific recalculations

No recalculations have been done in this submission.

5.1.5 Source-specific planned improvements

At this moment the 2G Category in the Dutch PRTR also includes emissions from the storage and handling of bulk products. In next submission the emissions from the storage and handling of bulk products will be reallocated. Furthermore incomplete TSP and Cd time series will be repaired, as far as possible, in subsequent 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) have been included in food and drink process emissions (2D2); those from asphalt roofing (2A5) and road paving with asphalt (2A6) have not been estimated, since no activity data was available.
Because of allocation problems, total emissions from mineral products (2A) have been reported in other mineral production (2A7d). Only emissions from cement production (2A1) could be reported separately because emissions in this category were derived from the environmental reports by the corresponding companies.

5.2.2 Key sources

Other mineral production (2A7d) has been identified as key sources for PM_{10} and $PM_{2.5}$.

5.2.3 Overview of emission shares and trends

From 1990 to 2011, PM_{10} emissions from 2A7d decreased from 2.6 Gg to 1.2 Gg and $PM_{2.5}$ emissions decreased from 1.5 Gg to 0.4 Gg. These reductions were mainly caused by the implementation of technical measures.

5.2.4 Emissions, Activity data and (implied) emission factors

The emissions were obtained from the environmental reports by the companies of these key sources.

5.2.5 Methodological issues

Method 1 was used for estimating the emissions from 2A7d.

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 (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 CO2 and N2O have been reported there). Because of allocation problems, all emissions from the chemical industry (2B) have been reported in category Other Chemical Industry (2B5a).

5.3.2 Key sources

Category 2B5a was identified as a key source for NMVOC, TSP, PM_{10}, $PM_{2.5}$ and Cd.

5.3.3 Overview of emission shares and trends

From 1990 to 2011, NMVOC emissions decreased from 9.7 Gg to 2.6 Gg and PM_{10} emissions from 4.1 Gg to 1.1 Gg. These reductions were mainly caused by the implementation of technical measures.

5.3.4 Emissions. Activity data and (implied emission factors

The emissions were obtained from the environmental reports by the above mentioned plants.

5.3.5 Methodological issues

Method 1 was used for estimating the emissions of 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;

Table 5.3 Overview of emissions from 2C1.

Pollutant	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
PM_{10}	Gg	9.32	5.57	2.09	1.92	1.75	1.85	1.88	1.72	1.71	1.81	1.58	1.46	1.53	1.48
$PM_{2.5}$	Gg	5.75	3.29	1.16	1.04	0.94	0.98	0.99	0.94	0.96	1.02	0.86	0.80	0.84	0.89
Pb	Mg	55.75	60.10	18.84	23.01	26.93	24.65	25.42	22.95	22.39	28.84	23.50	24.53	29.99	17.62
Cd	Mg	0.69	0.46	0.41	0.63	0.92	0.71	0.69	0.66	0.69	0.91	0.73	0.69	0.83	0.67
Hg	Mg	0.39	0.35	0.09	0.12	0.12	0.12	0.21	0.21	0.20	0.28	0.29	0.27	0.31	0.43
DIOX	g I-Teq	23.00	26.50	1.75	1.47	2.10	1.74	1.87	1.50[1)]	1.91	2.25	2.26	2.04	1.81	2.06
PAH	Mg	1.79	1.91	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.12	0.20	0.06	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 2C3.

Pollutant	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
PAH	Mg	6.91	1.66	0.13	0.16	0.13	0.07	1.54	0.13	0.04	0.54	0.71	0.44	0.11	0.29

2C5d Zinc production;
2C5e Other metal production;
2C5f Storage, handling and transport of metal products.

It is assumed that emissions from the storage and handling of companies with other main activities are included in the relevant categories of this NFR-sector.

5.4.2 Key sources

The Iron and Steel Production (2C1) category describes key sources for TSP, PM_{10}, $PM_{2.5}$, Pb, Cd and Hg, Aluminium Production (2C3) for PAH and Lead Production (2C5b) for 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 ores into steel by means of sintering, producing pig iron in blast furnaces and converting pig iron to steel in basic oxygen furnaces. The energy-related emissions are included in combustion emissions (1A) and the fugitive emissions in 1B.
Table 5.3 gives an overview of the process emissions of iron and steel production (2C1).

Besides TSP, PM_{10}, $PM_{2.5}$, Pb, Cd and Hg (the key-source pollutants) this source is also responsible for 6,6% of the total dioxines and for 2.2% of the total PAH emissions in the Netherlands. Most of the emissions from this source decreased during the 1990–2000 period. These reductions were mainly caused by the implementation of technical measures. During the period 2000-2010 emissions have remained rather stable. Because of the replacement of Electrostatic filters and optimization of some other reduction technologies at Tata Steel, the Pb and Cd emission decreased in 2011.

Aluminum Production (2C3)

Aluminum Production (2C3) is responsible for 7.5% of the total PAH emissions in the Netherlands. In the Netherlands, anodes are produced in two plants and primary aluminium is produced at two primary aluminium smelters. All the companies report their emissions in AERs. Table 5.4 gives an overview of the PAH emissions from Aluminium Production (2C3).

PAH emissions originate from 'Producing anodes' and the 'Use of anodes' during primary aluminium production. Emission fluctuations have mainly been caused by the varying process conditions combined with a measurement inaccuracy of 43% in the 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.

Lead production (2C5b)

Due to an increased emission level, Lead Production is a key source for Hg this submission. The Hg emission during the production of lead strongly depends on the contamination of the raw material.

5.4.4 Emissions. Activity data and (implied) emission factors

Part of the PAH emissions were obtained from the environmental reports by the above mentioned plants.

5.4.5 Methodological issues

Method 1 was used for estimating the emissions –except PAH emissions- from 2C1, 2C3 and 2c5b. Method 2 was used for estimating the PAH emissions from 2C1 and 2C3.

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 Category.

5.5.2 Key sources

2D2 Food and Drink 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 PM_{10} emissions from 4 to 2 Gg. These reductions were mainly caused by the implementation of technical measures.

5.5.4 Emissions. Activity data and (implied) emission factors

NMVOC and PM emissions in this category were derived from the environmental reports by the companies and completed with calculations using implied emission factors and production data.

5.5.5 Methodological issues

Method 1 was used for estimating the emissions of this key source.

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

The 2G Category in the Dutch PRTR includes emissions from the storage and handling
of bulk products and a lot of other different activities. Only companies with storage and handling of bulk products as main activity are included in the 2G Category. It is assumed that emissions from the storage and handling of companies with other main activities are included in the relevant other categories of this NFR-sector.

5.6.1 Key sources

2G, Other production, consumption, storage, transportation or handling of bulk products 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 2011 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. The PM_{10} emissions decreased from 5 Gg to 2.1 Gg during the period 1990-2011. The contribution of storage and handling was 1.5 Gg in 1990 and 0.9 Gg in 2011. The reductions of the NMVOC and PM_{10} emissions were mainly caused by the implementation of technical measures.

5.6.3 Emissions. Activity data and (implied) emission factors

NMVOC and PM emissions in this category were derived from the environmental reports by the companies and completed with calculations using implied emission factors and production data.

5.6.4 Methodological issues

Method 1 was used for estimating the emissions of this key source.

6
Solvents and product use

6.1 Overview of the sector

Emissions from this sector include emissions 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.

Emissions from Chemical products, manufacture and processing (3C) have been included in Chemical Industry (2B).

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

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

	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	0.35	25.0	2.48
1995	110.5	1.04	1.03	1.03	0.34	23.0	1.05
2000	79.5	1.06	1.21	1.21	0.40	20.0	0.06
2005	61.5	1.11	1.14	1.14	0.38	18.0	0.05
2010	54.0	1.08	1.20	1.20	0.40	15.0	0.04
2011	53.5	1.09	1.21	1.21	0.40	14.5	0.04
1990 -2011 period [1)]	- 79.9	0.10	0.16	0.16	0.05	- 10.5	- 2.45
1990 -2011 period [2)]	- 60%	11%	15%	15%	15%	- 42%	- 99%

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

6.1.1 Key sources

Due to a decreased emission level of 3A1, Decorative coating application, the following changes were made in the key source list of the Solvents and product use (NFR 3) sector:

- 3A1, Decorative coating application is no longer a key source for NMVOC emissions;
- 3B1, Degreasing has been added as key source for NMVOC.

The key sources in this sector are presented in Table 6.2

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

Category / Sub-category	Pollutant	Contribution to total in 2011 (%)
3 A 2 Industrial coating application	NMVOC	11.1
3B1 Degreasing	NMVOC	2.0
3D1 Printing	NMVOC	2.5
3D2 Domestic solvent use including fungicides	NMVOC	13.3
3D3 Other product use.	NMVOC TSP / PM_{10} / $PM_{2.5}$ DIOX	6.3 3.5 / 4.2 / 2.9 46.3

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 Section 1.6.2.

6.1.3 Source-specific recalculations

There were no source-specific recalculations 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 gives an overview of total paint consumption in the Netherlands and NMVOC contents and shows a decrease in the NMVOC content of 30% in 1990 to almost 10% in 2006. After 2006 the NMVOC content remained rather stable.

Table 6.3 Overview Total Paint Consumption in the Netherlands and the NMVOC contents.

Jaar	Total Paint Consumption (Gg)	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	196	10.3
2011	192	10.2

6.2.2 Key sources

Industrial Coating application (3A2) has been identified as a key source for NMVOC.

6.2.3 Overview of shares and trends in emissions

Mainly due to the lower average NMVOC content of the used paint (see Table 6.3) NMVOC emissions from industrial paint use decreased from 71 Gg in 1990 to 18 Gg in 2008. As a result of the credit crunch, paint consumption decreased during the period 2009-2011.
Therefore, NMVOC emissions decreased to 16 Gg in 2011.

