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 1990-2010

Informative Inventory Report 2012

Netherlands Informative Inventory Report 2012

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Rapport in het kort

Emissies van luchtverontreinigende stoffen in Nederland, 1990-2010. Toelichting op de jaarlijkse reeks emissiecijfers.

Tussen 1990 en 2010 is in Nederland de uitstoot van luchtverontreinigende stoffen gedaald. Het betreft de uitstoot van zwaveldioxide, stikstofoxiden, niet-methaan vluchtige organische stoffen (NMVOS), koolmonoxide, ammoniak, fijn stof (PM_{10}), zware metalen en persistente organische stoffen (POP's). Deze neerwaartse trend is vooral toe te schrijven aan de introductie van schonere auto's en brandstoffen, en aan emissiebeperkende maatregelen bij industriële sectoren.

Dit blijkt uit de toelichting van het RIVM op de Nederlandse emissiecijfers van grootschalige luchtverontreinigende stoffen, het Informative Inventory Report (IIR) 2012. Deze cijfers worden jaarlijks onder regie van het RIVM geleverd aan de Verenigde Naties (UNECE) en de Europese Commissie. De emissiecijfers beslaan een reeks jaren, vanaf 1990 tot het meest recente jaar. Dit keer zijn ook de geografische verdelingen van de emissiecijfers gerapporteerd, waartoe Europese lidstaten elke vijf jaar zijn verplicht.

Nieuwe inzichten in de emissies van motorfietsen en bromfietsen
Door de jaren heen resulteren nieuwe methoden om de emissies te berekenen in nauwkeurigere uitkomsten. De grootste verbetering heeft dit verslagjaar plaatsgevonden in de emissieberekening van bromfietsen en motorfietsen in Nederland. Deze emissies zijn berekend met een nieuw model dat beter rekening houdt met het motorvermogen en de leeftijd van de bromfietsen en motorfietsen. Het nieuwe model laat zien dat vooral oudere motorfietsen en bromfietsen meer fijn stof (PM_{10}) uitstoten dan eerder werd verwacht. Ook de uitstoot van stikstofoxiden ligt iets hoger dan eerder werd berekend. Motoren en bromfietsen leveren echter maar een kleine bijdrage aan de totale uitstoot van stikstofoxiden en fijn stof van wegverkeer in Nederland.
Oude bromfietsen blijken ook meer koolwaterstoffen uit te stoten dan eerder werd gedacht, maar nieuwe bromfietsen blijken juist wat schoner. Als gevolg hiervan dalen de emissies van koolwaterstoffen sneller dan eerder werd berekend: van 25 kiloton in 1990 tot 4 kiloton in 2010.

Uitstoot van stikstofoxiden door vrachtverkeer hoger dan gedacht
Ook de uitstoot van stikstofoxiden door vrachtverkeer in Nederland is opnieuw berekend, en wel op basis van nieuwe inzichten in de uitstoot van zogenoemde Euro-IV vrachtauto's. Deze aanduiding verwijst naar de Europese wetgeving voor de uitstoot van schadelijke stoffen door vrachtauto's. Euro-IV vrachtauto's zijn tussen 2005 en 2008 verkocht in Nederland. Uit metingen blijkt dat de uitstoot van stikstofoxiden door deze vrachtauto's op snelwegen hoger is geweest dan eerder werd gedacht. Tegelijkertijd blijken er in Nederland iets minder Euro-IV vrachtauto's rond te rijden dan eerder werd verondersteld: door een subsidieregeling zijn er vanaf 2006 al schonere vrachtauto's verkocht die aan strengere normen voldeden (Euro-V). Toch is de uitstoot van stikstofoxiden door vrachtverkeer in 2010 nu circa 5 kiloton hoger dan eerder werd berekend.
Daarnaast is nauwkeuriger inzicht verkregen in het aandeel van de diverse categorieën trucks in het totale Nederlandse vrachtwagenpark.

Trefwoorden: emissies, grootschalige luchtverontreiniging, emissieregistratie

Abstract

Emissions of transboundary air pollutants in the Netherlands, 1990-2010. Explanation of the annual series of emission data

Emissions of air pollutants in the Netherlands have decreased over the 1990–2010 period. This concerns emissions of sulfur dioxide, nitrogen oxides, non-methane volatile organic compounds (NMVOC), carbon monoxide, ammonia, particulate matter (PM_{10}), heavy metals and persistent organic pollutants (POPs). The downward trend may be attributed in particular to cleaner fuels, cleaner car engines and to emission reductions in the industrial sectors.

This has become apparent from RIVM's explanation of Dutch emission data on transboundary air polluting substances, in the Informative Inventory Report (IIR) 2012. Every year, the RIVM submits emission data to the United Nations Economic Commission for Europe (UNECE) and the European Commission. The figures consist of emission data on a series of years, from 1990 up to the most recent year. Moreover, this year's submission also includes data on the spatial distribution of emissions, which must be reported on every five years by all European Member States.

New insights into emissions from motorcycles and mopeds

New methods of calculating emissions, over the years, have led to ever more accurate results. This year, the largest improvement was made in emission calculations for motorcycles and mopeds in the Netherlands. Emissions were calculated using a new model that takes engine capacity and the age of motorcycles and mopeds more into account. This new model has shown that older motorcycles and mopeds produce higher levels of particulate matter (PM_{10}) than estimated before. Levels of nitrogen oxide emissions also proved to be higher than calculated earlier. However, in the Netherlands, emissions from motorcycles and mopeds only represent a small share of total nitrogen oxide and particulate matter emissions from road transport.

In addition, although older mopeds were shown to emit more hydrocarbons than previously estimated, newer mopeds appeared somewhat cleaner. This has resulted in a faster decrease in hydrocarbon emissions than had been previously calculated: from 25 kilotonnes in 1990 to 4 kilotonnes in 2010.

Levels of nitrogen oxide emissions from freight transport higher than expected

Nitrogen oxide emissions from freight transport in the Netherlands have also been recalculated based on new insights into the emissions from so-called Euro-IV trucks. This term refers to the EU directive on emissions of harmful substances from freight transport. Measurements have shown that nitrogen oxide emission levels from these trucks along motorways were higher than previously estimated. In addition, it was also shown that there are slightly fewer of these Euro-IV trucks on the Dutch roads than previously assumed; since as early as 2006, due to a subsidy regulation, cleaner trucks have been sold that comply with more stringent standards (Euro-V). Despite this fact, in 2010, the level of nitrogen emissions from freight transport was around 5 kilotonnes higher than previously calculated. Furthermore, a more accurate insight was obtained in the share of the various categories of trucks within the Dutch national fleet of trucks.

Key words: emissions, transboundary air pollution, emission inventory

Contents

1 Introduction

The United Nations Economic Commission for Europe's' Geneva 1979 Convention on Longe-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 2012 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 2010, 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. Moreover, this year, the spatial distributions of emission data have been reported, this has to be done every five years. A chapter on the followed methodology has therefore been included.

1.1 National inventory background

Emission estimates in the Netherlands are registered in the national Pollutant Release and Transfer Register (PRTR). This PRTR database is the national database for sectorial monitoring of emissions to air, water and soil. The database was set up to monitor pollutants to support national environmental policy as well as to report to the framework of National Emission Ceilings (EU), the CLRTAP, and to monitor the greenhouse gas emissions in conformance with 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 to obtain monitoring 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, 2011). Various external agencies contribute to the PRTR by performing calculations or submitting activity data (see next section). In addition to the RIVM, the following institutes contribute to the PRTR:

- Netherlands Environmental Assessment Agency (PBL);
- Statistics Netherlands (CBS);
- Netherlands Organisation for Applied Scientific Research (TNO);
- RWS Centre for Water Management (RWS-WD);
- RWS Centre for Transport and Navigation (RWS-DVS);
- Deltares;
- Alterra WUR;
- Wageningen UR Livestock Research;
- NL Agency (Waste management department);
- 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 (EPRTR), about 400 companies, representing even more facilities, are legally obligated to annually submit their emissions of pollutants when they exceed a certain threshold. For some pollutants lower thresholds have been set in the Dutch implementation of the EPRTR directive (VROM, 2008). This has been done to assure that the total reported amount of the main pollutants for each subsector meets approximately 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, which are then stored in the PRTR database (ER-I). 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).

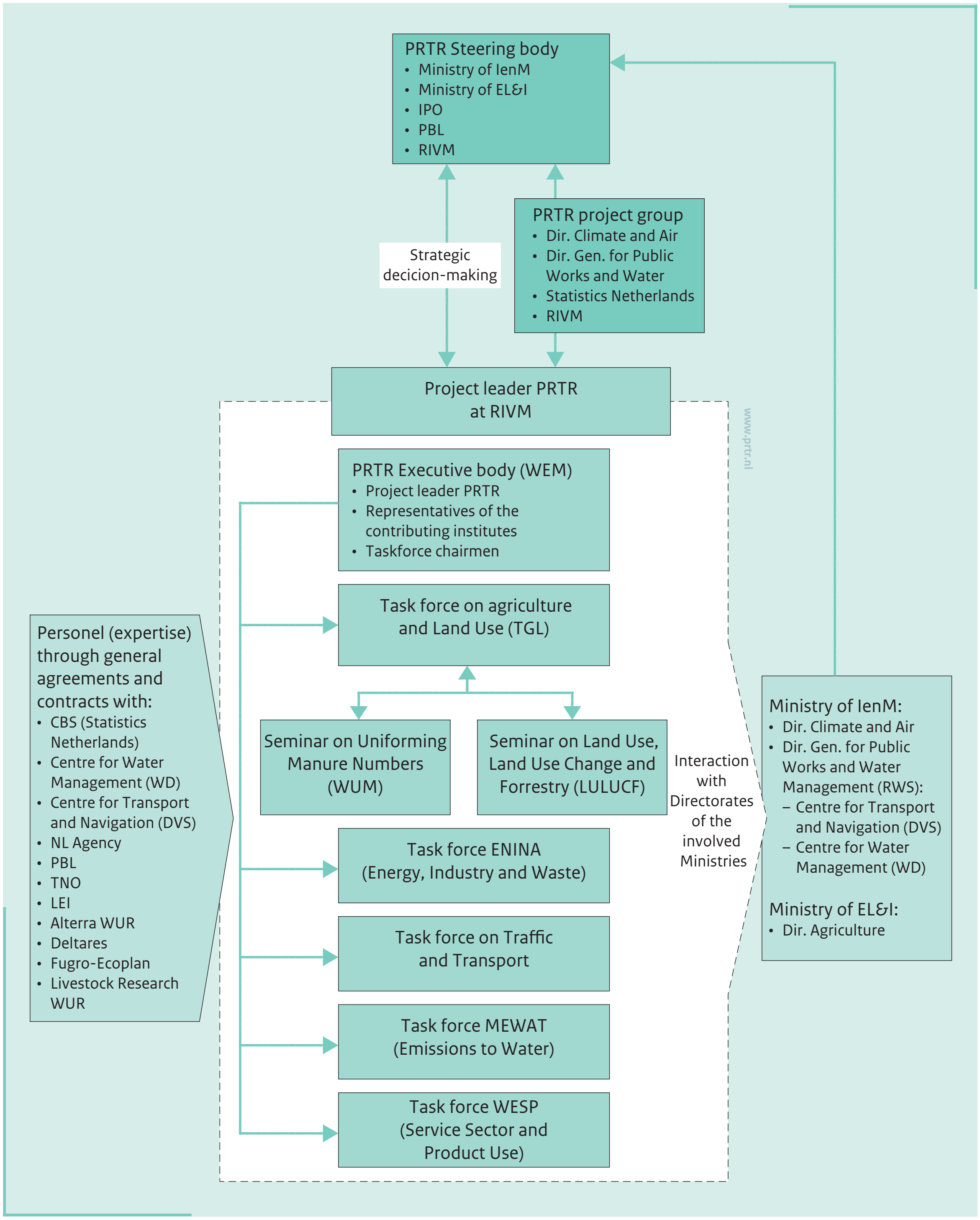
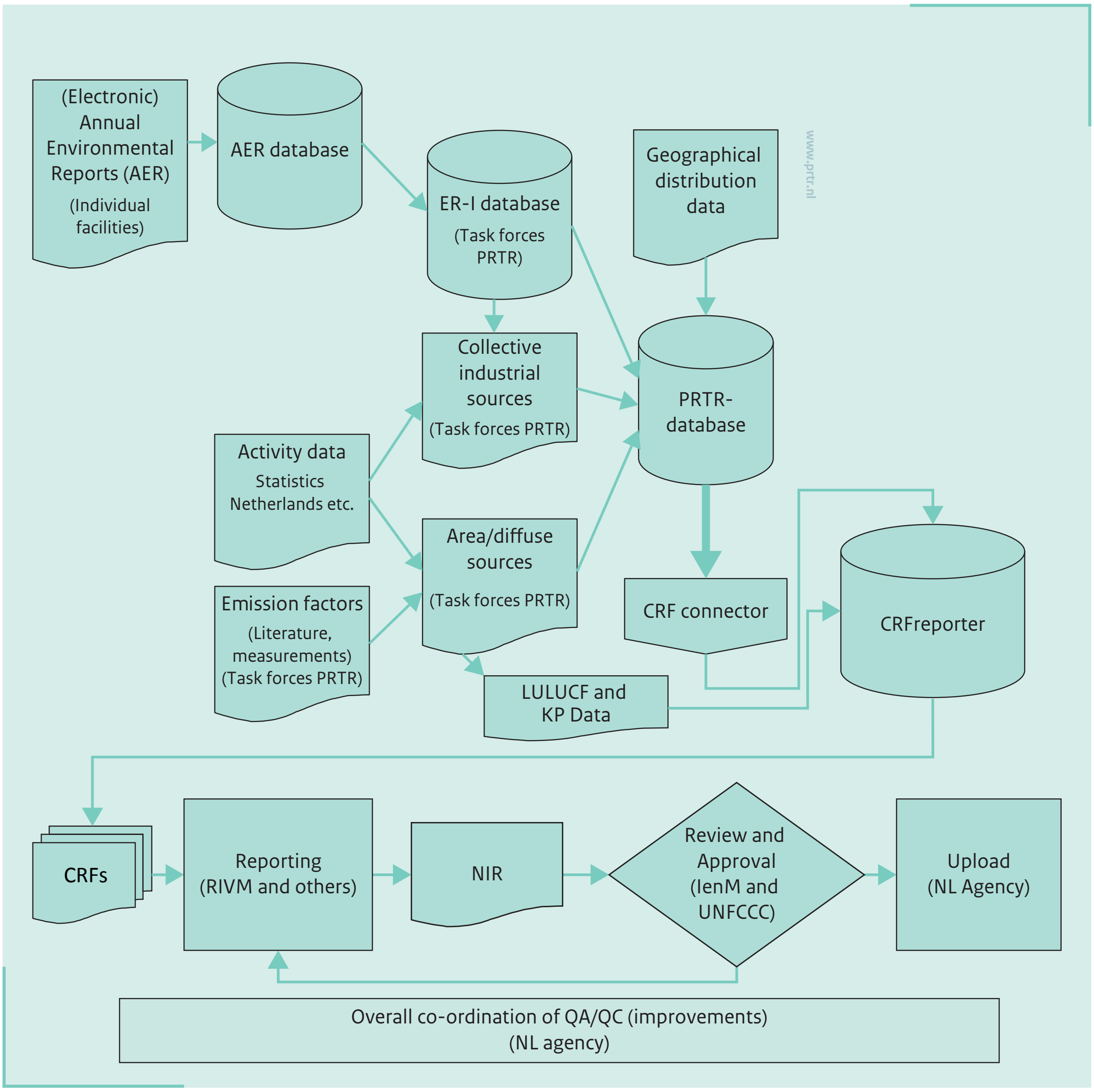


Figure 1.2 The data flow in the Netherlands Pollutant Release and Transfer Register.