6.2.4 Emissions, Activity data and (implied) emission factors

In the paint application sector, annual statistics on sales are provided by the Dutch branch organization for paint producers (VVVF).

6.2.5 Methodological issues

NMVOC emissions from paint use were calculated from annual national paint sales statistics (on paint that is both produced and sold in the Netherlands), provided by the Netherlands Association of Paint Producers (VVVF) and from paint imports, estimated by VVVF. The VVVF (through its members) directly monitors NMVOC in paints, while an assumption of the VVVF is used for the NMVOC in imported paints. Estimates have also been made for paint-related thinner use and the (reduction) effect of afterburners. For more information, see methodology report ENINA (ER, 2013: in preparation).

6.3 Other solvents use (3D)

6.3.1 Source-category description

The category Other solvents 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

The categories Printing (3D1), Domestic solvent use (3D2) and Other product use (3D3) have been identified as key sources of NMVOC. Other product use (3D3) is also a key source for dioxin.

6.3.3 Overview of emission shares and trends

Printing (3D1)
NMVOC emissions decreased from 14.4 Gg in 1990 to 4.2 Gg in 2008. These reductions were mainly caused by the implementation of technical measures (afterburners). As a result of the credit crunch, the production level decreased during the 2009-2011 period. Consequently, emissions of printing decreased to 3.5 Gg in 2011.

Domestic solvent use including fungicides (3D2)
The most important sources are Cosmetics (and personal care), Cleaning agents and Car products. The NMVOC emissions increased from 11 Gg in 1990 to 19 Gg in 2011. This was caused by the increased consumption of Cosmetics, Cleaning agents and Car products during the period 1990–2011.

Other product use (3D3)
The most important NMVOC sources are Cleaning agents and Refrigerants. NMVOC emissions decreased from 15 Gg in 1990 to 9 Gg in 2011. These reductions were mainly caused by the lower average NMVOC content of the cleaning agents.
Dioxin emissions originate from PCP treated wood. Because PCP was banned in 1989, a linear reduction in dioxin emissions has been assumed. This has resulted in an emission reduction from about 25 g I-TEQ in 1990 to about 14.5 g I-TEQ in 2011.

6.3.4 Emissions, Activity data and (implied) emission factors

Printing (3D1)
Up to 2008 (2007 emissions) the Dutch Government had an agreement with the printing industry from which data became available for the emission inventory. For the period 2008-2011 the emissions were calculated using the

production index of the printing industry.

Domestic solvent use including fungicides (3D2) and Other product use (3D3)
Sales data were obtained from annual reports of branch organizations and the NMVOC content of the products, while the fraction of the NMVOC contents that is emitted to the air comes from studies.

Other product use (3D3)
Dioxin emissions by wooden house frames are determined for 1990 based on Bremmer et al. (1993). Because PCP was banned in 1989, a linear reduction of dioxin emission has been assumed.

6.3.5 Methodological issues

Printing (3D1)
See Emissions, Activity data and (implied) emission factors.

Domestic solvent use including fungicides (3D2) and Other product use (3D3)
Total NMVOC emissions per product were calculated by multiplying the NMVOC emissions per product by the number of sold products. NMVOC emissions per product were calculated by multiplying the fraction of the NMVOC contents that is emitted to the air by the content of the product.

Other product use (3D3)
See Section 6.3.3.

7 Agriculture

7.1 Overview of the sector

Included in this sector are data on all the 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 source category 1A4c 'Agriculture/Forestry/ Fishing: Stationary'.

The agricultural sector consists of the following categories:
- 4B Manure management;
- 4D Agricultural soils;
- 4F Field burning of agricultural residues;
- 4G Other.

In the Netherlands no emissions are being allocated towards category 4G and as field burning is prohibited by law, activities belonging to the category 4F are negligible in actual practice. Emissions of the greenhouse gases nitrous oxide (N_2O) and methane (CH_4) are being reported on in the National Inventory Report (NIR). Therefore, this Informative Inventory Report (IIR) focuses on ammonia (NH_3), nitrogen oxides (NO_x) and particulate matter (PM) emissions from the source categories 4B and 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 major source of NH_3 and animal housing a large source of PM_{10}.

7.1.1 Key sources

Dairy cattle (4B1a) are the biggest key source of NH_3, followed by swine (4B8) and non-dairy cattle (4B1b). Synthetic N fertilizers (4D1a) and laying hens (4B9a) have also been identified as key sources for NH_3.

Laying hens (4B9a), broilers (4B9b) and swine (4B8) are key sources for both PM_{10} and TSP emissions.

7.1.2 Trends

NH_3 emissions have decreased sharply between 1990 and 2011 as the result of policy changes, with a significant reduction in the first few years of the time series. Already in 1991, it became mandatory to inject manure into the soil instead of surface spreading. This prevented NH_3 emissions following application of animal manure to a large extent. Maximum application standards for manure and synthetic fertilizer, and systems of production rights have further decreased emissions. Where productions per head have increased over the years, generally animal numbers thus show a decreasing trend (in recent years animal numbers are again slightly on the increase). The on-going improvement in diets, leading to lower N excretions per animal has also contributed significantly. Since national total is dominated by emissions from agriculture, this leads to high trend contributions from these categories and thus to an overall decreasing trend in the emission of NH_3.

Although PM emissions in most (animal) categories decreased slightly over the 1990 - 2010 period with falling animal numbers, they 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. Overall, this has led to higher PM emissions with a small increase from 2010 to 2011.

7.2 Manure management

7.2.1 Source category description

This source comprises emissions from handling and storage of animal manure. Within the category manure management, the following subcategories are distinguished:

- 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 livestock.

Animals in the category 4B5 do not occur in the Netherlands. Animal numbers in the categories 4B2, 4B7 and 4B9d are small, and therefore not estimated. Under category 4B13 Other livestock, rabbits and fur bearing animals are being reported.

7.2.2 Key sources

Dairy cattle (4B1a) are the largest contributors to NH_3 emissions, at 30.0% of the national total. Swine (4B8) and non-dairy cattle (4B1b) are key sources that contribute for 16.7% and 14.9%, respectively. Laying hens (4B9a; 7.7%) also are a key source for NH_3 within the manure management category.

At 9.9% laying hens (4B9a) are the largest source of national total PM_{10} emissions, and also form an important source of TSP by adding 8.2%. Broilers (4B9b) are responsible for 4.7% of the emissions of PM_{10} and 3.9% of TSP. Swine (4B8) contribute 4.2% and 3.5% respectively, and are key source too.

7.2.3 Overview of emission shares and trends

Table 7.1 presents an overview of emissions of the main pollutants NO_x and NH_3, together with the 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	109	4.69	4.69	0.42
2010	6.8	97	5.29	5.29	0.45
2011	7.1	92	5.72	5.72	0.46
1990-2011 period [1]	-0.9	-229	1.84	1.84	0.06
1990-2011 period [2]	-11%	-71%	47%	47%	14%

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

Between 1990 and 2010 NH_3 emissions have reduced by 71%, with already a sharp decrease in 1995. Different from the reporting category in the NIR (4D), emissions resulting from the application of animal manure are reported in category 4B. Therefore the initial decrease in emissions was mainly the result of changes in application methods (i.e. incorporation into soil instead of surface spreading). Higher productions per animal and quotas have resulted in a decreasing trend in animal numbers, even though in recent years a slight increase is seen. An on-going decrease in N-excretions per animal due to dietary improvements however more than counteracts the effect.

Since NO_x emissions from agriculture form a new source that was not accounted for in the National Emission Ceiling (NEC), most of these emissions are reported as memo item under other natural emissions (11C). Only emissions from manure management itself (stable and storage) have been included here, as these are deemed non-natural. NO_x resulting from the application of manure and synthetic fertilizer are considered to be related to land use and thus not reported under this category.

Table 7.2 Animal numbers 1990-2011 (in 1,000 heads).

Animal type	1990	1995	2000	2005	2010	2011
Cattle	4926	4654	4070	3799	3975	3885
- Adult dairy cattle	1878	1708	1,504	1,433	1479	1470
- Adult non-dairy cattle	120	146	163	152	115	105
- Young Cattle	2929	2800	2403	2214	2381	2311
Sheep	1702	1674	1308	1363	1130	1088
Goats	61	76	179	292	353	380
Horses[1]	370	400	418	433	441	436
Pigs (*1000)	13.9	14.4	13.1	11.3	12.3	12.4
Poultry (*1000)	94.9	91.6	106.5	95.2	103.4	98.9
Other animals	659	527	641	745	1001	1016

[1] including privately owned horses; 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	Change 2011 - 1990 (%)
Nitrogen fertilizer consumption	412.4	405.8	339.5	279.2	219.5	214.1	-48
Nitrogen excretion by animals	710.4	696.0	565.2	494.9	504.6	492.2	-31
Nitrogen excretion in animal houses	514.5	516.1	432.6	393.7	423.3	423.2	-18
- of which in solid form	102.1	104.3	94.8	88.4	96.5	93.8	-8
- of which in liquid form	412.4	411.8	337.7	305.2	326.8	329.4	-20
Nitrogen in manure exported abroad/incinerated	5.9	22.4	17.9	26.2	36.1	36.6	525
Available manure for application	410.3	399.8	336.3	299.0	293.4	289.5	-29
(N-excretion in animal houses - total N-emissions in animal houses - export)							
Nitrogen excretion on pasture	195.9	179.9	132.5	101.2	81.3	68.9	-65
Nitrogen in sewage sludge on agric. land	5.0	1.5	1.5	1.2	0.9	0.9	-82
Total nitrogen supply to soil	1121.9	1080.9	888.2	749.1	688.8	670.6	-40
(manure + fertilizer + sewage sludge - export)							
N_2O-N emission fertilizer application	5.4	5.3	4.4	3.6	2.9	2.8	-48
N_2O-N emission animal houses	2.4	2.4	2.1	1.9	2.1	2.2	-11
N_2O-N emission manure application	1.6	3.5	2.9	2.6	2.5	2.5	53
N_2O-N emission pasture	6.5	5.9	4.4	3.3	2.7	2.3	-65
N_2O-N emission sewage sludge	0.1	0.0	0.0	0.0	0.0	0.0	-82

7.2.4 Activity data and (implied) emission factors

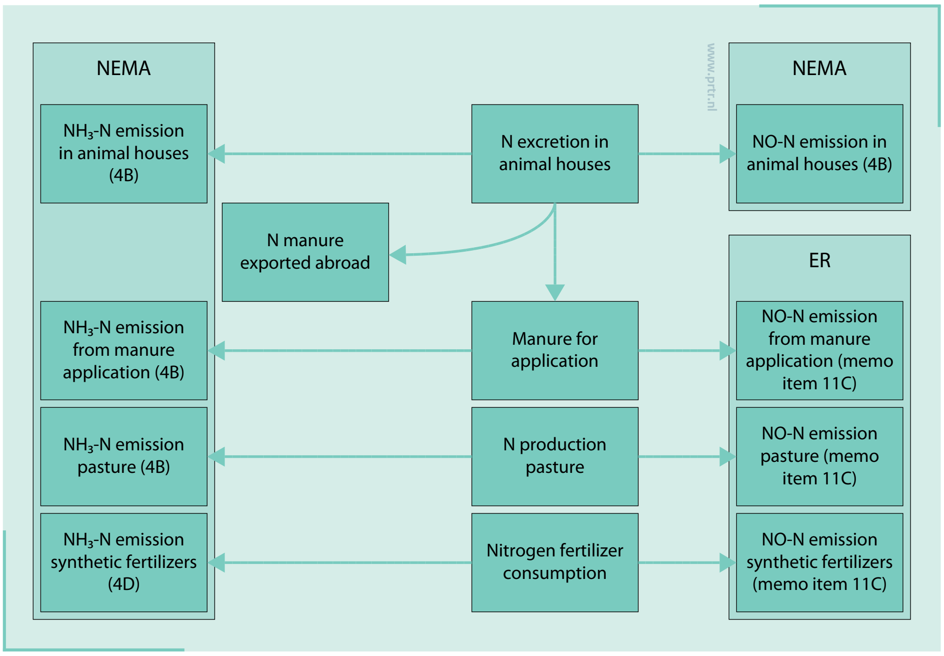
NH_3 and NO_x emissions from animal manure management were calculated using the National Emission Model for Ammonia (NEMA), managed by Statistics Netherlands (CBS). Input data included animal numbers as determined by the annual agricultural census (see Table 7.2), and the N-excretions per animal calculated annually by the Working group for Uniform calculations of Manure and mineral data (WUM).

For horses an estimation of 300,000 extra heads is taken up in the inventory, to account for privately owned animals. Emissions of NH_3 and PM from manure management are reported under 7A Other, but included in the N-flows presented here.

A distribution was made of animals over the various housing types, and corresponding emission factors were applied for NH_3, N_2O, NO_x and N_2 (Van Bruggen *et al.*, 2011). For N_2O the 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, processed or exported, the remaining amount

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



was allocated to pasture and arable land. Given implementation grades of application techniques and associated emission factors, this results in the NH_3 that is being emitted. Because NEMA focuses on NH_3, it ends calculations here and does not assess the NO_x emission during application. This amount has been calculated additionally through the Emission Registration (ER) using EMEP defaults. Subtraction of these emissions leaves the resulting N to soil, as input for category 4D 'Agricultural soils'. Figure 7.1 presents a schematic overview of NH_3 and NO_x emissions, including calculation method and their allocation. In table 7.3 a summary of associated N-flows is given for the 1990-2011 period within the inventory.

While synthetic fertilizer use and N-excretion by animals decreased considerably in the 1990-2011 period, export of manure increased by a factor five. These developments result in less nitrogen (N) being supplied to soils and therefore overall lower emissions. For manure application, incorporation into the soil is mandatory since the early 90's, leading to much lower NH_3 emissions. On the other hand, N_2O emissions from manure application have increased, because the emission factor is higher in comparison to surface spreading.

Particulate emissions from agriculture mainly originate from skin, manure, feed and bedding particles ventilated from animal housing. 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 through www.asg.wur.nl). Animal housing types not included were given a factor proportional to those used before. Where factors had to be derived within animal categories (e.g. laying hens under and over 18 weeks of age), this was done based on their respective P-excretions.

7.2.5 Methodological issues

Emissions of NH_3 and NO_x from animal manure, from stables and storage, as well as NH_3 during application, were calculated using NEMA. Total ammonia nitrogen in manure (TAN) was assessed, depending on faecal digestibility of nitrogen in rations, taking into account organic N-mineralisation and excretion in the meadow. From this, NH_3 emissions were calculated following the method described in Velthof *et al.* (2009).

Inputs for the model have been divided into general (activity data, i.e. animal numbers) and specific inputs; the latter concerned excretions of nitrogen and phosphate from different animal categories. Also considered were the ammonia volatilization rates from animal housing systems and from soil application systems for animal manure. The average nitrogen excretion per animal category is calculated annually as the difference between absorbed nitrogen from feeding and that captured in animal products. This 'balance' method takes into account annual changes, such as those in food consumption and food nitrogen content.

The excreted nitrogen partly volatilizes as ammonia in animal houses, on pasture, during storage and application to soil, taking into account the share of housing and manure application systems with a low ammonia volatilization rate. The volatilization 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 manure-air exposure area and the exposure time.

The main sources of PM emissions from agriculture are animal housing systems. Other small sources include applications of synthetic fertilizer and pesticides, the supply of concentrates, haymaking and harvesting of arable crops, to be reported under category 4D. 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 Section 7.2.4).

7.2.6 Uncertainties and time-series consistency

In the 2011 submission, the NEMA model was used for the first time. With insufficient data being available to assess the uncertainty of the calculations, this analysis was scheduled for a later submission. As uncertainty estimates for source data were also outdated, these needed to be assessed first and have now been published (CBS, 2012). Although work on uncertainty of calculations itself has been started, priority was given to the greenhouse gas emissions and is not yet completed.

As annual censuses have been conducted in the same way for many years (decades even) and the same calculations were used for the whole series, the consistency of time-series is very good. Additionally, it is assumed that policies and legislation for clean housing, manure storage and application are completely implemented and enforced. If the enforcement and implementation is only partial, emissions could amount higher.

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

In 2010, the definition of farms for inclusion in the agricultural census has changed. Before 2010, the lower limit was 3 Dutch size units (NGE) and this is now 3,000 Standard Output (SO). As the influence on population is minimal, official statistics have not been recalculated and therefore the inventory does not reflect this change either.

7.2.9 Source-specific planned improvements

At present the inventory only includes NO_x emissions from stable and storage within the agricultural sector. NO_x emissions from the application of animal manure and manure produced in the meadow have also been assessed, but are reported as memo-item under natural emissions (11C). This is to be reconsidered as soon as emission ceilings account for this new source.

An uncertainty analysis of NH_3 emissions calculated by NEMA is foreseen for the next submission.

7.3 Agricultural soils

7.3.1 Source category description

This source consists of all emissions related to the agricultural use of land. For this submission, the following categories are of relevance:
- 4D1a Synthetic N fertilizers;
- 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;
- 4F Field burning of agricultural wastes;
- 4G Agriculture other.

Within the category 4D1a, emissions of NH_3 from the application of synthetic fertilizers are included. Other than in the NIR, emissions from the application of animal manure and from production during grazing are not reported under category 4D but under 4B Manure Management. 4D2a contains PM emissions resulting from synthetic fertilizer and pesticide use, supply of concentrates, haymaking and harvesting of crops. Emissions from categories 4D2b and 4D2c are small and therefore not estimated. Activities included in categories 4F and 4G were not occurring in the Netherlands.

7.3.2 Key sources

Synthetic N fertilizers (4D1a) are a key source of NH_3 emissions, at 8.7% of the national total.

Table 7.4 Emissions of main pollutants and particulate matter from category 4D Agricultural soils.

	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	10.0	0.76	0.76	0.11
2011	10.3	0.75	0.75	0.11
1990-2011 period [1]	-3.6	-0.01	-0.01	0.00
1990-2011 period [2]	-26%	-2%	-2%	-1%

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

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 $PM_{2.5}$ originating from this category.

Data presented for NH_3 solely reflects emissions caused by synthetic fertilizer use, which have decreased over the years following policy measures. For particulate matter, use of pesticides and the harvesting of crops also contribute to emissions.

Since NO_x emissions from agricultural soils are not accounted for in the NEC, they have been reported as a memo item under 11C Other natural emissions. NO_x from synthetic fertilizer is also included in that category (see also Section 7.2.3).

7.3.4 Activity data and (implied) emission factors

Ammonia emissions from synthetic fertilizer were calculated using data on the amount of sold nitrogen fertilizer, corrected for usage outside agriculture. Several types of nitrogen fertilizer – each with their own specific ammonia emission factor – were distinguished. These emission factors were used in NEMA for calculating NH_3 emissions from synthetic fertilizers. Within the ER calculations the associated NO_x and PM emissions were assessed, using EMEP default emission factors for the former, and fixed annual amounts for the latter. These fixed amounts, together with PM from other agricultural processes, such as the use of concentrates and pesticides, are only minor sources.