1.3.2 Data storage

In cooperation with the contributing research institutes, emission data are collected and stored in a 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 Standard Industrial Classification code (SBI code) 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 annual project plan (RIVM, 2011). The general QA/QC activities meet the international inventory QA/QC requirements described in 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 CMM as part of the ISO certification;
- 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 2011 inventory the PRTR task forces filled in a standard-format database with emission data from 1990 to 2010. 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 1.1 Key items of the verification actions data processing 2011 and NRF/IIR 2012.

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.	30-06-2011	RIVM-PRTR	List of remaining issues/ actions from last inventory	Actiepunten trendanalyse definitieve emissiecijfers 2010 v 30 juni 2011.xls
Input for checking allocations from de PRTR-database to the NFR tables.	29-11-2011	RIVM-NIC	List of allocations	NFR-ER-Koppellijst 29nov2011.xls
Input for checking the integrity of the time series 1990-2009	30-11-2011	RIVM-PRTR	Comparison sheets to check for accidentally changed data in in the time series 1990-2009	historische reeksen vergeleken LUCHT v 28 november 2011.xls
Input for error checks	29-11-2011	RIVM-PRTR	Comparison sheets 2009-2010 data	Verschiltabel definitieve emissiecijfers 28 november 2011 LUCHT actueel.XLS
Input for trend analysis	02-12-2011	RIVM-PRTR	Updated list of required actions	Actiepunten trendanalyse definitieve emissiecijfers 2010 v 5 dec.xls
Input for trend analysis and checking of the result of resolved actions	06-12-2011	RIVM-PRTR	Comparison sheets 2009-2010 data	Verschiltabel definitieve emissiecijfers 6 december 2011 LUCHT IPCC.xls
Trend analysis workshops	08-12-2011	Sector specialists, RIVM-PRTR	explanations for observed trends and actions to resolve before finalising the PRTR dataset	Landbouw dataset 2011 definitief eo_ niveau JV.XLS Toelichting verschillen 2009 en 2010 (7-12-2011) LANDBOUW v Bruggen.doc Trendverklaring reeks 2011 definitief_ AFVAL.doc Trendanalyse verkeer T-1 2011 definitief. ppt
Input for resolving the final actions before finalising the PRTR dataset	Until 22-12-2011	RIVM-PRTR	Updated Action list	Document not available
Request to the contributing institutes to endorse the PRTR database	16-12-2011 till 21-12-2011	PRTR project leader, Representatives of the contributing institutes	Reactions of the contributing institutes	Email with the request Actiepunten trendanalyse definitieve emissiecijfers 2010 v 16 dec.xls Emails with consent from PBL, CBS and Deltares.
Input for compiling the NEC report (in NFR-format)	20-12-2011	RIVM-NIC	List of allocations for compiling from the PRTR-database to the NFR-tables	NFR-ER-Koppellijst 20dec2011.xls
Final PRTR dataset	22-12-2011	PRTR project leader	Updated Action list	Actiepunten trendanalyse definitieve emissiecijfers 2010 v 16 dec.xls
List of allocations for compiling from the PRTR-database to the NFR-tables	16-01-2012	RIVM	Input for compiling the EMEP/LRTAP report (NFR format)	NFR-ER-Koppellijst 16jan2012.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 years' 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 2009 from the new time series were compared with the time series of last year's inventory and 2) the data for 2010 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 put 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.
Each institution involved in the PRTR is responsible for QA/QC aspects related to reports based on the annually fixed database.

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 6) have been implemented. Therefore, it is necessary to update the uncertainty assessment. This is foreseen within the next years and results will be presented in the IIR in question. Then also a more detailed uncertainty analyses as suggested by the ERT in their Stage 3 in-depth review will be provided (UNECE, 2010).

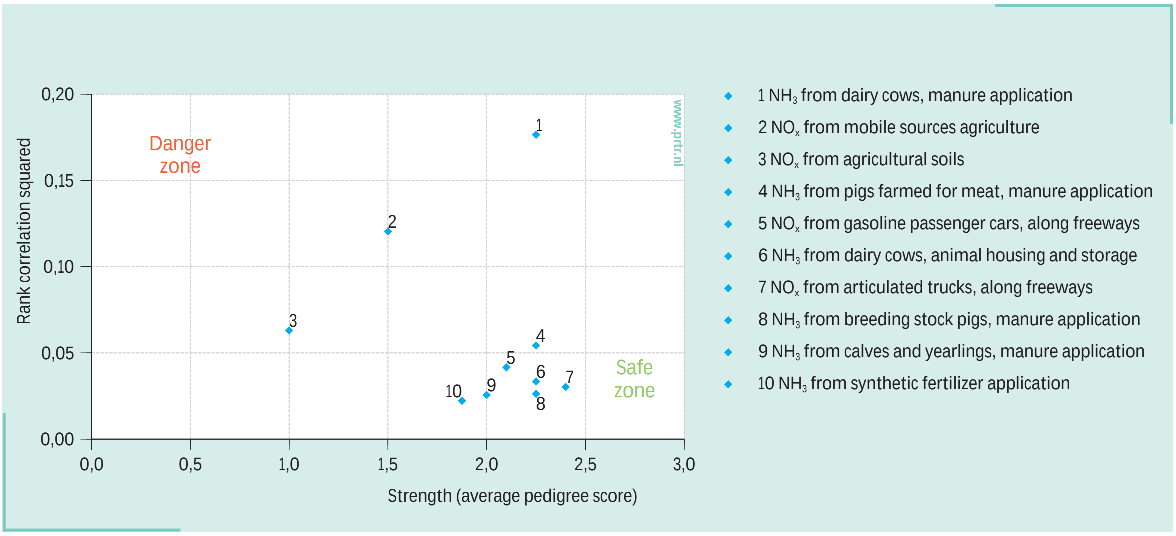
1.7.1 Quantitative uncertainty

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

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.



acidification (in acidification equivalents) according to the Tier-2 methodology (estimation of uncertainties per source category using Monte Carlo analysis). See Table 1.2 for results. A comparison was also made between the Tier-1 and Tier-2 methodologies. This was not straightforward, as the two studies used a different knowledge collection. The 2000 Tier-1 analysis used CLRTAP default uncertainties for several NOx processes, which explains the difference with the 1999 Tier-1 results. For NH3, 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 reporting NE
1A3ai(ii)	All	Not in PRTR
1A3aii(i)	All	Not in PRTR
1A3	NH_3, Cd - PCBs	Not in PRTR
2B2	NO_x	Not in PRTR
4B2	NO_x, NH_3	Not in PRTR
4B7	NO_x, NH_3, DIOX	Not in PRTR
6A	NO_x, SO_2, NH_3	Not in PRTR
6B	NO_x, NMVOC, SO_2, NH_3	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	All	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
6Cc	All	1A1a, 1A4ai

Table 1.5 Sub-sources accounted for in reported '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

The emissions of all substances showed a downward trend in the 1990-2010 period (see Table 2.1). The major overall drivers for this trend are:

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

Road transport emissions have decreased 84% since 1990 for NMVOC, 55% for PM, 56% for NO_x and 98% for SO_2, despite a growth in traffic of 20%. The decrease is mainly attributable to European emission regulations for new road vehicles. For PM and NO_x, standards have been set for installations by tightening up the extent of emission stocks of heating installations (BEES). In meeting these requirements Dutch industrial plants have realised a reduction of 92% in PM emissions and 60% 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, 1990-2010.

	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	398	756	238	73	161	46	39	24	33	0.9	1.0
2005	346	659	177	65	140	40	33	19	35	1.7	0.9
2009	280	580	152	37	125	35	30	16	37	1.8	0.6
2010	276	577	151	34	122	35	29	15	44	2.5	0.7
1990-2010 period [1]	-290	-548	-327	-158	-233	-55	-39	-29	-293	0.4	-2.8
1990-2010 period [2]	-51%	-49%	-68%	-82%	-66%	-61%	-57%	-66%	-87%	20%	-80%

[1] Absolute difference in Gg

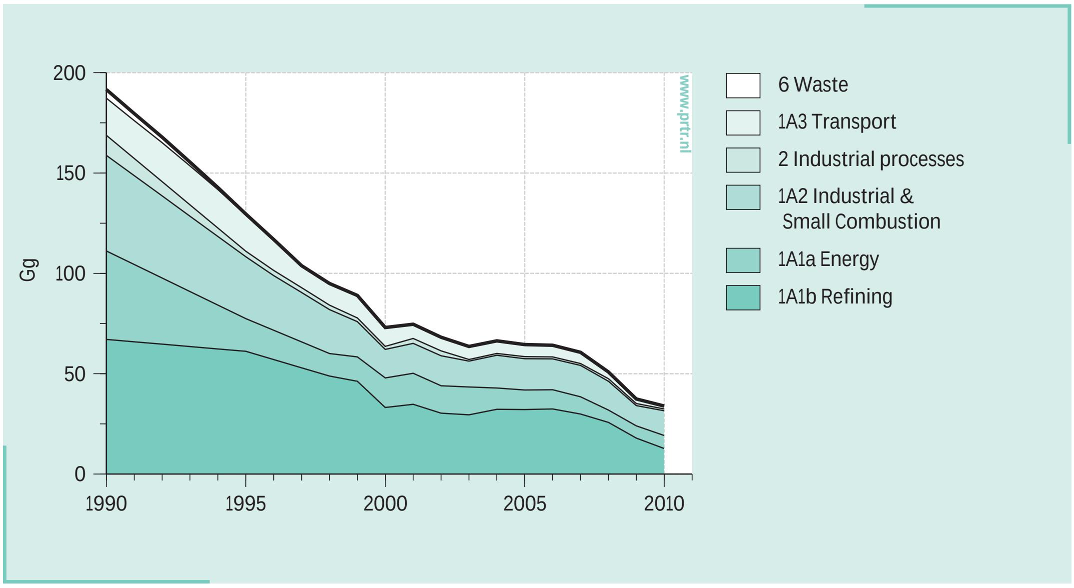
[2] Relative difference to 1990 in %

	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	31	3.8	1.5	2.3	74.8	10.7	2.6	84.2
2009	29	4.1	0.8	1.5	79.8	3.0	0.9	91.6
2010	30	3.7	0.8	1.6	81.9	1.8	1.5	105.6
1990-2010 period [1]	-712	-16.3	-0.6	-8.3	12.7	-73.5	1.1	-115.1
1990-2010 period [2]	-96%	-81%	-42%	-84%	18%	-98%	289%	-52%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

Figure 2.1. SO_2 emission trend, 1990-2010.



2.2 Trends in sulphur dioxide (SO_2)

The Dutch SO_x emissions (reported as SO_2) decreased by 158 Gg in the 1990-2010 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 NO_x emissions (NO and NO_2, expressed as NO_2) decreased by 290 Gg in the 1990-2010 period, corresponding to 51% 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, 1990–2010.

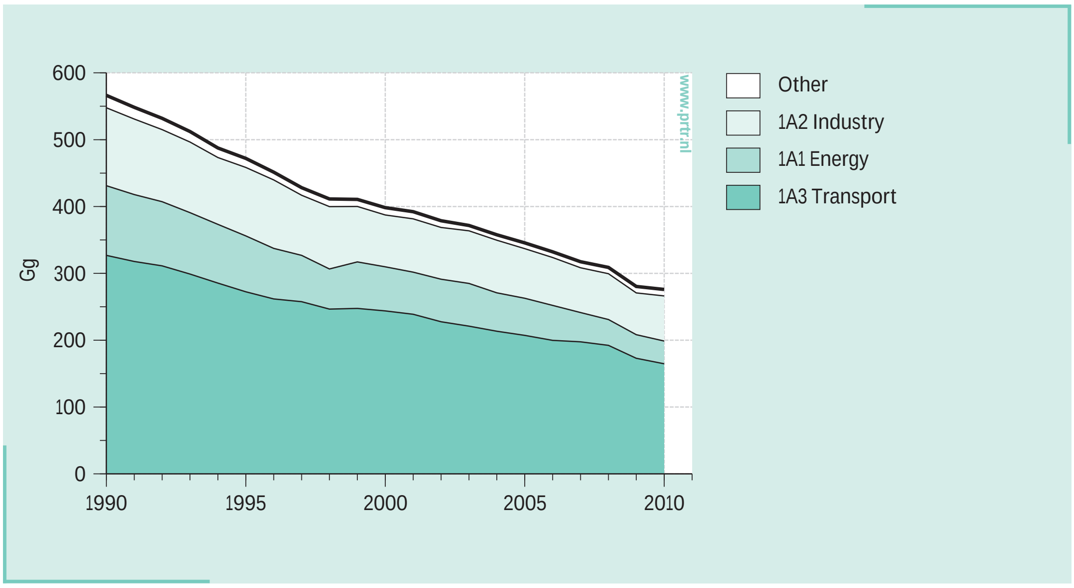
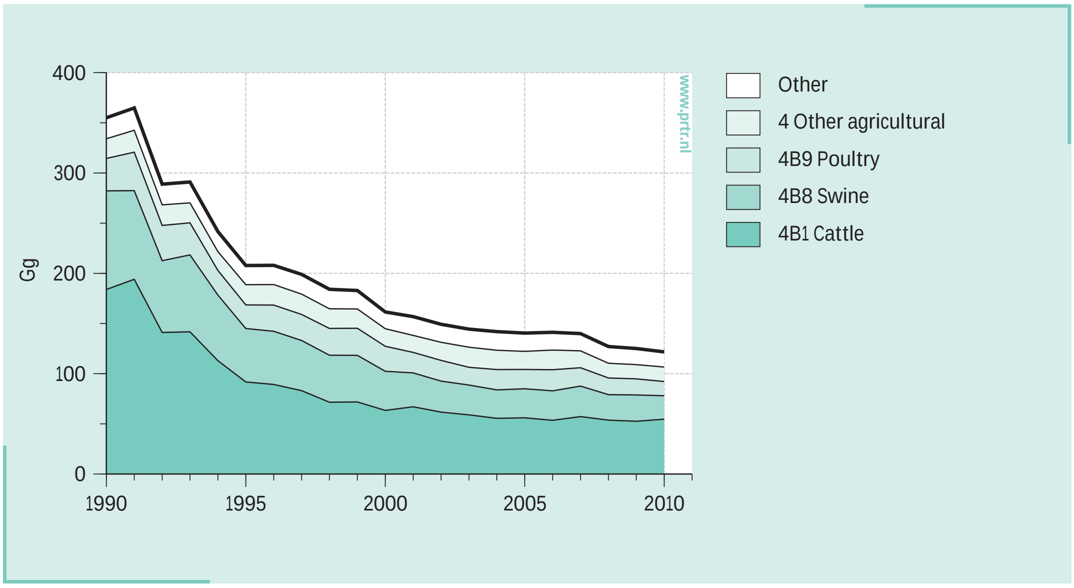


Figure 2.3 NH_3 emission trend, 1990–2010.



2.4 Trends in ammonia (NH_3)

The Dutch NH_3 emissions decreased by 233 Gg in the 1990-2010 period, corresponding to 66% of the national total in 1990 (Figure 2.3). This decrease was due to emission reductions from agricultural sources. The direct emissions from animal husbandry decreased slightly 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 90% of Dutch NH_3 emissions come from agricultural sources.

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

The Dutch NMVOC emissions decreased by 327 Gg in the 1990-2010 period, corresponding to 68% 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, 1990–2010.

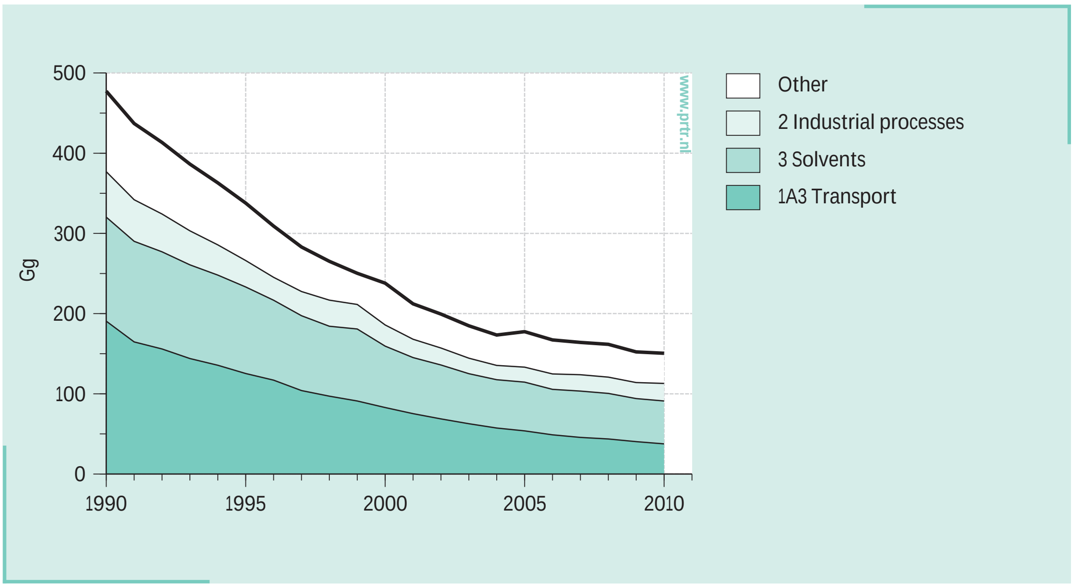
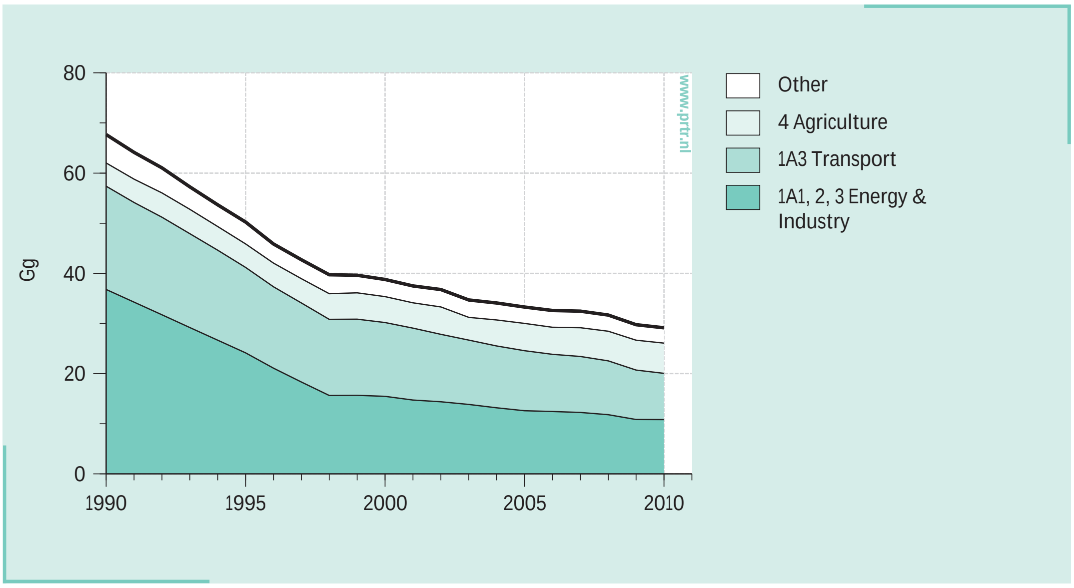


Figure 2.5 PM_{10}, emission trend, 1990–2010.



2.6 Trends in PM_{10}

Dutch PM_{10} emissions decreased by 39 Gg in the 1990-2010 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, and
- 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 2012 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 29 Gg in the 1990-2010 period, corresponding with 66% 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, 1990–2010.

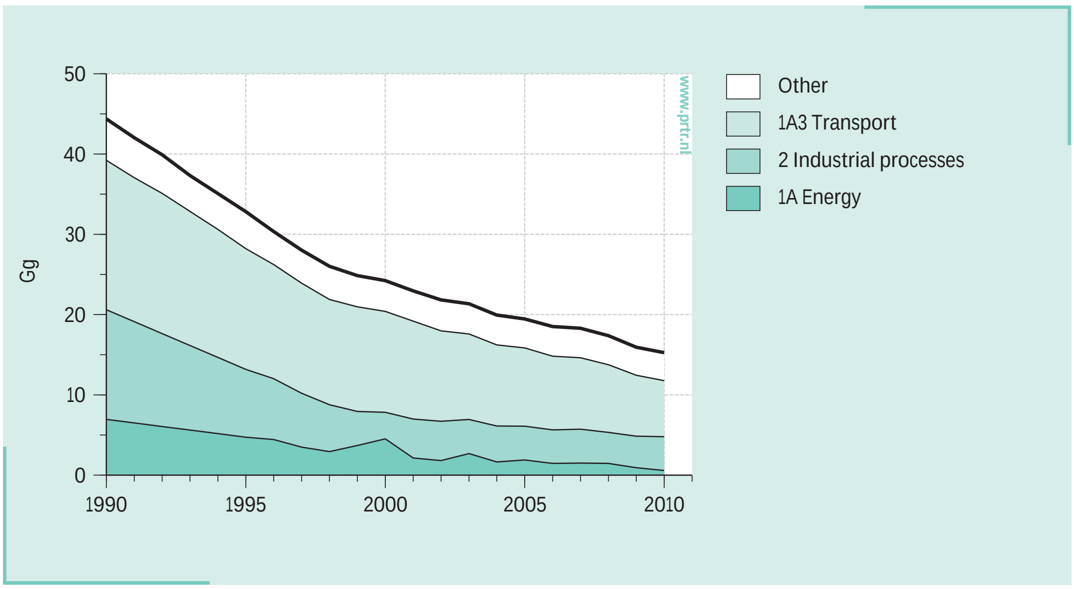
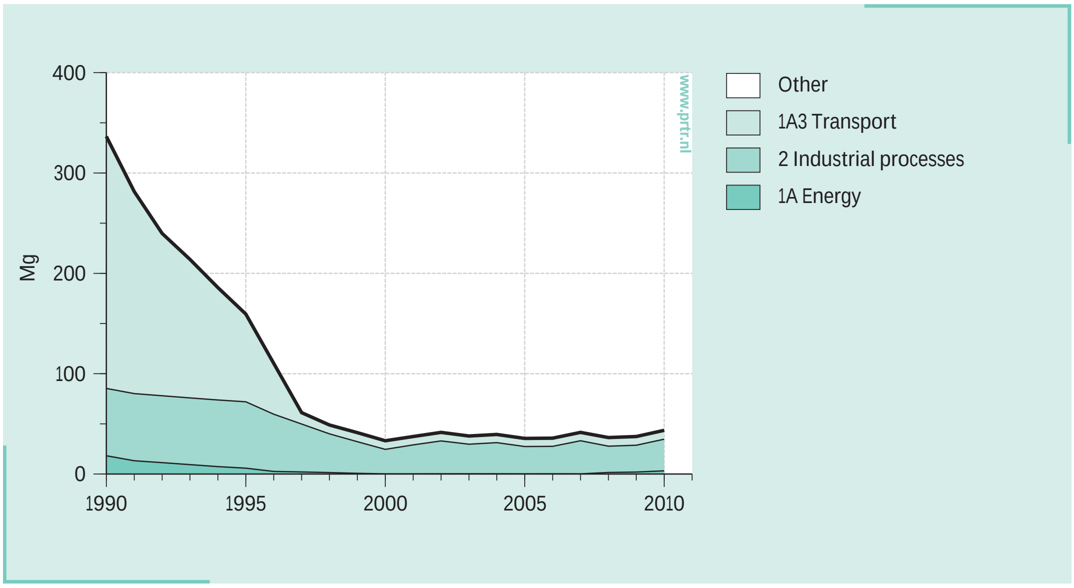


Figure 2.7 Pb, emission trend 1990-2010.



2.8 Trends in Pb

Lead (Pb) emissions in the Netherlands decreased by 293 Mg in the 1990-2010 period, corresponding with 87% of the national total in 1990 (Figure 2.7). This decrease is attributable to the transport sector, where, due to the removal of Pb from gasoline, the Pb emissions collapsed. The remaining sources are industrial process emissions, in particular from the iron and steel industry.

3 Energy

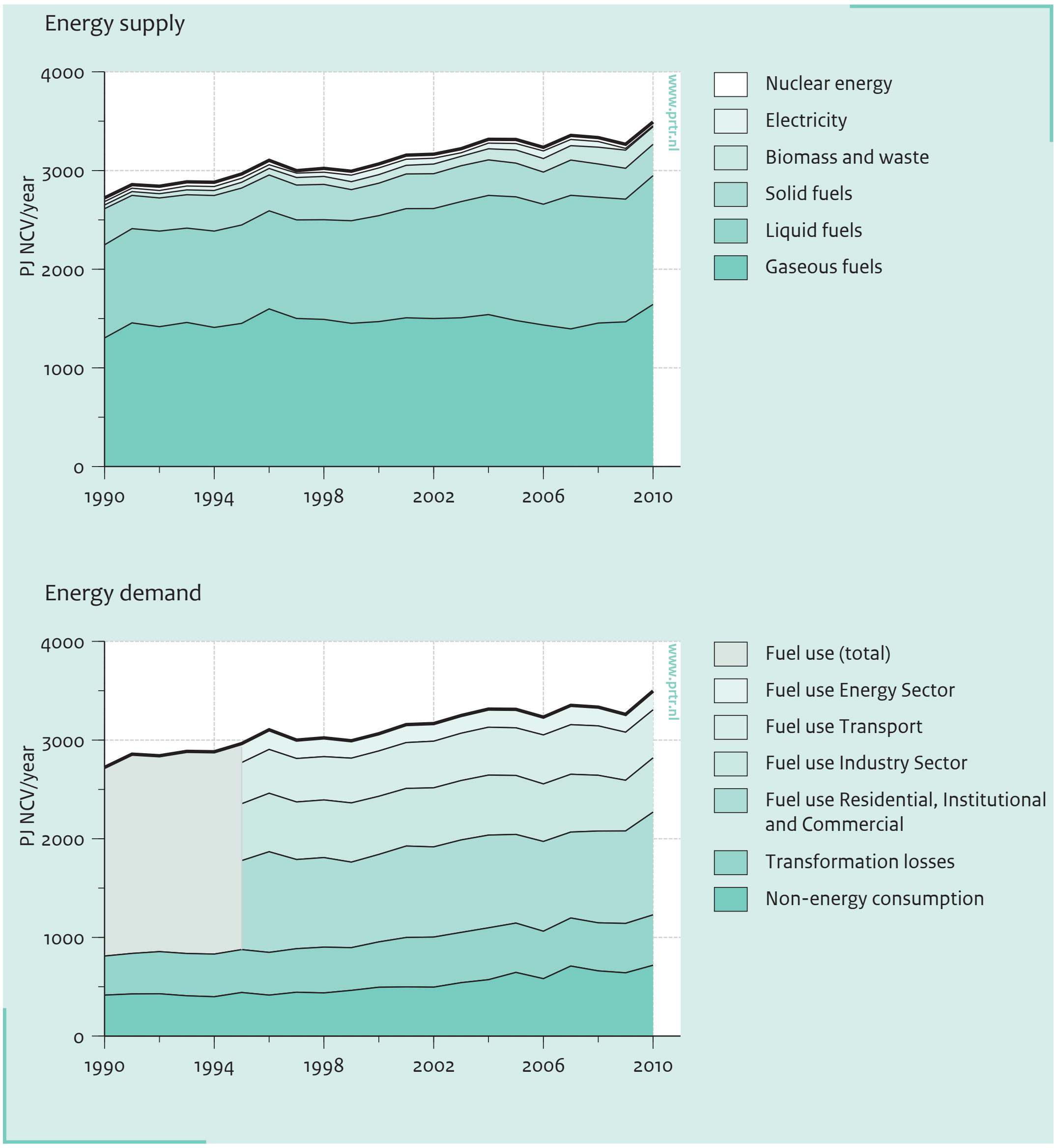
3.1 Overview of sector

This sector includes all stationary combustion emissions from electricity production and industry. 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 2010, natural gas supplied about 47% of the total primary fuels used in the Netherlands, followed by liquid fuels (37%) and solid fossil fuels (9%). The contribution of non-fossil fuels, including renewables and waste streams, is rather limited. Figure 3.1 shows the energy supply and energy demand in the Netherlands.

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



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

Key sources in this sector are presented in Table 3.1.

Table 3.1 Key sources in the Public Electricity and heat (NFR 1A1a) sector.

Category / Sub-category	Pollutant	Contribution to total in 2010 (%)
1A1a Public electricity and heat production	SO_x	19.8
	NO_x	9.5
	TSP	1.8
	$PM_{2.5}$	1.5
	Cd	7.3
	Hg	32

Table 3.2 Overview of trends in emissions from 1A1a Public Electricity and Heat Production.

	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	0.20	0.09	0.37
2009	26	4	0.4	6	0.08	0.70	0.36	0.27	0.33	0.23	0.22
2010	26	5	0.3	7	0.07	0.64	0.27	0.22	0.35	0.18	0.22
1990 -2010 period [1]	-56	-3	-0.3	-42	0.07	-1.82	-1.93	-1.72	-0.77	-0.77	-1.70
1990 -2010 period [2]	-68%	-38%	-50%	-86%		-74%	-88%	-89%	-98%	-81%	-89%

[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	0.15	0.32	0.28	1.91	1.67	0.44
2009	1.7	0.01	0.09	0.09	0.14	0.18	0.84	8.83
2010	1.2	0.01	0.12	0.05	0.14	0.20	1.33	11.04
1990-2010 period [1]	-566.8	-0.16	-0.38	-0.57	-1.92	-2.30	1.31	-29.63
1990-2010 period [2]	-99.8%	-92%	-76%	-92%	-93%	-92%		-73%

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

3.2.3 Overview of shares and trends in emissions

An overview of the trends in emissions is shown in Table 3.2. For almost all pollutants, emissions decreased between 1990 and 2010, while fuel consumption increased by 50% over the same period. The emissions from the main pollutants decreased by 1% to 85%, while emissions from other pollutants decreased by 21% to 98%. 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 pollutant for which emissions have increased is Se. This is a result from a re-allocation of the emissions from waste combustion from 6C to 1A1a.

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

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

where:

EF = emission factor

ER-I = Emission Registration database for individual companies

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

$$ER\text{-}I\_SBI\_emission_{(SBI\ category,\ fuel\ type)} = EF\ ER\text{-}I_{(SBI\ category,\ fuel\ type)} * Energy\ NEH_{(SBI\ category,\ fuel\ type)}$$

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 sufficient 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

Key sources in this sector are presented in Table 3.3.

Table 3.3 Key sources in the Industrial Combustion (NFR 1A1b, 1A1c and 1A2) sector.

Category / Sub-category	Pollutant	Contribution to total in 2010 (%)
1A1b Petroleum refining	SO_x	37.6
	NO_x	2.0
	NMVOC	1.0
	CO	1.1
	PM_{10}	1.0
	TSP	1.1
	$PM_{2,5}$	1.5
	PAH	0.7
1A1c Manufacture of solid fuels and other energy industries	NO_x	1.7
1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	SO_x	11.3
	NO_x	2.1
	CO	14.3
1A2b Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	SO_x	6.6
	CO	2.2
	Dioxins	5.4
1A2c Stationary combustion in manufacturing industries and construction: Chemicals	SO_x	6.2
	NO_x	4.6
	NMVOC	2.4
	CO	2.1
	Pb	6.7
	Cd	51.0
	Dioxins	12.9
1A2d Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	-	-
1A2e Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	SO_x	1.5
	NO_x	1.0
1A2fi Stationary combustion in manufacturing industries and construction: Other	NO_x	2.4
	NMVOC	1.3
	CO	0.9
	PAH	2.4

Table 3.4 Overview of trends in emissions from Industrial Combustion.