7.3.5 Methodological issues

Emissions of NH_3 caused by synthetic fertilizer use were calculated in the NEMA model, see Section 7.2.5 for a general description. More specifically, activity data and emission factors related to synthetic fertilizer use are discussed in the previous section.

7.3.6 Uncertainties and time-series consistency

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

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, 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

From 2010 on definition of farms for inclusion in the agricultural census has changed. Before the lower limit was 3 Dutch size units (NGE) and this is now 3,000 Standard Output (SO). As influence on population is very slight, official statistics have not been recalculated and therefore inventory does not reflect this change either.

7.3.9 Planned improvements

NO_x emissions from the application of synthetic fertilizer have currently been reported under natural emissions. This will be reconsidered as soon as emission ceilings account for this new source.

An uncertainty analysis of NH_3 emissions calculated by NEMA is foreseen for the next submission.

8 Waste

8.1 Overview of the sector

Emissions in the Waste sector include emissions 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 (6A)
Emission from this source category comprises emissions from landfills and emissions from extracted landfill gas. Since extracted landfill gas is mostly used for energy purposes these emissions are included in de sector Energy (source category Other stationary; 1A5a).

Waste-water handling (6B)
The emissions of industrial en urban Waste water treatment plants (WWTP) come from the annual environmental reports of the individual treatment plants/ companies. WWPT's produce amongst others methane. This methane is captured for approximately 80% and used in energy production or becomes flared. For this reason the emissions from WWPT's are reported under the source category Commercial/Institutional stationary (1A4ai).

Waste incineration (6C)
Sources from this category comprise emissions from urban and industrial waste incineration and emissions from crematoria. Since all waste incineration plants in the Netherlands produce electricity and/or heat used for energetic purposes, the emissions from the source category Waste incineration (category 6C) are therefore included in the sector Energy; source category Public electricity and heat production (1A1a).
NO_x and SO_x emissions from cremations (6Cd) originate mainly from fuel use (natural gas). For this reason, the emissions of NO_x and SO_x from this source have been included in the source category Commercial/institutional: Stationary (1A4ai).

Other waste (6D)
The emissions from the source sector Other waste comprises emissions from the sources 'Decontamination and other waste management', 'Industrial composting', 'Waste preparation for recycling' and 'Scrap fridges/ freezers'.

Table 8.1 Overview of total emissions in the Waste sector (NFR 6).

Year	Main Pollutants		Particulate Matter			Heavy Metals/POPs	
	NMVOC	NH_3*	TSP	PM_{10}	$PM_{2.5}$	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	0.012	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
2009	0.6	0.21	0.003	0.003	0.003	0.05	0.09
2010	0.5	0.22	0.007	0.002	0.002	0.04	0.06
2011	1.5	0.00	0.006	0.006	0.006	0.06	0.00
1990 -2011 period [1]	-1.0	0.21	0.001	-0.004	-0.004	-0.02	0.06
1990 -2011 period [2]	-65%	4535%	15%	-68%	-68%	-32%	

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

8.1.1 Key sources

There are no relevant key sources in the sector Waste.

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 were 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 Waste incineration

8.2.1 Source-category description

This source category Waste incineration comprises emissions from the 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 (6Ca) and industrial waste incineration (6Cb) have been included in municipal waste incineration (6Cc). In the Netherlands heat coming from waste incineration is used to produce electricity and for heat production. For this reason, the source category is reported under the sector Energy (source category Public electricity and heat production; 1A1a).
Because of a ban on small-scale waste burning (6Ce), this emission source does not occur in the Netherlands.

8.2.2 Key sources

Until 2010, cremations were a relevant key source for Hg. In 2011, almost all cremation centres are equipped with technological measures to reduce emissions. As a result, cremations are not a key source anymore.

8.2.3 Overview of shares and trends in emissions

The emissions in this source category are relative small, so it seems not relevant to elaborated on shares and trends in emissions.

8.2.4 Emissions, Activity data and (implied) emission factors

For calculation of the emission of cremations, activity data are obtained from branch reports. The average amalgam content is not constant in time. Due to better dental care, the amount of amalgam in corpses becomes higher in time. The emission factors were calculated based on an inventory of sold amalgam combined with a calculation model (Hoekstra, 1997). The used emission factors for the years 1995, 2000, 2002 and 2010 were 1.15, 1.37, 1.44 and 1.73 g per corpse, respectively. For years in between, emission factors have been linearly interpolated. For 2011, an emission factor of 1.73 g per corpse was used. Implementation of emission reducing technology became obligatory for new cremation centres in 2006 and all other cremation centres need to be equipped with this technology in 2013. During the period 2007-2010 no information on the progress of implementation of emission reducing technology was available. Over 2011 the branch reported that 86% of the centres where equipped with filters. Therefore, the implementation of this technology has been linearly interpolated in this period. From 2006 onwards, a lower emission factor (0.43 g Hg per corpse) is used for installations equipped with emission reducing technology.

8.2.5 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 human transpiration and respiration, from manure sold and applied to private properties and from manure sold and applied to 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 (9.2%), TSP (3.7%), PM_{10} (4.4%) and $PM_{2.5}$ (8.9%) as percentages of national total in 2011.

10 Recalculations and other changes

10.1 Recalculations of the 2012 submission

Compared to the 2012 submission (Jimmink *et al*., 2012) only for the transport sector methodological changes were implemented in the PRTR system:

- The emissions in the transport sector were recalculated (as every year) based on the updated VERSIT+ LD model (Ligterink and De Lange, 2009).
- The NO_x emissions of diesel passenger cars and light duty trucks in the 2008-2010 period have been recalculated in this year's submission using adjusted emission factors for Euro-5 vehicles.
- In this year's submission, emissions from so-called 'oldtimers' were recalculated using new annual mileages derived by Statistics Netherlands.

Above changes are elaborated in the section 4 and affected the emission for the total time series for all relevant pollutants.

10.2 Improvements

10.2.1 Included improvements

During the compilation of the IIR minor errors were detected and repaired in this submission. The following improvements, with more significance, can be mentioned in the process of improvement of the Dutch inventory:

- Particulate related combustion emissions erroneously allocated in the category 2.C.1 are now reallocated in category 1.A.2.
- New data on the fuel sales for railways came available from 2010 onwards. Based on extrapolating this data it was therefore concluded that fuel sales data to railways had been underestimated between 2006 and 2009 and are now corrected.
- Applying the new diesel fuel sales data from the Energy Balance led to an increase of emissions in the 2006-2009 period compared to last year's submission.
- Emissions of inland navigation in The Netherlands were improved using a new model and improved activity data from 2005 onwards.

10.2.2 Planned improvements

In the process of the inventory preparation activities are initiated for future improvements. For the coming submission the following improvements are envisaged:

General:

- New policy measures take time to implement. In some cases the introductions of measures is forced by law or regulated by permits. The implementation is checked by the competent authorities or inspectorates. Information about this inspection is often selective or based on

Table 10.1 Differences in National total emission level between current and previous submission for the years 1990. 2000 and 2010

National total for the entire territory		NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	$PM_{2.5}$	PM_{10}	TSP	CO
		Gg NO_2	Gg	Gg SO_2	Gg	Gg	Gg	Gg	Gg
1990	IIR 2012	566.3	477.3	191.6	355.1	44.4	67.7	89.9	1124.4
	IIR 2013	566.4	477.3	191.6	354.9	44.3	67.9	90.1	1124.4
Difference	absolute	0.1	0.0	0.0	-0.1	0.0	0.2	0.2	0.0
	%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.3%	0.3%	0.0%
2000	IIR 2012	398.3	237.9	73.0	161.5	24.2	38.8	45.6	756.0
	IIR 2013	393.5	232.5	73.0	161.5	24.1	39.0	45.8	743.8
Difference	absolute	-4.8	-5.4	0.0	0.0	-0.1	0.2	0.2	-12.2
	%	-1.2%	-2.3%	0.0%	0.0%	-0.4%	0.5%	0.4%	-1.6%
2010	IIR 2012	275.9	150.6	33.9	121.8	15.3	29.1	34.8	576.5
	IIR 2013	274.1	145.2	34.0	121.9	14.9	28.7	34.3	551.2
Difference	absolute	-1.7	-5.3	0.1	0.1	-0.3	-0.5	-0.5	-25.3
	%	-0.6%	-3.5%	0.3%	0.1%	-2.2%	-1.6%	-1.4%	-4.4%

Almost all changes shown in table 10.1 originate from the improvements made in the estimation methods for the transport category. Changes in the 2010 figures are also the result of using improved activity data for that year.

incidents. And therefore not easily translated into a national percentage. In the coming year we will develop a methodology that helps us to translate this information to a national scale.

Transport:
- Statistics Netherlands will derive new average annual mileages for so-called ‘special vehicles’ (e.g. garbage trucks, camper vans, tow trucks and fire trucks),motorcycles and mopeds.
- A study on the average load factors for heavy-duty trucks will be commissioned,as the load factors affect the fuel consumption and resulting emissions of heavy-duty vehicles.

10.3 Effects of recalculations and improvements

Tables 10.1 to 10.3 give the changes in national totals emission levels for the different compounds compared to the submission of 2010.