	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	8.95	8.12	5.01	1.89	0.14	0.18
1995	78	215	20.0	90	0.32	7.00	6.67	4.32	4.27	0.20	0.08
2000	49	161	7.4	46	0.05	6.33	6.22	4.26	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
2009	39	115	9.7	27	0.57	1.19	0.91	0.65	1.68	0.67	0.02
2010	40	124	8.5	24	0.45	0.77	0.53	0.39	3.08	1.28	0.02
1990 -2010 period [1]	-61	-143	-26.3	-86	-0.13	-8.17	-7.59	-4.62	1.20	1.15	-0.16
1990 -2010 period [2]	-60%	-53%	-76%	-78%	-22%	-91%	-93%	-92%	63%	835%	-91%

[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	2.49	1.39	64.60	0.04	2.95
1995	0.02	0.09	0.23	3.14	2.82	79.41	0.05	58.95
2000	0.00	0.00	0.00	0.51	0.15	17.40	0.00	24.28
2005	0.87	0.10	0.78	0.08	0.09	6.50	0.08	0.51
2009	3.12	0.09	0.01	0.10	1.07	1.39	0.01	9.11
2010	5.69	0.12	0.01	0.14	1.13	0.02	0.12	9.81
1990 -2010 period [1]	5.68	-0.75	-0.16	-2.34	-0.27	-64.58	0.08	6.87
1990 -2010 period [2]	59372%	-86%	-92%	-94%	-19%	-100%	174%	233%

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

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 some heavy metals and for dioxins. Reductions in emissions of main pollutants have been caused by improvements in abatement techniques. Increases in some other pollutants have been caused by increases in fuel use. Emission reduction of SO_2 and PM_{10} are mainly caused by shifts in fuel use by refineries from oil to natural gas. However, economic recovery also caused an increase in NO_x emissions compared to 2009.

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

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

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

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

$$\textbf{ER-I\_SBI\_emission}_{\text{(SBI category, fuel type)}} = \textbf{EF ER-I}_{\text{(SBI category, fuel type)}} * \textbf{Energy NEH}_{\text{(SBI category, fuel type)}}$$

3.3.6 Uncertainties and time-series consistency

Uncertainties are explained in Section 1.7.

3.3.7 Source-specific QA/QC and verification

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

3.3.8 Source-specific recalculations

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 wastewater 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 are used by space heating.
- 1A4ci 'Agriculture/Forestry/Fishing: Stationary'. This sector comprises stationary combustion emissions from agriculture, horticulture, greenhouse horticulture, cattle breeding and forestry.
- 1A5a 'Other stationary'. This sector includes stationary combustion of waste gas from dumping sites.

3.4.2 Key sources

Key sources in this sector are presented in Table 3.5.

Table 3.5 Key sources in the Small Combustion (NFR 1A4 and 1A5) sector.

Category / Subcategory		Pollutant	Contribution to total of 2009 (%)
1A4ai	Commercial/institutional, stationary	NO_x	4.8
		NMVOC	1.0
1A4bi	Residential, stationary	SO_x	1.7
		NO_x	4.6
		NMVOC	6.2
		CO	10.2
		TSP	10.1
		PM_{10}	5.7
		$PM_{2.5}$	10.3
		Hg	3.5
		Dioxins	18.6
		PAH	77.7
1A4ci	Agriculture/forestry/fishing, stationary	NO_x	4.2
		NMVOC	1.2
1A5a	Other stationary	-	-

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 in the 1A4 category by 20%. Because of the cold winter of 2009/2010, the fuel use and the consequent emissions in 2010 are higher than in 2009.

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
2009	12	3	1.2	0	0.06	0.06	0.05	0.00	0.00	0.00
2010	13	4	1.5	0	0.05	0.05	0.05	0.00	0.00	0.00
1990–2010 period [1]	0	1	0.3	-2	-0.32	-0.30	-0.26	-0.63	-0.03	-0.09
1990–2010 period [2]	-3%	28%	27%	-97%	-85%	-85%	-84%	-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
2009	0.01	0.01	0.00	0.00	0.00	0.12	0.01
2010	0.01	0.01	0.00	0.00	0.00	0.02	0.00
1990–2010 period [1]	-100.01	-0.46	-0.01	-3.53	-0.39	-2.95	-1.14
1990–2010 period [2]	-100%	-97%	-97%	-100%	-100%	-99%	-100%

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

3.4.4 Activity data and (implied) emission factors

Commercial/institutional (1A4ai)
Combustion emissions from the commercial and institutional sector have been based on fuel consumption data (Statistics Netherlands) and emission factors (see Table 3.7).

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).

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)

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
- 1B2av Refining
- 1B2b Gas transport and gas distribution

3.5.2 Key sources

Key sources in this sector are presented in table 3.9

Table 3.9 Key sources in the Fugitives (NFR 1B) sector.

Category / Sub-category	Pollutant	Contribution to total in 2009 (%)
1B2ai Oil and gas production	NMVOC	3.5
1B2av Refining	NMVOC	5.7
1B2b Gas transport and gas distribution	NMVOC	1.0

3.5.3 Overview of shares and trends in emissions

An overview of the trends in emissions is shown in Table 3.10. The emissions from NMVOC decreased between 1990 and 2010 due to improved abatement techniques.

Table 3.10 Overview of trends in fugitive emissions.

	NMVOC	PAH
Year	Gg	Mg
1990	47.3	0.01
1995	33.6	0.02
2000	29.3	0.00
2005	21.0	0.04
2009	15.2	0.03
2010	15.4	0.00
1990–2010 period [1]	-31.9	-0.01
1990–2010 period [2]	-67%	-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 derived from the environmental reports by the companies, covering 100% of the emissions (Tier-3 methodology).
The fugitive NMVOC emissions from category 1B2aiv comprise dissipation losses from gasoline service stations, leakage losses during vehicle and airplane refuelling and refinery processes. Emissions were calculated based on annual fuel consumption (Tier-2 methodology).
The fugitive NMVOC emissions from category 1B2b comprise emissions from gas transport (compressor stations) and gas distribution networks (pipelines for local transport). The NMVOC emissions from gas transport have been derived from the environmental reports by the companies, covering 100% of the emissions (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 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 sector and the methodologies used for calculating emissions from the transport sector. For all four source categories, national activity data and (mostly) country-specific emission factors were used for calculating emissions. 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, as shown in Table 4.1. Emissions from non-road mobile machinery are calculated using a Tier-3 method based on fuel used, mostly using national activity data and emission factors. Emissions from recreational craft are reported under 1A5b 'Other, mobile' and were calculated using a Tier-3 methodology. Emissions from fisheries are 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 calculation, are also described in general. A more detailed description of these methodologies and overviews of transport volumes, energy use and emission factors for these source categories, can be found in Klein *et al*. (2012).

4.1.1 Key sources

The different source categories within the transport sector are key sources for different pollutants, as is shown in Table 4.2. Some source categories are key sources for both the trend and the 2010 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.

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	NMVOC	CO	TSP	PM_{10}	$PM_{2.5}$	Pb	PAH
1A3bi	Passenger cars	4.3%	27.2%	14.1%	41.1%	5.3%	6.4%	12.1%	43.5%	5.4%
1A3bii	Light duty trucks		4.9%	1.9%	7.2%	4.6%	5.5%	10.5%		
1A3biii	Heavy duty vehicles	7.6%	21.4%		3.1%	5.9%	7.9%	11.6%		
1A3biv	Motorcycles and mopeds			4.0%	5.5%					
1A3bv	Gasoline evaporation			9.8%						
1A3bvi	Tyre and break wear					4.7%	5.0%	2.2%	7.4%	
1A3bvii	Road abrasion					3.9%	4.2%			
1A3di(ii)	International inland waterways		5.3%					3.0%		
1A3dii	National navigation		4.2%					2.7%		
1A2fii	Mobile Combustion in manufacturing industries and construction		4.0%					1.9%		
1A4aii	Commercial/institutional mobile				4,5%					
1A4bii	Residential household gardening (mobile)				10.4%					
1A4cii	Agriculture/forestry/ fishing: off-road vehicles and other machinery		3.7%					3.2%		
1A5b	Other, Mobile (including military, land based and recreational boats)			1.7%	6.9%					

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.

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) increased by 90% between 1990 and 2010, from 4.9 to 9.4

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
2009	2.67	4.05	0.24	0.09	0.051	0.051	0.039	2.61	0.0056	0.0007
2010	2.76	4.09	0.24	0.09	0.052	0.052	0.040	2.53	0.0057	0.0007
1990-2010 period [1]	1.40	-0.16	-0.16	-0.02	0.017	0.017	0.010	-1.10	-0.0042	-0.0005
1990-2010 period [2]	102%	-4%	-40%	-17%	50%	50%	33%	-30%	-43%	-40%

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

PJ. Amsterdam Airport Schiphol is responsible for over 90% of fuel consumption in 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 fuel consumption in 2009 due to the economic crisis, energy use at Schiphol increased again by 2% in 2010 compared to 2009. This is roughly in line with the trends in the number of air passengers (+4%) and the number of flights (-1%) at Schiphol.
Total fuel consumption in civil aviation at regional airports in the Netherlands remained fairly constant at 0.4 to 0.5 PJ between 1990 and 2003. Between 2003 and 2010, fuel consumption increased to 0.7 PJ. This can be attributed to an increase in the number of air passengers at regional airports. The number of passengers at Rotterdam Airport has increased by 50% since 2003, whereas the number of air passengers at Eindhoven Airport increased from 0.4 million to 2.2 million in this time span.
The trends in emissions from civil aviation in the Netherlands are shown in Table 4.3.

The increase in fuel consumption has led to an increase in emissions of NO_x, TSP, PM_{10} and $PM_{2.5}$. NO_x and PM_{10} emissions at Amsterdam Airport Schiphol show similar trends to the fuel consumption time series, with NO_x emissions increasing from 1.36 to 2.76 Gg between 1990 and 2010. Emission levels at regional airports have increased much faster than levels of fuel consumption, with NO_x emissions more than doubling between 2004 and 2010 (from 80 Mg in 2004 to 190 Mg in 2010).

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 Statistics Netherlands. These data have been used in the EMASA model from TNO to calculate fuel consumption and resulting emissions (see also Klein *et al*., 2012). EMASA 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 emissions due to tyre and brake wear were calculated from the maximum permissible take-off weight and the number of take-offs according to a methodology described by British Airways (Morris, 2007). The 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 (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 TIMCODE category (TIM = Time In Mode) 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

There was no data available on the division of aviation emissions into those from national and international aviation. Since by far most aviation in the Netherlands is international, all emissions from civil aviation are reported under 1A3ai 'International aviation'.

4.2.6 Uncertainties and time-series consistency

There was no recent and 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 calculated fuel consumption in civil aviation were compared with trends in LTOs and passenger numbers at Amsterdam Airport Schiphol and regional airports, see also Subsection 4.2.3.

4.2.8 Source-specific recalculations

In last year's submission, the emissions reported under domestic aviation consisted of the emissions at regional airports and the emissions at Amsterdam Airport Schiphol were reported under international aviation. There is no information on the division of total emissions between national and international aviation. Since by far most aviation in the Netherlands is international, all emissions from civil aviation are now reported under 1A3ai 'International 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 have not been included.

4.3.2 Key sources

The source category 1A3bi 'Passenger cars' is a key source of emissions of SO_2, NOx, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Pb and PAH. The source category 1A3bii 'Light duty trucks' is a key source of emissions of NO_x, NMVOC, CO, TSP, PM_{10} and $PM_{2.5}$. The source category 1A3biii 'Heavy-duty vehicles' is a key source for emissions of SO_2, NO_x, CO, TSP, PM_{10} and $PM_{2.5}$. The source category 1A3biv 'Motorcycles and mopeds' is a key source of emissions of NMVOC and CO. The source category 1A3bv 'Gasoline evaporation' is a key source of emissions of NMVOC. The source categories 1A3bvi 'Road vehicle tyre and brake wear' and 1A3bvii 'Road surface wear' are both key sources of emissions of TSP and PM_{10}. Source category 1A3bvi 'Road vehicle tyre and brake wear' is also a key source of emissions of $PM_{2.5}$ and Pb.

4.3.3 Overview of shares and trends in emissions

Road transport is a major contributor to air pollutant emissions in the Netherlands. The trends in emissions from road transport in the Netherlands are shown in Table 4.4.

Emissions from the main pollutants and particulate matter have decreased significantly throughout the time-series with the exception of NH_3, but road transport is only a minor source of NH_3 emissions. The decrease in emissions has mainly been caused by the introduction and subsequent tightening of EU emission standards for road vehicles. Emissions of SO_2 decreased by 98% between 1990 and 2010, 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). Emissions from heavy metals have increased, with the exception of Pb.

Table 4.4 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	13	0.90	15.5	15.5	13.8	246.2	0.03
1995	187	523	110	12	1.89	12.3	12.3	10.5	83.0	0.03
2000	155	425	68	3	2.50	10.4	10.4	8.5	5.1	0.04
2005	131	344	42	0	2.46	8.7	8.7	6.6	5.4	0.04
2009	114	306	31	0	2.49	7.5	7.5	5.3	5.6	0.04
2010	106	292	29	0	2.47	7.0	7.0	4.8	5.6	0.04
1990-2010 period [1]	-137	-405	-148	-12	1.58	-8.5	-8.5	-8.9	-240.5	0.01
1990-2010 period [2]	-56%	-58%	-84%	-98%	176%	-55%	-55%	-65%	-98%	30%

[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	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	0.78	0.69	0.20	0.21	50.4	0.28	0.01	34.4
2005	0.61	0.45	0.21	0.23	53.8	0.30	0.01	36.7
2009	0.48	0.36	0.22	0.24	56.3	0.32	0.01	38.2
2010	0.43	0.33	0.22	0.23	56.3	0.31	0.01	37.9
1990-2010 period [1]	-1.76	-1.15	0.06	0.06	4.4	0.07	0.00	8.3
1990-2010 period [2]	-80%	-78%	34%	35%	8%	31%	30%	28%

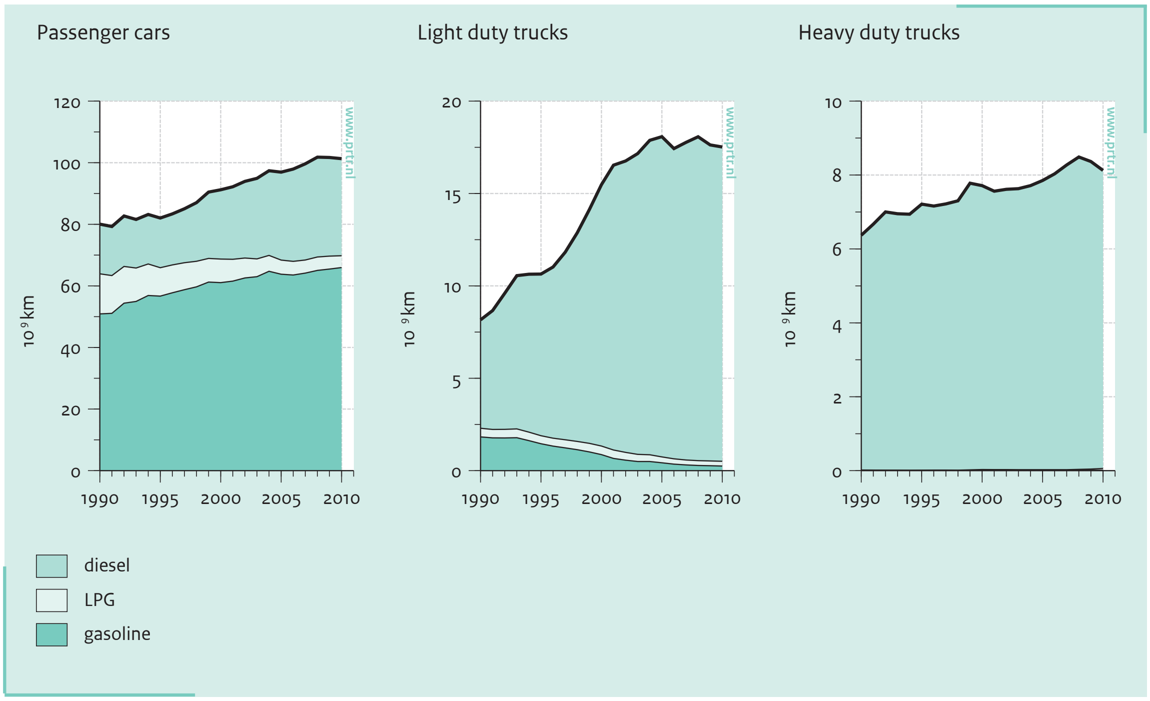
[1] Absolute difference in Gg [2] Relative difference to 1990 in %

1A3bi Passenger cars

The total number of kilometres driven in the Netherlands by passenger cars has steadily increased from approximately 80 billion kilometres in 1990 to over 100 billion kilometres in 2008 (see Figure 4.1). Between 2008 and 2010, the number of kilometres driven decreased slightly by 0.5%. This can be attributed to the economic crisis. The number of diesel kilometres has grown the fastest: since 1995, the share of diesel-powered passenger cars in the car fleet has grown significantly, leading to an increase in diesel mileages by more than 95% between 1995 and 2010. In comparison: gasoline mileages have increased by 16% 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 70% between 1990 and 2010. NO_x emissions from passenger cars have decreased by 75% between 1990 and 2010, from 138 Gg to 33 Gg. This decrease has been caused by the introduction of the (closed loop) three-way catalyst (TWC), which has led to a major decrease in NO_x emissions from gasoline-powered passenger cars (86% between 1990 and 2010). The NO_x emission standards for diesel-powered cars have been less stringent and the real-world NO_x emission reductions have been smaller than anticipated based on the tightening of the emission standards. Combined with the strong increase in diesel mileages, NO_x emissions from diesel-powered passenger cars have increased by more than 55% between 1995 (10 Gg) and 2008 (17 Gg). Since 2008, NO_x emissions have decreased slightly to 16 Gg in 2010.