Table 10.2 Differences in National total emission level between current and previous submission for the years 1990, 2000 and 2010 (metals)

National total for the entire territory		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
		Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	IIR 2012	336.4	2.1	3.5	1.5	9.9	69.2	75.3	0.4	220.7
	IIR 2013	336.4	2.1	3.5	1.5	9.9	69.2	75.3	0.4	220.7
Difference	absolute	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2000	IIR 2012	33.1	0.9	1.0	1.1	3.1	70.7	18.7	0.5	91.0
	IIR 2013	33.1	0.9	1.0	1.1	3.1	70.7	18.7	0.5	91.0
Difference	absolute	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2010	IIR 2012	43.6	2.5	0.7	0.8	1.6	81.9	1.8	1.5	105.6
	IIR 2013	43.6	2.5	0.6	0.8	1.7	81.8	1.8	1.5	105.4
Difference	absolute	0.0	0.0	0.0	0.0	0.1	-0.1	0.0	0.0	-0.3
	%	0.0%	-0.3%	-6.5%	-0.7%	4.7%	-0.1%	-2.1%	0.0%	-0.3%

Metal emissions did not change for the base year 1990. Also in the other years no major changes occurred. Changes in the 2010 figures are mainly the result of using improved activity data for that year.

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

National total for the entire territory		PCDD/ PCDF (dioxines/ furanes)	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3 -cd) pyrene	PAHs Total 1-4
		g I-Teq	Mg	Mg	Mg	Mg	Mg
1990	IIR 2012	742.5	5.2	8.0	4.0	2.8	20.0
	IIR 2013	742.5	5.2	8.0	4.0	2.8	20.0
Difference	absolute	0.0	0.0	0.0	0.0	0.0	0.0
	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2000	IIR 2012	29.8	1.3	1.2	0.7	0.6	3.8
	IIR 2013	29.7	1.3	1.2	0.7	0.6	3.8
Difference	absolute	-0.1	0.0	0.0	0.0	0.0	0.0
	%	-0.3%	-0.5%	-0.5%	-1.0%	-1.4%	-0.7%
2010	IIR 2012	30.4	1.2	1.2	0.6	0.6	3.7
	IIR 2013	30.2	1.2	1.2	0.6	0.6	3.7
Difference	absolute	-0.2	0.0	0.0	0.0	0.0	0.0
	%	-0.7%	-0.9%	-0.9%	-1.5%	-1.5%	-1.1%

Almost all changes shown in table 10.3 originate from the improvements made in the estimation methods for the transport category. Changes in the 2010 figures are also the result of using improved activity data for that year.

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 & 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, 2013).

		Historical (RIVM, 2012)					*NEC*	Projected (Verdonk and Wetzels, 2012)	
Pollutant:/year		1990	2000	2005	2010	2011	*2010*	2020	2030
SO_2	Gg	192	73	64	34	34	*50*	37	34
NO_x	Gg	566	394	337	274	259	*260*	187	165
NH_3	Gg	355	161	141	122	119	*128*	109	110
NMVOC	Gg	477	233	169	145	144	*185*	149	158
PM_{10}	Gg	68	39	33	29	29	*NA*	27	27
$PM_{2.5}$	Gg	44	24	19	15	14	*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 m3 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, uncertainty margins have been calculated, giving a 90-percent confidence interval (Verdonk & Wetzels, 2012).

This year's projection data delivery, 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 latest 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 & Wetzels 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

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

wind farm of 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 & 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. In 2013 the connection to Germany will be expanded (1000-2000 MW), since 2008 the connection to Norway (700 MW) has been fully operational, and in 2011 the connection to the United Kingdom will be operational (1000 MW).

The Netherlands have a high and still increasing degree of interconnection with Germany as a neighbouring country. Although, at the moment, the Netherlands are still a net importer of German electricity, from 2012 onwards, they are switching to become a net exporter of electricity.

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	2011	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	5.7	5.1	4.9
Energy sector	82.7	52.1	43.1	26.1	22.6	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 PM10 and PM2.5 exhaust emissions as more DPFs enter the Dutch vehicle fleet in coming years. PM10 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.

Table 11.5 Development NO_x emission and emission trade.

NO_x emission [in Gg]	2020
Small sources	19.1
Trade in incineration emissions	54.1
Trade in process emissions	13.3
Total emission trade	67.3
Total	86.4

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

Activity	2000	2010	2011	2020	2030
Beef Cattle	2566	2497	2416	2236	2181
Dairy Cows	1504	1479	1470	1475	1418
Sheep	1487	1482	1469	1483	1491
Swine	13118	12255	12429	10273	9423
Poultry	53078	56500	53007	59099	61610
Broilers	53439	46871	45918	47378	48231
Horses	418	441	436	428	432
Rabbits and mink	641	1001	1016	1001	911

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 (Van Schijndel & Van der Sluis, in prep.). 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). NH_3 emissions are expected to increase slightly between 2020 and 2030, by 0.3 Gg (Van Schijndel & Van der Sluis, in prep.). 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, PM10, $PM_{2.5}$, 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.

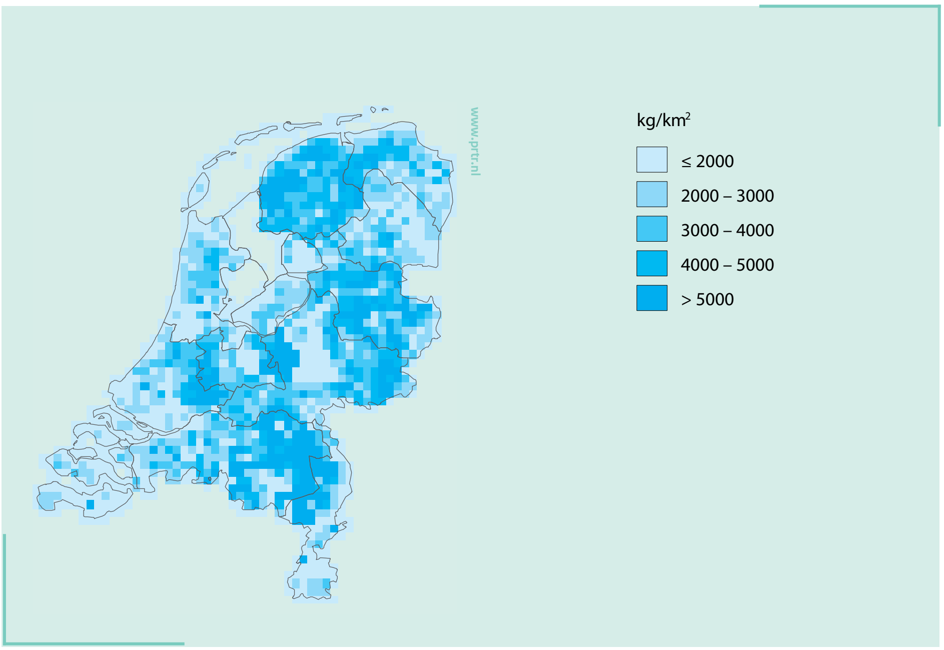
12.2 Methodology for disaggregation of emission data

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:

- direct linkage to location;
- model calculation;
- 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.



Altogether, this category encloses almost three thousand sources.

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

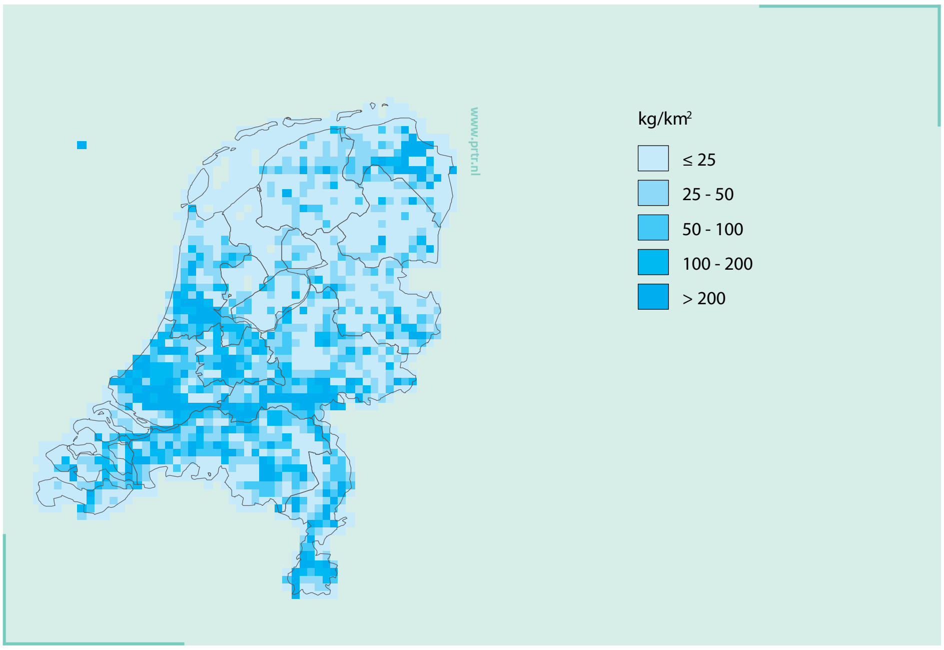
- Ammonia from agriculture;
- Particulate matter (PM_{10}) from agriculture;
- Deposition on surface water;
- Leaching and run-off to surface water (heavy metals and nutrients);
- Emissions of crop protection chemicals to air and surface water.