NMVOC exhaust emissions from passenger cars have decreased significantly, from 97 Gg in 1990 to 18 Gg in 2010. This 81% decrease was primarily caused by the introduction of the TWC, leading to a decrease in NMVOC exhaust emissions from gasoline passenger cars from 80 Gg in 1990 to 17 Gg in 2010. NMVOC exhaust emissions from diesel and LPG-powered passenger cars have also decreased significantly. CO emissions from passenger cars have decreased by 60%, between 1990 and 2010. Gasoline passenger cars are responsible for over 90% of total CO emissions from passenger cars. The introduction of the closed-loop TWC has led to a major reduction in CO emissions: the average CO emission factor for the Dutch gasoline car fleet has decreased by 68% between 1990 and

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



2010. CO emissions from diesel and LPG passenger cars have also decreased significantly, but the share of both fuel types in total CO emissions remains small.

PM_{10} exhaust emissions from passenger cars have decreased by over 60% between 1990 and 2010. Both emissions from gasoline and diesel cars have decreased significantly throughout the time series due to the tightening of EU emission standards for new passenger cars. Emissions in 2010 were 1.9 Gg, down 0.2 Gg (10%) from 2009. This relatively large decrease in emissions is primarily caused by the increased market penetration of diesel passenger cars with diesel particulate filters (DPF) from 2006 on. In 2009, over 98% of newly registered diesel passenger cars were equipped with a DPF.

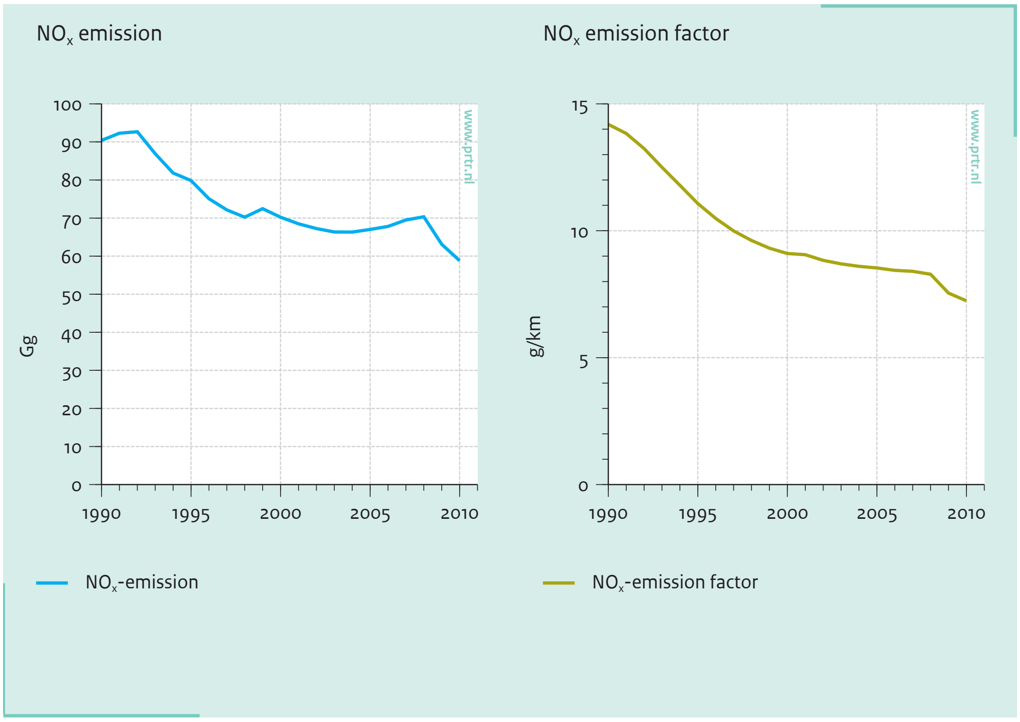
With the introduction of unleaded gasoline, Pb emissions from passenger cars decreased from 225 Mg in 1990 to 0.04 Mg in 1997. Since then, Pb is no longer present in exhaust emissions from road traffic.

1A3bii Light duty trucks

The light-duty truck fleet in the Netherlands has grown significantly since 1990, leading to a major increase in kilometres driven between 1990 and 2005 (see Figure 4.1). Since 2005, the fiscal regime for light-duty trucks has changed, making their private ownership 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 national truck 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 2000, but have slowly decreased since. NO_x emissions in 2010 were slightly lower than in 1990 (13.5 Gg vs. 14.9 Gg), even though the total vehicle kilometres driven have 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 2000, remained fairly constant between 2000 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. The fleet average NO_x emission factor for diesel light-duty trucks in the Netherlands has decreased by approximately 4% annually in recent years.

The exhaust emissions of NMVOC and CO from light-duty trucks have also shown a major decrease throughout the time series. NMVOC emissions decreased from 8 Gg in 1990 to 1 Gg in 2010, whereas CO emissions decreased from 40 to 6 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

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



gasoline and diesel trucks of 70 to 80% between 1990 and 2010. Gasoline-powered trucks emit far more NMVOC and CO than diesel-powered trucks; therefore, the decrease in gasoline-driven kilometres has had a major impact on the decrease in these emissions as well.

The exhaust emissions of PM_{10} from light-duty trucks have only started to decrease since 2000. 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 diesel 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 6% annually, between 2000 and 2010. Combined with the stabilisation of the amount of vehicle kilometres driven since 2005, this has led to a significant decrease in emissions since 2005.

1A3biii Heavy duty vehicles including buses

The vehicle kilometres driven by heavy-duty trucks and buses in the Netherlands have increased by approximately 28%, between 1990 and 2010 (see Figure 4.1). The economic crisis has led to a decrease in total vehicle kilometres of 4% between 2008 and 2010. Diesel dominates the national heavy-duty vehicle fleet in the Netherlands with a share of over 99%. Total NO_x emissions from heavy-duty vehicles decreased from 90 Gg in 1990 to 59 Gg in 2010 (see Figure 4.2). The fleet average NO_x emission factor decreased by 50% in this period, from 14 g/km to 7 g/km. This decrease has mainly been caused by tightening of EU emission standards for heavy-duty engines. NMVOC exhaust emissions decreased by 80%, from 10 Gg in 1990 to 2 Gg in 2010, whereas PM_{10} exhaust emissions decreased by 84%, from 5 Gg to 1 Gg. These decreases have also been caused by EU emission legislation.

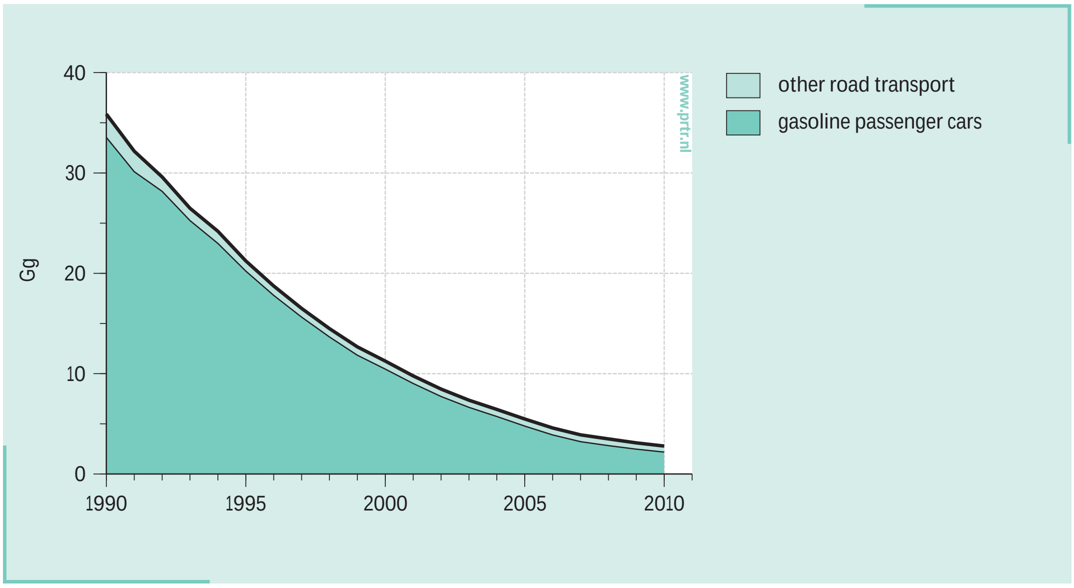
1A3biv Motorcycles and mopeds

The kilometres driven by motorcycles and mopeds have increased by 36%, between 1990 and 2010. NMVOC emissions from motorcycles and mopeds decreased from 25 Gg to 4 Gg, between 1990 and 2010, due to the introduction of European emission standards for two-wheelers. The emission standards have also led to a 29% decrease in CO emissions during this time period.

1A3bv Gasoline evaporation

Evaporative NMVOC emissions from road transport have decreased significantly due to the 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 3 Gg in 2010 (see Figure 4.3). Evaporative emissions from motorcycles and mopeds have increased by 40%, from 0.4 Gg in 1990 to 0.5 Gg in 2010.

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



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

PM_{10} emissions from brake wear, tyre wear and road surface wear increased by 24% between 1990 and 2010, 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 in the Netherlands were calculated using statistics on vehicle kilometres driven and emission factors expressed in grams per vehicle kilometer (g km^{-1}). Emissions of SO_2 were calculated using data on total fuel consumption and 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

The vehicle kilometres driven in the Netherlands by different vehicle types were calculated by Statistics Netherlands, using data on 1) the size and composition of the Dutch vehicle fleet, 2) average annual mileages for different vehicle types, and 3) data on 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 by Statistics Netherlands, using different data sources:

- The Dutch Mobility Survey (MON): the MON (formerly OVG) is an annual survey, held in the Netherlands, on travel behaviour of Dutch residents. The MON was used for data on the total kilometres driven in the Netherlands by passenger cars and mopeds.
- 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 data and uses this data combined with the data from RDW 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 average annual mileages were corrected for the amount of kilometres driven abroad, using different statistics.
- 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 vehicles (3) were estimated using different data

sources. For passenger cars, a distinction was made between trips including overnight stays (e.g. holiday, business trips) and trips without overnight stays (e.g. commuting, shopping, family visits). A survey by Statistics Netherlands on accommodations, during 1998 to 2004, has been used to estimate the number of vehicle kilometres driven on trips with an overnight stay. The estimation of kilometres driven without an overnight stay was based on a German survey on traffic intensities at 9 German-Dutch border-crossings, carried out in 1998 and in 2003. The years in between were interpolated and years since have been extrapolated. Traffic behaviour of foreigners during the 1990 to 1997 period was extrapolated with the use of data from the Dutch Mobility Survey (OVG) and the ratio between the kilometres driven by Dutch citizens and foreigners from 1998 to 2004.
The vehicle kilometres travelled by foreign trucks in the Netherlands 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 kilometres driven per vehicle category were also subdivided by road types. 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-duty and heavy-duty trucks. Subsequently, number plates were registered alongside different road types to differentiate these distributions according to fuel type and vehicle age. The resulting road type distributions for different vehicle categories have been reported in Klein *et al*. (2012).

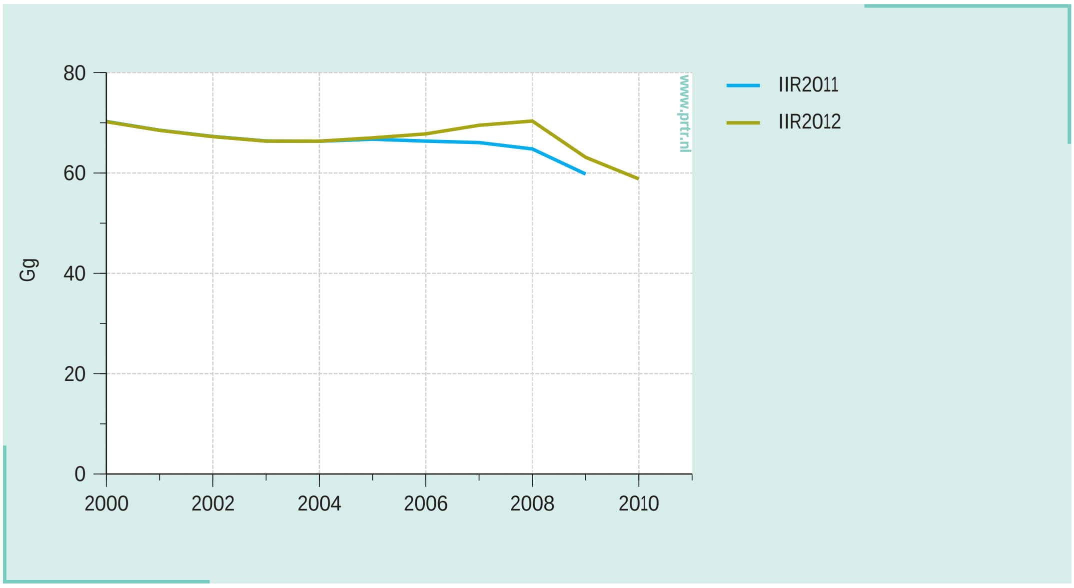
The fuel consumption per vehicle and fuel type was calculated by combining the data on vehicle kilometres driven per vehicle type with average fuel consumption figures (litre per vehicle kilometer driven). These figures on specific fuel consumption (litre/kilometer) were derived from surveys among owners of passenger cars, heavy-duty trucks and motorcycles.

Emission factors
The CO, NMVOC, NOx and PM exhaust emission factors for road transport were calculated by TNO with the VERSIT+ model (Smit *et al*., 2007). This model 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 has been 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 emission measurements, 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 a cold start. The extra 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*. (2012). 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 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).

Figure 4.4 Emissions of NO_x from heavy duty vehicles in last year's and this year's submission.



4.3.5 Methodological issues

The fuel consumption data (liters/kilometre) and NH_3 emission factors for all road vehicles have not been updated recently and therefore require revision.

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.

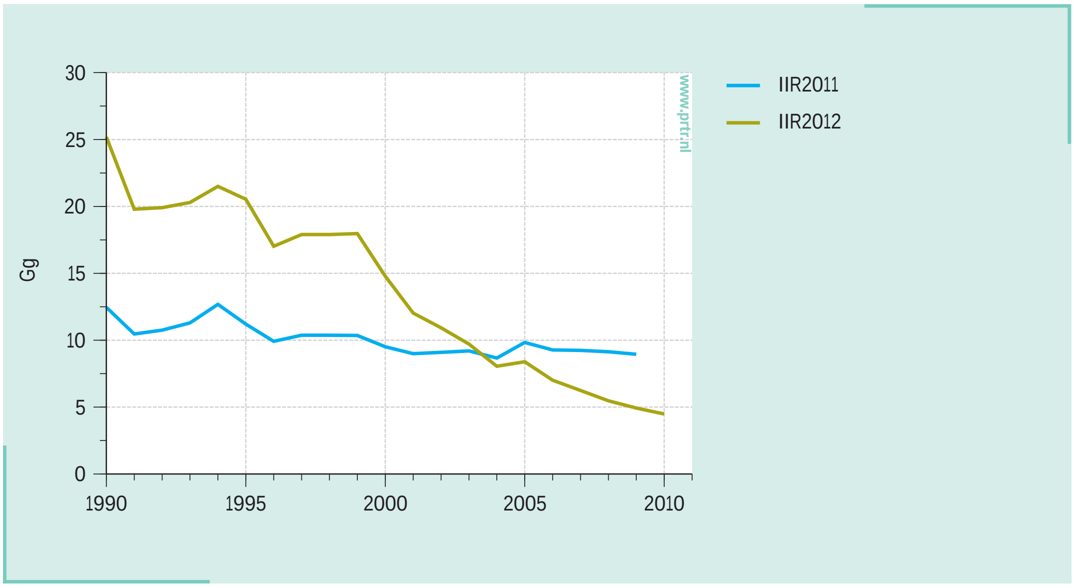
4.3.8 Source-specific recalculations

The NO_x emissions of heavy duty vehicles have been recalculated using new emission factors for Euro-IV trucks on motorways and new data on the share of Euro-III, Euro-IV and Euro-V trucks in de Dutch heavy-duty truck fleet. In 2009, on-road emission measurements on Euro-V trucks using a Portable Emission Measurement System (PEMS) showed that real-world NO_x emissions were higher than previously estimated, especially on urban roads (e.g. Ligterink *et al.*, 2009). Since Euro-IV and Euro-V trucks use similar technologies, the euro-IV emission factors were set at the same level as the new Euro-V emission factors. Last year, TNO made a new estimate of Euro-IV emission factors based on literature study (Hensema & Verbeek, 2010). This showed that NO_x emissions from Euro-IV trucks on motorways were actually higher than those from Euro-V trucks. The new emission factors have been used to recalculate NO_x emissions from heavy duty vehicles.

The share of Euro-III, Euro-IV and Euro-V trucks in the Dutch heavy duty truck fleet was also adjusted in the emission calculations. Since 2005, the Dutch government has introduced a subsidy programme to stimulate the early market penetration of Euro-IV and, later, Euro-V trucks in the Netherlands. The evaluation of this programme showed that between 2006 and 2007 the share of Euro-V trucks in new truck sales in the Netherlands increased significantly to over 60% (DHV, 2007). These insights have been taken into account. As a consequence of these new insights, NO_x emissions of heavy duty vehicles are higher than reported last year, see also Figure 4.4. Euro-IV trucks entered the Dutch market in 2005 and were sold until 2008. Therefore, the higher emission factors for Euro-IV trucks only affect the emissions from 2005 onwards. NO_x emissions of heavy duty trucks in 2008 are 5.6 Gg higher than reported last year. The decrease in total NO_x emissions of heavy duty vehicles from 2008 onwards is for the most part caused by the decrease in vehicle kilometres driven due to the economic crisis, see also Figure 4.1.

The emissions of motorcycles and mopeds have been recalculated using a new emission model that was developed by TNO (Dröge *et al.*, 2011). New emission factors were derived based on literature study and new data was collected on the size and age composition of the two wheeled vehicle fleet in the Netherlands. In the old

Figure 4.5 Emissions of NMVOC from motorcycles and mopeds in last year's and this year's submission.



emission model, the subsequent stages of European emission legislation for two-wheelers were not taken into account. The trends in emissions throughout the time series were therefore incorrect. The new model shows a much faster decline of NMVOC-emissions, as shown in Figure 4.5. As a consequence of using an average emission factor for all mopeds, the old time series showed only a minor decrease in emissions. In the new model, the subsequent stages of EU emission legislation for mopeds are taking into account. As a consequence, NMVOC emissions decrease from 25 to 4 Gg between 1990 and 2010.

NO_x emissions have increased throughout the time series due to technological adjustments aimed at reducing CO and HC emissions. PM_{10} emissions decrease over time but are higher than previously estimated. Especially older vehicles emit more PM_{10} than was previously expected (Dröge *et al*., 2011). Motorcycles and mopeds are only a small contributor to NO_x and PM_{10} emissions from road transport though.

4.3.9 Source-specific planned improvements

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

- New average annual mileages are being derived for motorcycles by Statistics Netherlands, 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). Unfortunately, the NAP register did not contain enough odometer readings to estimate average annual mileages for several vehicle types. Therefore a survey will be held among motorcycle owners next year to complement the NAP-data.
- TNO is preparing a study on the average load factors for heavy-duty trucks, using data from the '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 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.

4.4 Railways

4.4.1 Source-category description

The source category 1A3c 'Railways' includes emissions from all fuel sold to diesel-powered rail transport in the Netherlands. 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.

Table 4.5 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
2009	1.16	0.19	0.05	0.02	0.0002	0.05	0.04	0.04	0.28
2010	1.93	0.29	0.08	0.02	0.0003	0.07	0.06	0.06	0.29
1990 -2010 period [1]	0.32	0.03	0.01	-0.08	0.0000	0.01	0.01	0.01	0.07
1990 -2010 period [2]	20%	11%	9%	-84%	17%	14%	13%	13%	34%

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

4.4.3 Overview of emission shares and trends

Up until 2008, diesel fuel sales to railways remained fairly constant throughout the time series: in both 1990 and 2008, total energy use was 1.2 PJ. In 2009 diesel fuel consumption decreased by 26% compared to 2008. This decrease was mainly caused by the economic crisis leading to a decrease in traffic volume. Total freight transport by rail (in tonkm) decreased by 20% in 2009 according to Statistics Netherlands. The increasing share of electric traction in rail freight traffic also contributed to the decrease in diesel fuel consumption. The share of electric locomotives in the locomotive fleet used in the Netherlands increased from 10% to 40%, between 2007 and 2010 (Rail Cargo, 2007; 2011).
In 2010, diesel fuel consumption in railways increased by approximately 60% (0.5 PJ) to 1,4 PJ. This large increase can partly be explained by an increase in traffic volume of 15% in 2010 compared to 2009. Also in 2010 a new data source was used to obtain fuel sales data to railways, see Section 4.4.4.

The trends in emissions from railways in the Netherlands are shown in Table 4.5. NO_x and PM_{10} emissions from railways show similar trends to the diesel fuel consumption time series. NO_x emissions from Railways increased from 1.2 Gg in 2009 to 1.7 Gg in 2010, whereas PM_{10} emissions increased from 44 Mg to 62 Mg. Emissions of heavy metals are very low and therefore not shown in the table. SO_2 emissions from railways have decreased by more than 80% between 2007 and 2010 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 consumption data and country-specific emission factors. Up until 2009, information on diesel fuel sold to the railway sector, as reported by Statistics Netherlands in the Energy Balance, was obtained from the Dutch Railways (NS). In last year's submission it was noted that fuel sales to the railway sector in the Netherlands might be underestimated in the inventory. A research project by Ecorys (2010) showed higher diesel fuel sales in 2008. Therefore, fuel sales data to the railway sector in the Energy Balance is now derived from Vivens, a recently founded co-operation of rail transport companies that now purchases diesel fuel for the railway sector in the Netherlands. Vivens only has data available from 2010 onwards. This has led to an inconsistency in the time-series: diesel fuel sales to the railway sector in the Netherlands in 2010, as reported by Vivens, is 60% (0.5 PJ) higher than diesel fuel sales in 2009, as reported by NS. This increase can only partially be explained by the increase in transport volumes of approximately 15% between 2009 and 2010. In 2012 Statistics Netherlands will assess if an adjustment of the historical time series is required.

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. Due to the use of a different data source for fuel sales to the railways sector, there is an inconsistency in the time series, see also Section 4.4.4.

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 showed good agreement up until 2009. As was reported in Section 4.4.3, total fuel sales to rail transport might have been underestimated. This will be sorted out in 2012 and, if necessary, adjusted in next year's submission.

4.4.8 Source-specific recalculations

There were no source-specific recalculations for railways.

4.4.9 Source-specific planned improvements

In 2012 Statistics Netherlands will assess if fuel sales data have been underestimated until 2009 and if an adjustment of the time series is required.

4.5 Waterborne navigation and recreational craft

4.5.1 Source-category description

The source category 1A3d 'Waterborne navigation' includes emissions from national (1A3di(ii)) and international (1A3dii) inland navigation in the Netherlands and from international maritime navigation (1A3di(i)). The emissions from recreational craft are reported under 1A5b 'Other mobile' but are also described in this Section.

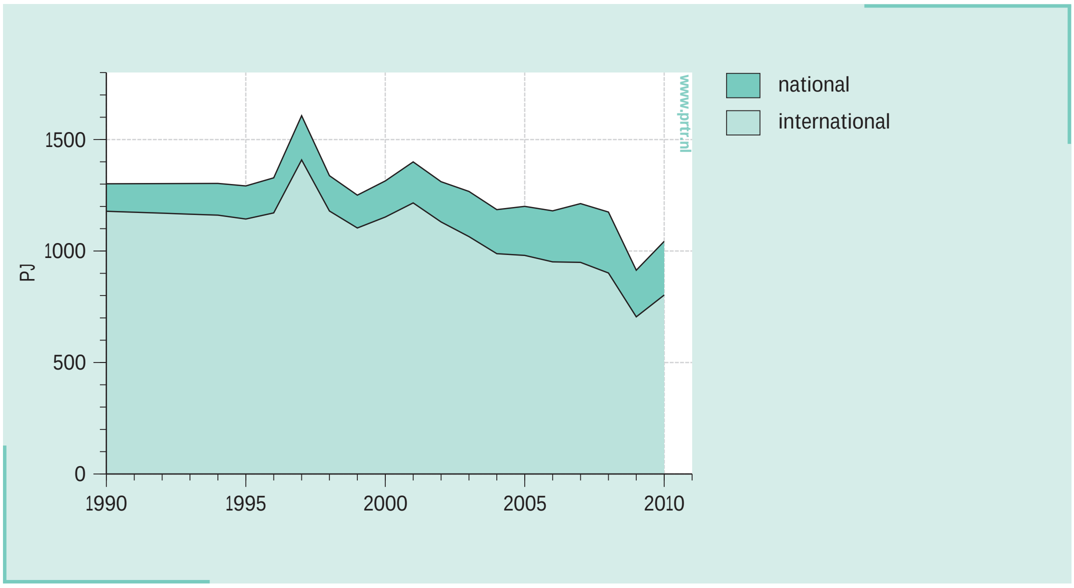
4.5.2 Key sources

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 NMVOC and CO.

4.5.3 Overview of emission shares and trends

Fuel consumption in international inland navigation decreased slightly between 2001 and 2008 from 18 to 16 PJ. The year 2009 saw a major drop in fuel consumption of 22%, which can be attributed to the economic crisis and the resulting drop in freight transportation. In 2010 fuel consumption increased again by 14% (2 PJ) due to the recovery of transport volumes. Fuel consumption for national inland navigation, including passenger vessels and ferries, has remained fairly constant in recent years (see Figure 4.6). Fuel consumption from recreational craft increased from 2 PJ in 1990 to 2.5 PJ in 2010. In recent years, fuel consumption has been fairly constant.

Figure 4.6 Fuel consumption in national and international inland shipping in the Netherlands.



The trends in emissions from inland shipping in the Netherlands are shown in Table 4.6.

Emissions of NO_x, CO, NMVOC and PM from inland navigation have shown similar trends to the fuel consumption time series. SO_2 emissions from waterborne navigation have decreased by more than 70% between 2007 and 2010 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).

4.5.4 Activity data and (implied) emission factors

Fuel consumption and emissions from inland waterborne navigation (both national and international) were calculated using a Tier-3 method. The methodology for calculating the emissions was developed as part of Emissieregistratie en Monitoring Scheepvaart (EMS). The emission calculation was conducted in two steps for each vessel class. In total, 28 vessel classes have been distinguished. The calculation of the emissions has been based on the energy consumption per vessel class. For all 28 vessel classes, the power demand (kW) was calculated for the various inland waterway types and rivers in the Netherlands. A distinction was made between loaded and

Table 4.6 Trends in emissions from Inland shipping 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	29	8	2.0	2	0.01	1.31	1.31	1.25
1995	25	7	1.8	2	0.01	1.32	1.32	1.25
2000	28	7	1.7	2	0.01	1.31	1.31	1.24
2005	27	6	1.5	2	0.01	1.15	1.15	1.10
2008	22	5	1.1	1	0.00	0.85	0.85	0.81
2009	23	5	1.2	1	0.01	0.86	0.86	0.81
1990 -2010 period [1]	-6	-3	-0.8	-1	0.00	-0.45	-0.45	-0.43
1990 -2010 period [2]	-20%	-38%	-41%	-72%		-35%	-35%	-35%

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

unloaded vessels. In addition, the average speed, of the various vessel classes has been ascertained 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*

The formula in the text box was 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) on the Dutch inland waterways.

The combination of the number of vessels, their power and their speed is the explanatory variable for emissions. The unit of the explanatory variable for emissions is kWh. The emission factor is expressed in kg/kWh, the same unit that is used to express emission standards. The emission factors are dependent on the engine's year of construction. The average emission factor is determined by a distribution of ship engines over the various years of construction classes to which emission factors have been linked. This distribution is calculated by means of a Weibull function. The values of the Weibull parameters (κ and λ) have been derived from sample survey by telephone, carried out by TNO among the captains of 146 vessels. They were asked about the age of the ship and the age of the ship's engine. By means of a smallest square estimate the optimal values for κ and λ have been determined to be 1.2 and 1.3. The median age of the engines in the survey was 9.0 years and the average age was 14.9 years.

For calculating the emission formula in the text box, a calculation model was designed. This model is managed by TNO. The calculation protocols and backgrounds of the EMS form the basis of the emission calculations (Hulskotte *et al*., 2005). In the emission calculations for inland shipping, a distinction is made between primary engines intended for propelling the vessel, and auxiliary engines required for manoeuvring the vessel (bow propeller engines) and generating electricity for the operation of the vessel and the residential compartments (generators).

No recent information was available on the fuel consumption in passenger ships and ferries, therefore the fuel consumption data for 1994 were applied to all subsequent years. 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. 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*. (2012).

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.

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

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.

4.5.7 Source-specific QA/QC and verification

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

4.5.8 Source-specific recalculations

The emissions from recreational craft are reported separately in the inventory this year under 1A5b 'Other mobile'. In last year's submission, emissions from recreational craft were reported under 1A3d ii 'National navigation'.

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 by 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 by enterprises and private persons, such as of 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

The source category 1A4cii 'Agriculture/forestry/fishing: off-road vehicles and other machinery' is a key source of emissions of NO_x and $PM_{2.5}$, whereas the source categories 1A4aii 'Commercial/institutional mobile' and 1A4bii 'Residential: household and gardening (mobile)' are key sources of emissions of CO.