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

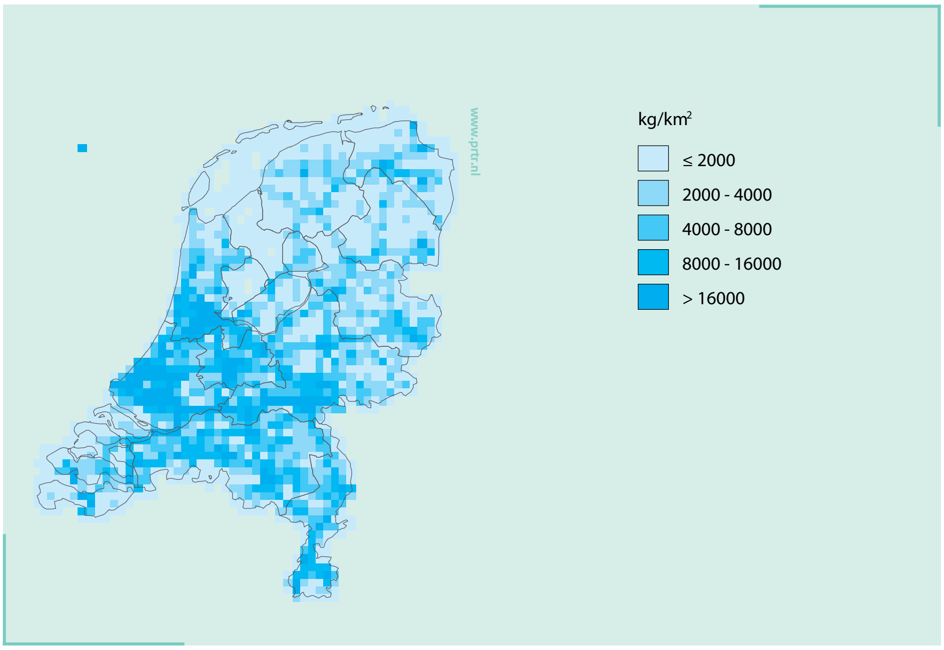
Examples of combinations of the three methods can be seen in all the maps from the latest reporting year (2010). The selected air pollutants are: Ammonia (NH_3), sulphur dioxide (SO_2), nitrogen dioxide (NO_x) and fine particulate matter ($PM_{2.5}$). Figures 12.1 - 12.4 show the geographically distributed 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 2010.



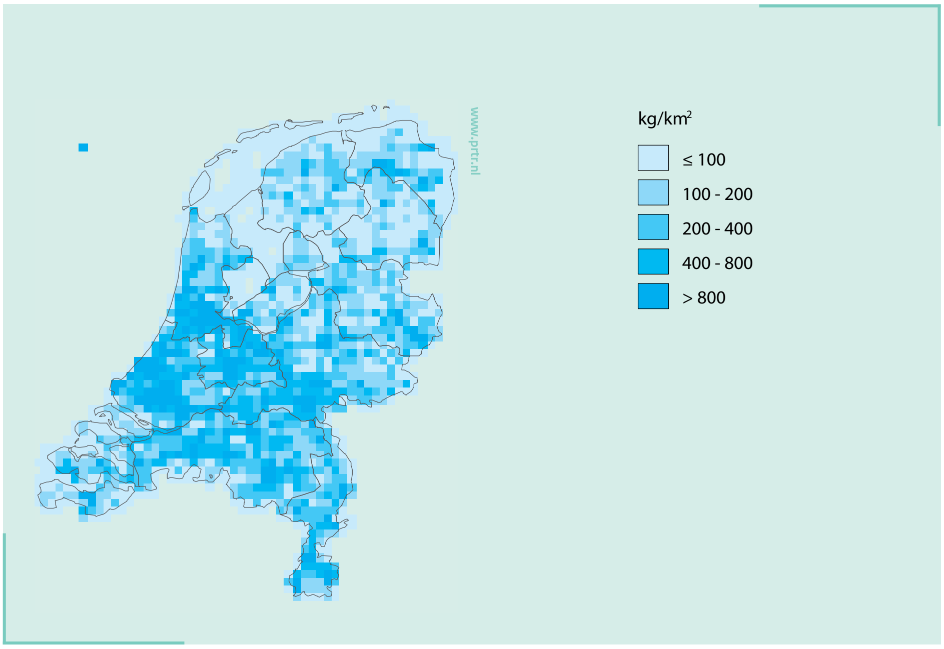
The agricultural sector is the major contributor to the national total NH_3 emission. Emissions of NH_3 are mainly related to livestock farming and especially to the handling of manure from the animals. Emissions of NH_3 are therefore related to storage and spreading of manure as well as emissions from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

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 12.3 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, animal houses, road traffic and shipping, all known as important sources of PM.

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Annex 1 Key source analysis results

Results from the key source analysis have been calculated and sorted for every component. In addition to a 2011 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 2011 level assessment (Emissions in Gg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
1A1b	1A1b Petroleum refining	12.49	37.23%	37.23%
1A1a	1A1a Public electricity and heat production	6.63	19.75%	56.97%
1A2b	1A2b Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	3.50	10.42%	67.39%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	2.90	8.65%	76.04%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	2.67	7.95%	83.99%

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	35.01%	35.01%
1A1a	1A1a Public electricity and heat production	48.37	25.25%	60.26%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	19.95	10.41%	70.67%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	9.14	4.77%	75.44%
2A7d	2A7d Other Mineral products	7.47	3.90%	79.34%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	6.27	3.27%	82.62%

Table 1.1.c SO_x key source categories identified by 1990-2011 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative Trend contribution
1A2b	1A2b Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	4.97	3.50	1.37%	18.91%	18.91%
1A1a	1A1a Public electricity and heat production	48.37	6.63	0.96%	13.29%	32.20%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	5.91	2.67	0.92%	12.67%	44.87%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	9.14	2.90	0.68%	9.37%	54.23%
1A2a	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	19.95	2.36	0.59%	8.12%	62.36%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	6.27	0.04	0.55%	7.59%	69.95%
1A1b	1A1b Petroleum refining	67.09	12.49	0.39%	5.34%	75.29%
1A3bi	1A3bi Road transport: Passenger cars	4.51	0.20	0.31%	4.22%	79.51%
2A7d	2A7d Other Mineral products	7.47	0.88	0.22%	3.05%	82.56%

Table 1.2.a NO_x key source categories identified by 2011 level assessment (Emissions in Gg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
1A3biii	1A3biii Road transport:, Heavy duty vehicles	56.91	21.94%	21.94%
1A3bi	1A3bi Road transport: Passenger cars	27.72	10.69%	33.62%
1A1a	1A1a Public electricity and heat production	22.56	8.70%	41.32%
1A3di(ii)	1A3di(ii) International inland waterways	16.87	6.50%	47.82%
1A3bii	1A3bii Road transport:Light duty vehicles	13.65	5.26%	53.09%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	11.95	4.61%	57.69%
1A4ci	1A4ci Agriculture/Forestry/Fishing: Stationary	10.82	4.17%	61.87%
1A4bi	1A4bi Residential: Stationary plants	10.14	3.91%	65.77%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	10.07	3.88%	69.65%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	9.66	3.72%	73.38%
1A4ai	1A4ai Commercial / institutional: Stationary	9.53	3.67%	77.05%
1A3dii	1A3dii National navigation (Shipping)	9.38	3.62%	80.67%

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	137.55	24.29%	24.29%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	90.60	16.00%	40.28%
1A1a	1A1a Public electricity and heat production	82.71	14.60%	54.89%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	35.89	6.34%	61.22%
1A3di(ii)	1A3di(ii) International inland waterways	22.34	3.95%	65.17%
1A4bi	1A4bi Residential: Stationary plants	20.23	3.57%	68.74%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	19.99	3.53%	72.27%
1A1b	1A1b Petroleum refining	18.85	3.33%	75.60%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	18.83	3.33%	78.92%
1A4ciii	1A4ciii Agriculture/Forestry/Fishing: National fishing	16.46	2.91%	81.83%

Table 1.2.c NO_x key source categories identified by 1990-2011 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	137.55	27.72	6.23%	27.74%	27.74%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	90.60	56.91	2.72%	12.12%	39.87%
1A1a	1A1a Public electricity and heat production	82.71	22.56	2.71%	12.05%	51.92%
1A3bii	1A3bii Road transport:Light duty vehicles	14.66	13.65	1.22%	5.46%	57.37%
1A4ci	1A4ci Agriculture/Forestry/Fishing: Stationary	8.73	10.82	1.20%	5.37%	62.74%
1A3di(ii)	1A3di(ii) International inland waterways	22.34	16.87	1.17%	5.22%	67.96%
1A3dii	1A3dii National navigation (Shipping)	6.44	9.38	1.14%	5.06%	73.01%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	35.89	11.95	0.79%	3.53%	76.54%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	14.47	10.07	0.61%	2.70%	79.24%
1A4ai	1A4ai Commercial / institutional: Stationary	13.65	9.53	0.58%	2.58%	81.82%

Table 1.3.a NH_x key source categories identified by 2011 level assessment (Emissions in Gg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
4B1a	4B1a Cattle dairy	35.63	30.02%	30.02%
4B8	4B8 Swine	19.81	16.69%	46.72%
4B1b	4B1b Cattle non-dairy	17.67	14.89%	61.61%
7A	7A Other	10.90	9.18%	70.79%
4D1a	4D1a Synthetic N-fertilizers	10.33	8.70%	79.50%
4B9a	4B9a Laying hens	9.18	7.73%	87.23%

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 1990-2011 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
4B8	4B8 Swine	98.28	19.81	3.68%	29.09%	29.09%
7A	7A Other	14.30	10.90	1.72%	13.64%	42.73%
4D1a	4D1a Synthetic N-fertilizers	13.91	10.33	1.60%	12.66%	55.39%
4B1a	4B1a Cattle dairy	120.90	35.63	1.35%	10.69%	66.08%
4B1b	4B1b Cattle non-dairy	62.99	17.67	0.96%	7.56%	73.63%
1A3bi	1A3bi Road transport: Passenger cars	0.84	2.47	0.62%	4.87%	78.51%
4B9a	4B9 Laying hens	21.23	9.18	0.59%	4.64%	83.14%

Table 1.4.a NMVOC key source categories identified by 2011 level assessment (Emissions in Gg).

NFR Code	Long name	2011	Contribution	Cumulative Contribution
3D2	3D2 Domestic solvent use including fungicides	19.14	13.25%	13.25%
3A2	3A2 Industrial coating application	15.97	11.06%	24.31%
1A3bi	1A3bi Road transport: Passenger cars	13.97	9.68%	33.99%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	12.04	8.34%	42.33%
3D3	3D3 Other product use	9.11	6.31%	48.64%
1A4bi	1A4bi Residential: Stationary plants	9.09	6.29%	54.93%
1B2aiv	1B2a iv Refining / storage	8.31	5.75%	60.68%
1B2ai	1B2a i Exploration, production, transport	7.18	4.98%	65.66%
2D2	2D2 Food and drink	5.12	3.55%	69.21%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	4.67	3.24%	72.44%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	4.20	2.91%	75.35%
3D1	3D1 Printing	3.54	2.45%	77.80%
3B1	3B1 Degreasing	2.91	2.02%	79.82%
2B5a	2B5a Other chemical industry	2.58	1.79%	81.61%

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	97.07	20.34%	20.34%
3A2	3A2 Industrial coating application	70.97	14.87%	35.21%
1A3bv	1A3bv Road transport: Gasoline evaporation	35.46	7.43%	42.63%
1B2aiv	1B2aiv Refining / storage	31.67	6.64%	49.27%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	30.48	6.39%	55.66%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	25.19	5.28%	60.93%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	24.50	5.13%	66.07%
3D3	3D3 Other product use	15.31	3.21%	69.27%
1B2ai	1B2ai Exploration, production, transport	14.39	3.01%	72.29%
3D1	3D1 Printing	14.36	3.01%	75.29%
3A1	3A1 Decorative coating application	13.52	2.83%	78.13%
1A4bi	1A4bi Residential: Stationary plants	13.22	2.77%	80.90%

Table 1.4.c NMVOC source categories identified by 1990-2011 trend assessment (Emissions in Gg).

NFR Code	Longname	1990	2011	Trend	Trend contribu-tion	Cumulative trend contribution
3D2	3D2Domestic solvent use including fungicides	11.31	19.14	3.29%	17.84%	17.84%
1A3bi	1A3bi Road transport: Passenger cars	97.07	13.97	3.22%	17.47%	35.30%
1A3bv	1A3bv Road transport: Gasoline evaporation	35.46	1.79	1.87%	10.14%	45.44%
3A2	3A2 Industrial coating application	70.97	15.97	1.15%	6.24%	51.68%
1A4bi	1A4bi Residential: Stationary plants	13.22	9.09	1.07%	5.77%	57.46%
3D3	3D3 Other product use	15.31	9.11	0.94%	5.08%	62.54%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	25.19	4.20	0.72%	3.88%	66.42%
2D2	2D2 Food and drink	7.06	5.12	0.63%	3.39%	69.81%
1B2ai	1B2ai Exploration, production, transport	14.39	7.18	0.59%	3.21%	73.02%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	30.48	12.04	0.59%	3.20%	76.22%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	24.50	4.67	0.57%	3.11%	79.33%
3A1	3A1 Decorative coating application	13.52	2.38	0.36%	1.94%	81.26%

Table 1.5.a CO key source categories identified by 2011 level assessment (Emissions in Gg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
1A3bi	1A3bi Road transport: Passenger cars	207.17	39.14%	39.14%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	65.46	12.37%	51.51%
1A4bi	1A4bi Residential: Stationary plants	57.28	10.82%	62.33%
1A4bii	1A4bii Residential: Household and gardening (mobile)	29.86	5.64%	67.97%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	29.86	5.64%	73.62%
1A5b	1A5b Other, Mobile (including military, land based and recreational boats)	21.18	4.00%	77.62%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	16.40	3.10%	80.71%

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	585.88	52.11%	52.11%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	187.72	16.70%	68.80%
1A4bi	1A4bi Residential: Stationary plants	71.88	6.39%	75.20%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	44.70	3.98%	79.17%
1A3bii	1A3bii Road transport:Light duty vehicles	38.77	3.45%	82.62%

Table 1.5.c CO key source categories identified by 1990-2011 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	585.88	207.17	6.10%	30.88%	30.88%
1A4bi	1A4bi Residential: Stationary plants	71.88	57.28	2.08%	10.55%	41.43%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	187.72	65.46	2.04%	10.31%	51.74%
1A4bii	1A4bii Residential: Household and gardening (mobile)	14.99	29.86	2.03%	10.26%	62.00%
1A5b	1A5b Other, Mobile (including military, land based and recreational boats)	14.12	21.18	1.29%	6.54%	68.54%
1A3bii	1A3bii Road transport:Light duty vehicles	38.77	4.68	1.21%	6.11%	74.65%
1A4aii	1A4aii Commercial / institutional: Mobile	7.71	13.95	0.92%	4.65%	79.29%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	44.70	29.86	0.78%	3.97%	83.26%

Table 1.6.a TSP key source categories identified by 2011 level assessment (Emissions in Gg).

NFR Code	Long name	2011	Contribution	Cumulative Contribution
1A4bi	1A4bi Residential: Stationary plants	3.42	9.94%	9.94%
2C1	2C1 Iron and steel production	3.17	9.21%	19.14%
4B9a	4B9a Laying hens	2.83	8.21%	27.35%
2D2	2D2 Food and drink	2.16	6.28%	33.63%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.97	5.73%	39.36%
2B5a	2B5a Other chemical industry	1.86	5.41%	44.77%
1A3bii	1A3bii Road transport:Light duty vehicles	1.69	4.91%	49.68%
1A3bi	1A3bi Road transport: Passenger cars	1.44	4.19%	53.87%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.44	4.18%	58.05%
4B9b	4B9b Broilers	1.34	3.89%	61.94%
7A	7A Other	1.27	3.70%	65.64%
3D3	3D3 Other product use	1.21	3.53%	69.17%
4B8	4B8 Swine	1.21	3.51%	72.68%
2A7d	2A7d Other Mineral products	1.21	3.51%	76.18%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	1.16	3.37%	79.55%
2C3	2C3 Aluminum production	0.81	2.36%	81.91%

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	19.46%	19.46%
2C1	2C1 Iron and steel production	9.97	11.06%	30.52%
1A1b	1A1b Petroleum refining	6.47	7.18%	37.70%
2B5a	2B5a Other chemical industry	6.01	6.66%	44.37%
2D2	2D2 Food and drink	5.84	6.48%	50.85%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	5.94%	56.79%
1A4bi	1A4bi Residential: Stationary plants	5.33	5.91%	62.70%
1A3bi	1A3bi Road transport: Passenger cars	5.19	5.75%	68.45%
2A7d	2A7d Other Mineral products	3.40	3.78%	72.23%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	2.79%	75.02%
1A1a	1A1a Public electricity and heat production	2.46	2.73%	77.75%
7A	7A Other	1.86	2.06%	79.81%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.72	1.91%	81.72%

Table 1.6.c TSP key source categories identified by 1990-2011 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
2G	2G Other production, consumption, storage, transportation or handling of bulk products	17.54	1.97	5.25%	21.16%	21.16%
4B9a	4B9a Laying hens	0.45	2.83	2.94%	11.88%	33.03%
1A1b	1A1b Petroleum refining	6.47	0.39	2.31%	9.30%	42.34%
1A4bi	1A4bi Residential: Stationary plants	5.33	3.42	1.54%	6.20%	48.54%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	0.80	1.38%	5.57%	54.11%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.18	1.44	1.10%	4.43%	58.54%
4B9b	4B9b Broilers	1.30	1.34	0.93%	3.76%	62.30%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.87	1.16	0.92%	3.70%	66.00%
3D3	3D3 Other product use	1.05	1.21	0.90%	3.63%	69.63%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	1.69	0.81%	3.27%	72.90%
2C1	2C1 Iron and steel production	9.97	3.17	0.71%	2.86%	75.76%
4B8	4B8 Swine	1.68	1.21	0.63%	2.53%	78.29%
7A	7A Other	1.86	1.27	0.63%	2.52%	80.81%

Table 1.7.a PM_{10} key source categories identified by 2011 level assessment (Emissions in Gg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
4B9a	4B9a Laying hens	2.83	9.87%	9.87%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	2.37	6.85%	16.73%
2D2	2D2 Food and drink	1.79	6.24%	22.96%
1A3bii	1A3bii Road transport:Light duty vehicles	1.69	5.91%	28.87%
1A4bi	1A4bi Residential: Stationary plants	1.60	5.60%	34.47%
2C1	2C1 Iron and steel production	1.48	5.16%	39.63%
1A3bi	1A3bi Road transport: Passenger cars	1.44	5.04%	44.67%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.44	5.03%	49.70%
4B9b	4B9b Broilers	1.34	4.68%	54.37%
7A	7A Other	1.27	4.45%	58.82%
3D3	3D3 Other product use	1.21	4.24%	63.03%
4B8	4B8 Swine	1.21	4.21%	67.27%
2A7d	2A7d Other Mineral products	1.19	4.17%	71.44%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	1.16	4.06%	75.50%
2B5a	2B5a Other chemical industry	1.12	3.90%	79.40%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	0.80	2.79%	82.19%