4.6.3 Overview of shares and trends in emissions

Fuel consumption in non-road mobile machinery has fluctuated between 35 PJ and 40 PJ throughout the time series. Energy use in 2010 was approximately 6% lower than in 2009 due to the effects of the economic crisis, which led to a decrease in energy use by mobile machinery in the industrial sector (-7%) and in construction (-12%). Figure 4.7 shows the fuel consumption within the different sectors where mobile machinery is applied. Construction and agricultural machinery are responsible for approximately 80% of total energy use. Diesel is the dominant fuel type, with 87% of energy use in 2010 coming from diesel fuel. Gasoline and LPG have a share of 5% and 8% respectively in total energy use. LPG is used in the

Table 4.7 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	56	6.0	3	0.01	1.67	1.67	1.59
2009	24	55	4.6	1	0.01	1.20	1.20	1.14
2010	22	55	4.2	0	0.01	1.06	1.06	1.01
1990 -2010 period [1]	-12	18	-3.3	-3	0.00	-2.21	-2.21	-2.09
1990 -2010 period [2]	-36%	47%	-44%	-92%	-3%	-67%	-67%	-67%

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

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

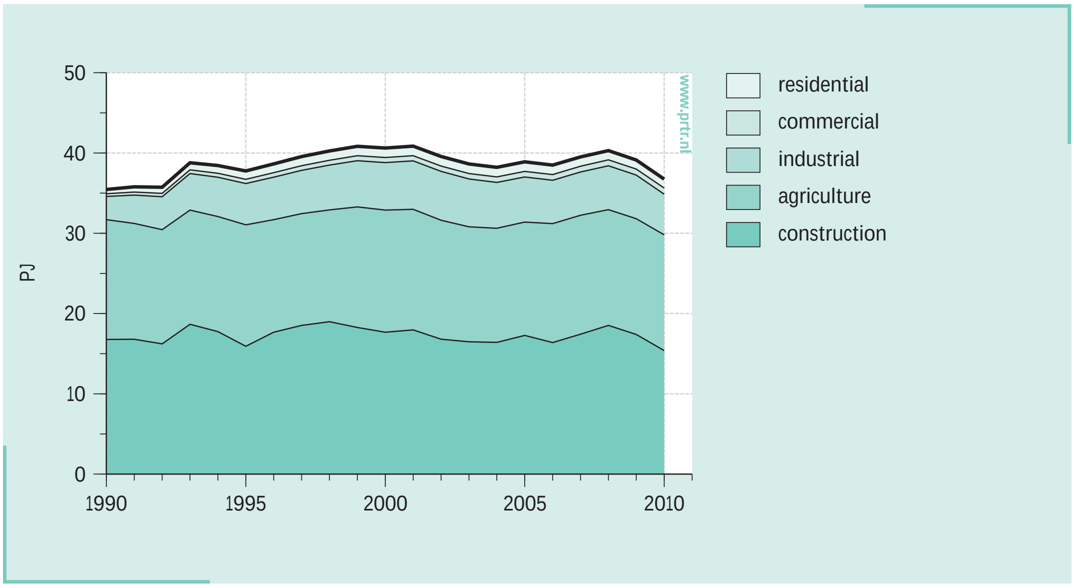
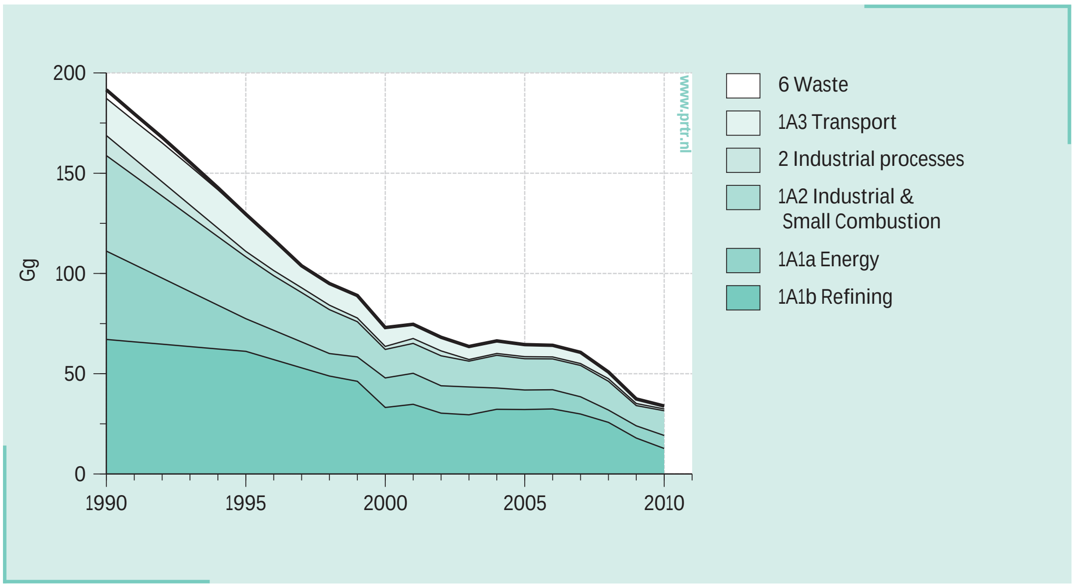


Figure 4.8 NO_x emissions by 5 different types of non-road mobile machinery in the Netherlands.



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 4.7.

Between 1990 and 1999, the time series for NO_x emissions from non-road mobile machinery showed similar trends to the time series of fuel consumption (see Figure 4.8).

With the introduction of EU emissions standards for non-road mobile machinery in 1999 and the subsequent tightening of these emission standards in later years, NO_x emissions of non-road mobile machinery have steadily decreased. Since 1999, NO_x emissions have decreased by 44%, whereas fuel consumption has only decreased by 10%. NO_x emissions of gasoline and LPG machinery are not regulated. Combined with the increase in gasoline and LPG fuel consumption, NO_x emissions from gasoline-and LPG-powered machinery have steadily increased throughout the time series. In 2010, gasoline and LPG machinery had a combined share of 18% in total NO_x emissions, whereas in 1990 their combined share was only 5%.

Emissions from most other substances have also decreased significantly throughout the time series. For CO 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. Also in recent years, sulphur-free diesel fuel has been used by part of the non-road mobile machinery fleet (see also Subsection 4.6.4). The use of sulphur-free diesel fuel will be required from 2011 onwards, but the early introduction of sulphur-free fuel has led to a further decrease in SO_2 emissions in recent years. The decrease in sulphur content has also led to a (further) decrease in emissions of particulate matter.

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:

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 (hours)
- 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 (emission standard, 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 LEI. 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.

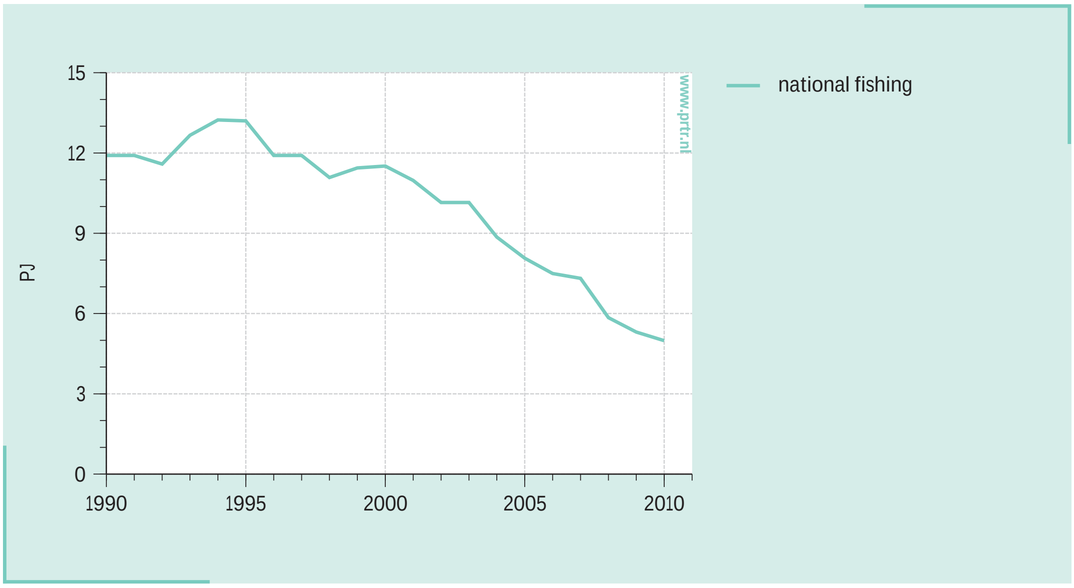
4.6.8 Source-specific recalculations

In this year's submission, energy use and emissions from forklift trucks in the Netherlands have been recalculated using adjusted load factors and average engine power (kW). New sales data for LPG forklift trucks showed an average engine power of 50 kW, whereas the average engine power in the EMMA model was previously set at 30 kW (Hulskotte and Verbeek, 2009). The average engine load factor of diesel and LPG forklift trucks was previously estimated to be 78%, but has now been reduced to 60%. This is more in line with figures that are used internationally (e.g. EPA, 2010). Also, in the Belgian version of the EMMA, the load factor for forklift trucks was also set to 60% after a workshop with sector representatives (TML and TNO, 2005). The readjustment of the load factor for diesel forklift trucks has led to a decrease of (calculated) diesel fuel consumption of approximately 1% (0.3/0.4 PJ) in the time series. The adjustments of the average engine power and load factors for LPG forklift trucks combined have led to an increase in the estimated LPG fuel consumption in forklift trucks of approximately 1 PJ throughout the time series. As a consequence of both changes, total NO_x emissions from forklift trucks are approximately 0.5 Gg (1-2%) higher than reported last year throughout the entire time series. The increase in energy use and resulting emissions from LPG forklift trucks more than compensates the decrease in energy use and emissions from diesel trucks. Since PM_{10} emissions from LPG forklift trucks are very low, the time series for PM_{10} has decreased slightly (1%) due to the decrease in energy use by diesel trucks.

4.6.9 Source-specific planned improvements

There are no source-specific planned improvements for non-road mobile machinery.

Figure 4.9 Fuel consumption by the fishing fleet in the Netherlands.



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.

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

Fuel consumption in national fishing has shown a decreasing trend (see Figure 4.9).

Since 1995, fuel consumption in national fishing has decreased by 8 PJ (62%). This is in line with the decrease in the number of cutter vessels (32%) and the installed engine power in the cutter fleet (50%) between 1995 and 2009, as reported by Statistics Netherlands (figures for 2010 are not yet available).
The trends in emissions from national fishing are shown in Table 4.8.

Emissions from national fishing show similar trends to fuel consumption, since the same emission factors were used

Table 4.8 Trends in emissions for Inland shipping 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
2009	7.3	1.0	0.3	0.1	0.17	0.17	0.17
2010	6.9	0.9	0.3	0.1	0.16	0.16	0.16
1990 -2010 period [1]	-9.6	-1.3	-0.4	-0.9	-0.23	-0.23	-0.22
1990 -2010 period [2]	-58%	-58%	-58%	-0.9	-58%	-58%	-58%

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

for the entire time series. NO_x emissions decreased from 16.5 to 6.9 Gg between 1990 and 2010, whereas PM_{10} emissions decreased from 0.39 to 0.16 Gg.

4.7.4 Activity data and (implied) emission factors

Because fuel sales to the fishing sector in the Netherlands cannot be distinguished from the sales data for bunker fuels, as reported by Statistics Netherlands, fuel consumption in fishing was derived from calculations based on vessel movements. These calculations are performed by the LEI 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 4.3.3.

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 of 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
2009	0.5	19.4	1.0	1.1	11.2	8.4	3.5
2010	0.5	21.5	0.9	1.2	12.0	8.9	3.8
1990 -2010 period [1]	-4.5	-31.4	-9.1	-2.9	-32.4	-17.3	-9.5
1990 -2010 period [2]	-90%	-59%	-91%	-71%	-73%	-66%	-71%

	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
2009	26.68	0.80	0.29	2.04	0.50
2010	31.51	0.96	0.33	1.81	0.19
1990 -2010 period [1]	-35.59	0.06	-0.90	-35.69	-10.64
1990 -2010 period [2]	-53%	7%	-73%	-95%	-98%

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

5.1.1 Key sources

Because of a change in the allocation of emissions to another sector, decreased emission levels and error corrections, the following (sub)categories are from now on no longer a key source in the industrial processes sector:

- 2A1 Cement Production for Hg (error correction)
- 2A7 Other, specified in categories a-c and d further specified for Hg (error correction)
- 2C1 Iron and Steel Production for Dioxines and PAH (decreased emission levels)
- 2C3 Aluminium Production for PAH (decreased emission level)
- 2C3 Aluminium Production for CO (reallocation)

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 SBI 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

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

where

ER-I = Emission Registration database for individual companies

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

Subsequently, total process emissions in this SBI category were calculated from the production data, as provided in

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

Category / Sub-category		Pollutant	Contribution to total in 2009 (%)
2A7	Other, specified in categories a-c and d further specified	TSP / PM_{10} / $PM_{2.5}$	3.4 / 4.0 / 2.9
2B5	Other Chemical Industry	NMVOC TSP / PM_{10} / $PM_{2.5}$	2.0 6.0 / 4.6 / 6.5
2C1	Iron and Steel Production	TSP / PM_{10} / $PM_{2.5}$ Pb Cd Hg	9.5 / 4.9 / 5.9 68.5 32.9 45.1
2D2	Food and Drink	NMVOC TSP / PM_{10}	3.4 6.5 / 6.3
2G	Other production, Consumption, storage, transportation or handling of bulk products	NMVOC TSP / PM_{10} / $PM_{2.5}$	8.3 7.0 / 8.3 / 5.0

the Production Statistics (Statistics Netherlands), multiplied by the implied emission factor.

$$\text{ERI\_SBI\_Emission}_{\text{(SBI category)}} = \text{Emission factor ER-I}_{\text{(SBI category)}} * \text{Production}_{\text{(SBI category)}}$$

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 for which there is no (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

Incomplete Hg time series in 2B5a have been repaired.

5.1.5 Source-specific planned improvements

In subsequent submissions, incomplete TSP and Cd time series will be repaired, as far as possible.

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 source for PM_{10} and $PM_{2.5}$.

5.2.3 Overview of emission shares and trends

From 1990 to 2010 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 0.45 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 CO_2 and N_2O 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} and $PM_{2.5}$.

5.3.3 Overview of emission shares and trends

From 1990 to 2010, NMVOC emissions decreased from 10 to 3 Gg, and PM_{10} emissions from 4.1 to 1.3 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;
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

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% of the total dioxines and for 2.2% of the total PAH emissions in the Netherlands.

Table 5.3 Overview of emissions from 2C1.

Pollutant	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
PM_{10}	*Gg*	8.90	4.56	0.35	1.68	1.52	1.61	1.64	1.61	1.56	1.68	1.46	1.33	1.41
$PM_{2.5}$	*Gg*	5.66	2.81	0.23	1.07	0.97	1.01	1.02	1.02	0.99	1.07	0.93	0.85	0.90
Pb	*Mg*	55.74	57.46	18.84	23.01	26.93	24.65	25.42	22.95	22.39	28.84	23.38	24.45	29.86
Cd	*Mg*	0.69	0.41	0.41	0.63	0.92	0.71	0.69	0.66	0.69	0.91	0.73	0.69	0.83
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
DIOX	*g I-Teq*	23.00	26.50	1.75	1.47	2.10	1.74	1.87	1.50	1.91	2.25	2.26	2.04	1.81
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

Table 5.4 Overview of PAH emissions from 2C3.

Pollutant	Unit	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
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

Most of the emissions from this source decreased during the 1990–2000 period. These reductions were mainly caused by the implementation of technical measures. Since 2000, emissions have remained rather stable.

Aluminum Production (2C3)

Although Aluminum Production (2C3) is no key source, this source is responsible for 2.9% 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.

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 2 was used for estimating the emissions from 2C1.

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 2010, 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. Compared with the last submission some NMVOC sources and thus the corresponding emission figures from the 2G category have been reallocated. In this submission these sources have been allocated in the 3A2 category.

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 2010 NMVOC emissions decreased from 30 to 12 Gg. The contribution of storage and handling was 15 Gg in 1990 and 12 Gg in 2010. The PM_{10} emissions decreased from 5 to 2.4 Gg during the period 1990-2010. The contribution of storage and handling was 1.5 Gg in 1990 and 0.9 Gg in 2010.
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). Compared with the last submission some NMVOC sources (paint use) and thus the corresponding emission figures from the 2G category have been reallocated. In this submission these sources are allocated in the 3A2 category.