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	9.32	13.72%	13.72%
1A1b	1A1b Petroleum refining	6.46	9.51%	23.23%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	7.88%	31.10%
1A3bi	1A3bi Road transport: Passenger cars	5.19	7.63%	38.74%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	4.92	7.24%	45.98%
2B5a	2B5a Other chemical industry	4.11	6.05%	52.03%
2D2	2D2 Food and drink	3.85	5.67%	57.70%
2A7d	2A7d Other Mineral products	2.64	3.89%	61.58%
1A4bi	1A4bi Residential: Stationary plants	2.53	3.72%	65.31%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	3.70%	69.01%
1A1a	1A1a Public electricity and heat production	2.21	3.25%	72.26%
7A	7A Other	1.86	2.74%	75.00%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.72	2.53%	77.53%
4B8	4B8 Swine	1.68	2.47%	80.00%

Table 1.7.c PM_{10} key source categories identified by 1990-2011 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
4B9a	4B9a Laying hens	0.45	2.83	3.88%	13.84%	13.84%
2C1	2C1 Iron and steel production	9.32	1.48	3.61%	12.86%	26.70%
1A1b	1A1b Petroleum refining	6.46	0.32	3.53%	12.60%	39.30%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	0.80	2.14%	7.65%	46.95%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.18	1.44	1.39%	4.95%	51.90%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.87	1.16	1.17%	4.16%	56.06%
4B9b	4B9b Broilers	1.30	1.34	1.16%	4.14%	60.21%
3D3	3D3 Other product use	1.05	1.21	1.13%	4.04%	64.24%
1A3bi	1A3bi Road transport: Passenger cars	5.19	1.44	1.09%	3.90%	68.14%
1A1a	1A1a Public electricity and heat production	2.21	0.21	1.06%	3.79%	71.93%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	1.69	0.93%	3.31%	75.24%
2B5a	2B5a Other chemical industry	4.11	1.12	0.90%	3.23%	78.47%
1A4bi	1A4bi Residential: Stationary plants	2.53	1.60	0.79%	2.83%	81.29%

Table 1.8.a $PM_{2.5}$ key source categories identified by 2011 level assessment (Emissions in Gg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
1A3bii	1A3bii Road transport: Light duty vehicles	1.69	12.00%	12.00%
1A4bi	1A4bi Residential: Stationary plants	1.52	10.76%	22.76%
1A3bi	1A3bi Road transport: Passenger cars	1.44	10.24%	33.00%
7A	7A Other	1.26	8.91%	41.91%
2C1	2C1 Iron and steel production	0.89	6.32%	48.22%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	0.80	5.67%	53.89%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	0.64	4.54%	58.43%
2B5a	2B5a Other chemical industry	0.58	4.13%	62.56%
1A3di(ii)	1A3di(ii) International inland waterways	0.50	3.56%	66.13%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.47	3.35%	69.48%
2A7d	2A7d Other Mineral products	0.43	3.08%	72.56%
3D3	3D3 Other product use	0.40	2.87%	75.43%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	0.37	2.60%	78.03%
1A3dii	1A3dii National navigation (Shipping)	0.36	2.53%	80.57%

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	5.75	12.96%	12.96%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	12.07%	25.03%
1A3bi	1A3bi Road transport: Passenger cars	5.19	11.70%	36.72%
1A1b	1A1b Petroleum refining	4.19	9.45%	46.18%
2B5a	2B5a Other chemical industry	3.03	6.83%	53.01%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	5.68%	58.68%
1A4bi	1A4bi Residential: Stationary plants	2.32	5.24%	63.93%
1A1a	1A1a Public electricity and heat production	1.94	4.37%	68.29%
7A	7A Other	1.84	4.15%	72.44%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.64	3.69%	76.13%
2A7d	2A7d Other Mineral products	1.53	3.46%	79.59%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.49	3.37%	82.96%

Table 1.8.c $PM_{2.5}$ key source categories identified by 1990-2011 trend assessment (Emissions in Gg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
1A1b	1A1b Petroleum refining	4.19	0.25	2.44%	12.19%	12.19%
2C1	2C1 Iron and steel production	5.75	0.89	2.11%	10.53%	22.72%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	0.80	2.03%	10.16%	32.88%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	1.69	2.01%	10.03%	42.91%
1A4bi	1A4bi Residential: Stationary plants	2.32	1.52	1.75%	8.75%	51.66%
7A	7A Other	1.84	1.26	1.51%	7.55%	59.21%
1A1a	1A1a Public electricity and heat production	1.94	0.18	0.99%	4.95%	64.16%
2B5a	2B5a Other chemical industry	3.03	0.58	0.86%	4.28%	68.45%
3D3	3D3 Other product use	0.35	0.40	0.66%	3.30%	71.74%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	0.34	0.36	0.56%	2.80%	74.54%
1A3dii	1A3dii National navigation (Shipping)	0.90	0.50	0.48%	2.42%	76.96%
1A3bi	1A3bi Road transport Passenger cars	5.19	1.44	0.46%	2.31%	79.27%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	0.21	0.26	0.44%	2.20%	81.47%

Table 1.9.a. Pb key source categories identified by 2011 level assessment (Emissions in Mg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	17.62	62.22%	62.22%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	5.66	20.00%	82.21%

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	224.99	66.87%	66.87%
2C1	2C1 Iron and steel production	55.75	16.57%	83.44%

Table 1.9.c Pb key source categories identified by 1990-2011 trend assessment (Emissions in Mg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	224.99	0.04	5.62%	44.18%	44.18%
2C1	2C1 Iron and steel production	55.75	17.62	3.84%	30.22%	74.39%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	5.17	5.66	1.55%	12.22%	86.62%

Table 1.10.a Hg key source categories identified by 2011 level assessment (Emissions in Mg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	0.434	52.69%	52.69%
1A1a	1A1a Public electricity and heat production	0.129	11.50%	0.222
2C5b	2C5b Lead production	0.095	8.48%	0.055

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 1990-2011 trend assessment (Emissions in Mg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
2C1	2C1 Iron and steel production	0.388	0.434	9.75%	39.74%	39.74%
1A1a	1A1a Public electricity and heat production	1.923	0.222	6.52%	26.55%	66.29%
2B5a	2B5a Other chemical industry	0.702	0.000	4.68%	19.07%	85.36%

Table 1.11.a Cd key source categories identified by 2011 trend level assessment (Emissions in Mg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	0.434	52.69%	52.69%
1A1a	1A1a Public electricity and heat production	0.222	26.91%	79.60%
2C5b	2C5b Lead production	0.055	6.65%	86.25%

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%	78.33%
1A1b	1A1b Petroleum refining	0.110	5.26%	83.59%

Table 1.11.c Cd key source categories identified by 1990-2011 trend assessment (Emissions in Mg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
1A1a	1A1a Public electricity and heat production	0.949	0.089	20.13%	41.43%	41.43%
2C1	2C1 Iron and steel production	0.687	0.674	14.64%	30.15%	71.58%
2B5a	2B5a Other chemical industry	0.000	0.129	6.17%	12.71%	84.28%

Table 1.12.a Dioxine key source categories identified by 2011 level assessment (Emissions in g I-Teq).

NFR Code	Long name	2011	Contribution	Cumulative contribution
3D3	3D3 Other product use	14.500	46.31%	46.31%
1A1a	1A1a Pubilc electricity and heat production	7.576	24.20%	70.51%
1A4bi	1A4bi Residential: Stationary plants	5.559	17.76%	88.27%

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

NFR Code	Long name	1990	Contribution	Cumulative Contribution
1A1a	1A1a Public electricity and heat production	568.009	76.50%	76.50%
1A4ai	1A4ai Commercial / institutional: Stationary	100.018	13.47%	89.97%

Table 1.12.c Dioxine key source categories identified by 1990-2011 trend assessment (Emissions in g I-Teq).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
1A1a	1A1a Public electricity and heat production	568.01	7.58	2.21%	39.26%	39.26%
3D3	3D3 Other product use	25.00	14.50	1.81%	32.24%	71.50%
1A4bi	1A4bi Residential: Stationary plants	8.61	5.56	0.70%	12.46%	83.96%

Table 1.13.a PAH key source categories identified by 2010 level assessment (Emissions in Mg).

NFR Code	Long name	2011	Contribution	Cumulative contribution
1A4bi	1A4bi Residential: Stationary plants	2.908	75.80%	75.80%
2C3	2C3 Aluminum production	0.290	34.49%	83.35%

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

NFR Code	Long name	1990	Contribution	Cumulative Contribution
2C3	2C3 Aluminum production	6.909	34.49%	34.49%
1A4bi	1A4bi Residential: Stationary plants	3.550	17.72%	52.21%
3A2	3A2 Industrial coating application	2.417	12.07%	64.28%
2C1	2C1 Iron and steel production	1.788	8.93%	73.20%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.370	6.84%	80.04%

Table 1.13.c PAH key source categories identified by 1990-2011 trend assessment (Emissions in Mg).

NFR Code	Long name	1990	2011	Trend	Trend contribution	Cumulative trend contribution
1A4bi	1A4bi Residential: Stationary plants	3.550	2.908	11.12%	57.58%	57.58%
2C3	2C3 Aluminum production	6.909	0.290	5.16%	26.71%	84.29%

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Emissions the Netherlands in 2011 under national ceilings
Emissions of nitrogen oxides (NO_x) have decreased in 2011 to the level that for the first time they were below the cap the European Union has set for 2010. Herewith, the Netherlands comply with all four so-called emission ceilings (NEC). For ammonia, sulphur dioxide and non-methane volatile organic compounds (NMVOC) the Netherlands already complied with the ceilings in 2010.

This has become apparent from RIVM's explanation of Dutch emission data on transboundary air polluting substances, in the Informative Inventory Report (IIR) 2013. This concerns emissions of sulfur dioxide, nitrogen oxides, NMVOC, carbon monoxide, ammonia, particulate matter (PM10), heavy metals and persistent organic pollutants (POPs) which have all decreased over the 1990–2011 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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