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
2009	54.2	1.09	1.24	1.24	0.41	15.5	0.04
2010	53.8	1.08	1.18	1.18	0.39	15.0	0.04
1990 -2010 period [1)]	-79.6	0.10	0.13	0.13	0.04	-10.0	-2.45
1990 -2010 period [2)]	-60%	10%	12%	12%	12%	-40%	-98%

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

6.1.1 Key sources

3A1, Decorative coating application has been added as key source in the Solvents and product use (NFR 3) sector.

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 2009 (%)
3A1 Decorative coating application	NMVOC	2.0
3A2 Industrial coating application	NMVOC	10.1
3D1 Printing	NMVOC	2.7
3D2 Domestic solvent use including fungicides	NMVOC	12.7
3D3 Other product use.	NMVOC TSP / PM_{10} / $PM_{2.5}$ DIOX	6.0 3.4 / 4.1 / 2.6 49.3

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

Table 6.3 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	191	10.7

6.2.2 Key sources

Decorative coating application (3A1) and Industrial Coating application (3A2) have been identified as key sources 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 6.1) NMVOC emissions from Decorative paint application (3A1) decreased from 13.5 Gg in 1990 to 2.9 Gg in 2010. NMVOC emissions from industrial paint use decreased from 71.0 Gg in 1990 to 18.0 Gg in 2008, mainly due to the lower average NMVOC content of the used paint (see Table 6.1). As a result of the credit crunch, paint consumption decreased in both 2009 and 2010. For that reason, the emissions decreased to 15.2 Gg in 2010.

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 the protocol 'Calculation of NMVOC emissions from paint use in the Netherlands' (Peek, 2010).

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 in both 2009 and 2010. For that reason, the emissions decreased to 4.1 Gg in 2010.

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 2010. These extra emissions were caused by the increased consumption of Cosmetics, Cleaning agents and Car products during the period 1990–2010.

Other product use (3D3)
The most important NMVOC sources are Cleaning agents and Refrigerants. NMVOC emissions decreased from 15.3 Gg in 1990 to 9.1 Gg in 2010. These reductions were mainly caused by the lower average NMVOC content of the cleaning agents. Dioxin emissions originate from PCP treated wood. Since 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 15 g I-TEQ in 2010.

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 become available for the emission inventory. For the period 2008-2010 the emissions were calculated with the help of 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). Since 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.

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, emissions from category 4G are not reported on 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) from categories 4B and 4D are reported in the National Inventory Report (NIR). Therefore, the IIR focuses on ammonia (NH_3), nitric oxide (NO) and particulate matter (PM) emissions from 4B and 4D.

The agricultural sector is responsible for more than 90% 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), laying hens (4B9a) and broilers (4B9b) have also been identified as key sources for NH_3.

Laying hens (4B9a), broilers (4B9b) and swine (4B8) have been identified as key sources for PM_{10} and TSP emissions.

7.1.2 Trends

NH_3 emissions have decreased sharply between 1990 and 2010, with a significant reduction in the first few years of the time series. This decrease has been the result of policy changes in the application of manure, resulting in manure being incorporated into the soil instead of being surface spread. Although in recent years animal numbers are again slightly increasing, the whole period shows a decreasing trend because of higher productions per animal coupled with quotas. However the main reason for the decrease in emissions is the on-going improvement in diets, leading to lower N excretions per animal. Since the 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 2009 to 2010, mainly due to increasing animal numbers.

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, have not been estimated. From this year on, rabbits and fur bearing animals are being reported under 4B13 Other livestock.

7.2.2 Key sources

Dairy cattle (4B1a) are the largest contributors to NH_3 emissions, at 29.6% of the national total. Swine (4B8) and non-dairy cattle (4B1b) are key sources that contribute for 19.2%and 15.3%, respectively. Laying hens (4B9a; 7.5%) and broilers (4B9b; 4.2%) are also key sources for NH_3 within the manure management category.

At 7.6% laying hens (4B9a) are the second largest contributor to the national total PM_{10} emissions, and also form an important source of TSP by adding 6.4%. Broilers (4B9b) are responsible for 4.8% of the emissions of PM_{10} and 4.0% of TSP. Swine (4B8) contribute 4.6% and 3.9% 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	7.9	320	3.88	3.88	0.44
1995	7.8	175	3.94	3.94	0.44
2000	6.8	133	4.40	4.40	0.47
2005	6.2	109	4.69	4.69	0.45
2009	6.7	99	5.19	5.19	0.48
2010	6.8	97	5.29	5.29	0.48
1990-2010 period [1]	-1.1	-224	1.41	1.41	0.04
1990-2010 period [2]	-14%	-70%	36%	36%	10%

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

Between 1990 and 2010 NH_3 emissions have reduced by 70%, 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 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 resulting from the application of manure and synthetic fertilizer are considered to be related to land use and thus not reported under this category.

7.2.4 Activity data and (implied) emission factors

NH_3 and NO emissions from animal manure management were calculated using the National Emission Model for Ammonia (NEMA), managed by Statistics Netherlands

Table 7.2 Animal numbers 1990-2010 (in 1,000 heads), including privately owned horses.

Animal type	1990	1995	2000	2005	2008	2009	2010
Cattle	4,926	4,654	4,070	3,799	3,890	3,968	3,975
- Adult dairy cattle	1,878	1,708	1,504	1,433	1,466	1,489	1,479
- Adult non-dairy cattle	120	146	163	152	127	123	115
- Young Cattle	2,929	2,800	2,403	2,214	2,297	2,355	2,381
Sheep	1,702	1,674	1,308	1,363	1,213	1,117	1,130
Goats	61	76	179	292	355	374	353
Horses	370	400	418	433	144	145	141
Pigs (*1000)	13.9	14.4	13.1	11.3	12.0	12.2	12.3
Poultry (*1000)	95.6	92.2	107.2	95.9	99.7	100.0	104.4

Source: CBS, 2011.

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

	1990	1995	2000	2005	2008	2009	2010	Change 2010 - 1990 (%)
Nitrogen fertilizer consumption	412.4	405.8	339.5	279.2	238.1	225.7	219.5	-47
Nitrogen excretion by animals	710.4	696.0	565.2	494.9	506.0	499.0	504.6	-29
Nitrogen excretion in animal houses	514.5	516.1	432.6	393.7	413.0	418.1	423.3	-18
- of which in solid form	102.1	104.3	94.8	88.4	93.6	95.2	96.5	-5
- of which in liquid form	412.4	411.8	337.7	305.2	319.4	322.9	326.8	-21
Nitrogen in manure exported abroad/incinerated	5.9	22.4	18.0	26.2	38.3	38.8	36.1	517
Available manure for application	410.5	399.9	336.4	299.0	301.5	300.3	293.4	-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	93.0	80.8	81.3	-59
Nitrogen in sewage sludge on agric. land	5.0	1.5	1.5	1.2	1.0	0.9	0.9	-82
Total nitrogen supply to soil	1121.9	1080.9	888.2	749.1	706.9	686.7	688.8	-39
(manure + fertilizer + sewage sludge - export)								
N_2O-N emission fertilizer application	5.4	5.3	4.4	3.6	3.1	2.9	2.9	-47
N_2O-N emission animal houses	2.4	2.4	2.1	1.9	2.0	2.0	2.1	-14
N_2O-N emission manure application	1.6	3.5	2.9	2.6	2.6	2.6	2.5	55
N_2O-N emission pasture	6.5	5.9	4.4	3.3	3.1	2.7	2.7	-59
N_2O-N emission sewage sludge	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-82

(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).

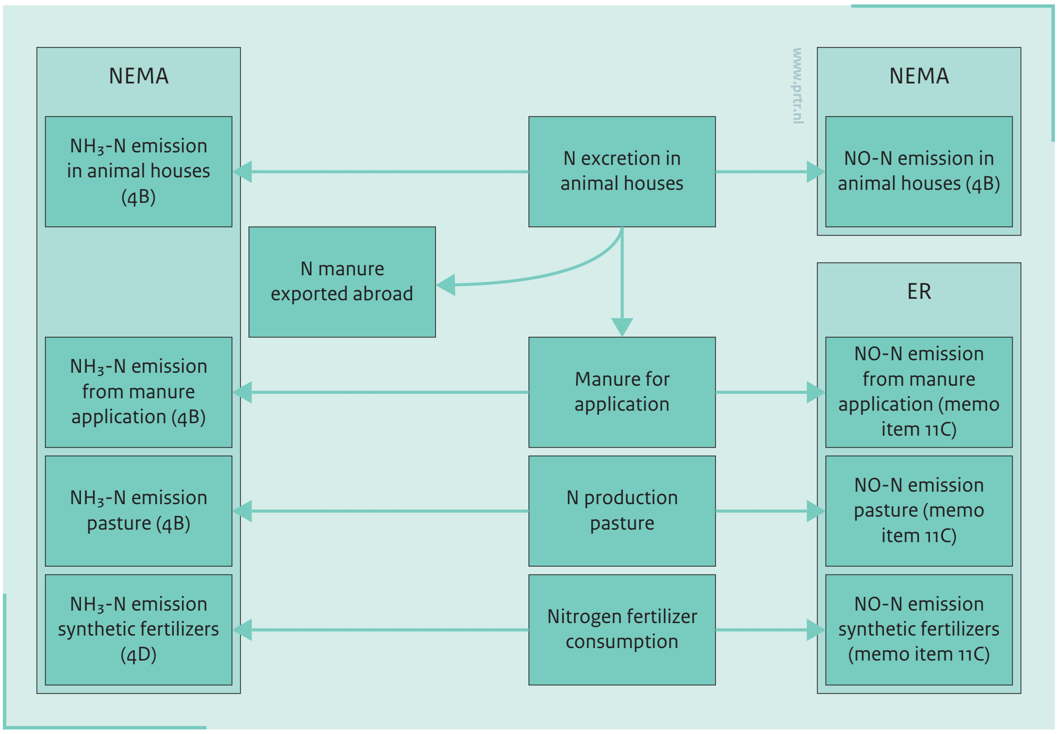
For horses an estimation of 300,000 extra heads is taken up in the inventory, to account for privately owned animals. Emissions of NH_3 and PM from manure management are reported under 7A Other, but included in the N-flows presented here.

A distribution was made of animals over the various housing types, and corresponding emission factors were applied for NH_3, N_2O, NO 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 was allocated to pasture and arable land. Given implementation grades of application techniques and associated emission factors, this then results in the NH_3 that is being emitted. Because NEMA focuses on NH_3 and does not need NO emission for the calculation, this amount has been assessed by 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 emissions, including calculation method and their allocation.

Figure 7.1 Nitrogen flows in relationship to NH_3 and NO_2 emissions



In table 7.3 a summary of associated N-flows is given for the 1990-2010 period within the inventory.

While synthetic fertilizer use and N-excretion by animals decreased considerably in the 1990-2010 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 90s, 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 originate mainly from skin, manure, feed and bedding particles ventilated from animal housing. Previous emission factors were possibly outdated and not very precise, thus between 2007 and 2009 a measurement programme was conducted by Wageningen UR Livestock Research. 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). Stable 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 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 the current submission. However as source data also lacked uncertainty estimates, these needed to be assessed first and NEMA calculations had to be postponed for a year.

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.

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

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.

In the measurement program towards PM-emissions from animal housing publications came available for rabbits and fur bearing animals. These animals have now been taken up in the inventory for fine dust. Emissions are reported under 4B13 Other livestock, including those of NH_3 and NO (accounted for in 4B9 previously).

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 8.2% of the national total.

7.3.3 Overview of shares and trends in emissions

Table 7.4 presents an overview of emissions of the main pollutant NH_3, together with the particulate matter species TSP, PM_{10} and $PM_{2.5}$ originating from this category.

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
2009	9.8	0.77	0.77	0.11
2010	10.0	0.76	0.76	0.11
1990-2010 period [1]	-3.9	-0.01	-0.01	0.00
1990-2010 period [2]	-28%	-1%	-1%	0%

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

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. For the Pollutant Release and Transfer Register (PRTR), 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.

Last year synthetic fertilizer statistics were not available on time, and are therefore included in this submission.

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).

Wastewater handling (6B)
The emissions of industrial and urban Wastewater 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 this 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_{25}	Hg	DIOX
	Gg	Gg	Gg	Gg	Gg	Mg	g I-Teq
1990	1.5	0.00	0.006	0.006	0.006	0.06	0.00
1995	1.3	0.28	0.013	0.012	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	0.24	0.005	0.005	0.005	0.08	0.20
2010	0.6	0.21	0.005	0.005	0.005	0.09	0.20
1990 -2010 period [1]	-0.9	0.21	0.000	0.000	0.000	0.04	0.20
1990 -2010 period [2]	-61%	4428%	-8%	-8%	-8%	63%	

[1] Absolute difference in Gg [2] Relative difference to 1990 in %
* Period 1995-2010

Table 8.2 Relevant key sources in the Waste sector (NFR 6).

Category / Sub-category	Pollutant	Contribution to total (%)		
		Level 1990	Level 2010	Trend 1990-2010
6Cd Cremations	Hg	no key source	12.9	11.2

8.1.1 Key sources

In the sector Waste the only key source is mercury (Hg) coming from cremations (Table 8.2).

8.1.2 Methodological issues

Waste incineration (6C)
The total emissions for the source category Waste incineration were based on the annual environmental reports from the individual companies (ENINA, 2007). All incineration plants submit an annual environmental report to the EPRTR and the AER database (see Section 1.3.1).
The emissions from 6Cd Crematoria were estimated based on the number of cremated corpses, their average amalgam content and the degree of implementation of reduction techniques (Nijdam and Koch, 2007).

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

In 2012 new data on implementation of emission reducing technology will come available.

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.

Table 8.3 Overview of the key source emissions from Cremations (NFR 6Cd).

Pollutant	Year								
	1990	1995	2000	2005	2006	2007	2008	2009	2010
Hg (Mg)	0.06	0.07	0.10	0.09	0.09	0.08	0.07	0.08	0.09

8.2.2 Key sources

Relevant key sources have been described for the source 6Cd (cremations) for level and trend (Hg).

8.2.3 Overview of shares and trends in emissions

Cremations

The emission of Hg during cremation originates from the amalgam fillings in teeth. In the period 1990 to 2002 the Hg emissions from cremations gradually increased as a result of increasing activity (period 1990-2009; 33%) and as result of a steady increase in the amount of amalgam in corpses. As of 1998, new cremation centres have been equipped with technical measures to reduce emissions. In the period 2002 onwards, emissions decrease as a result of implementation of technical measures in older cremation centres. In 2005, 18% of all cremations took place in installations equipped with emission reducing technology. In 2011 85% of all cremation centres have emission reducing measures in place. As of 2013 all cremation centres will be equipped with technological measures to reduce emissions. Table 8.3 gives an overview of the emissions from this source.

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.
During the period 2006-2010 no information on the progress of implementation of emission reducing technology was available. Therefore, the implementation of this technology is considered constant (18%) since 2005. From 2005 onwards, a lower emission factor (0.43 g Hg per corpse) is used for these installations.

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 privately owned horses (stable and storage only), human transpiration and respiration, and from manure sold and applied to private properties or nature parks. Please note that the Netherlands has included these NH_3 sources in the national total, whereas other parties have not. There is no clear guidance on whether or not these emissions should be included in the national total for NH_3.
Category 7A describes a key source for the following components: NH_3 (7.9%), TSP (3.7%), PM_{10} (4.4%) and $PM_{2.5}$ (8.2%) as percentages of national total in 2010.

10 Recalculations and other changes

10.1 Recalculations of the 2011 submission

Compared to the 2011 submission (Jimmink *et al.*, 2011) the following methodological changes were implemented in the PRTR system:

Transport:

- The emissions in the transport sector were recalculated (as every year) based on the updated VERSIT+ LD model (Ligterink and De Lange, 2009).
- A new emission model for mopeds and motorcycles is implemented for the total time series. This new method yields higher emissions for PM_{10} and NO_x for the total time series and for NMVOC higher values in the period prior to 2005 and decreased emissions since 2005 (compared to the submission for 2010)
- Furthermore, emissions changed due to several (methodological) improvements, such as:
  road type distribution for different vehicles types (with effect on non-combustion emissions a.o. metals);
  new VOC and PAH species profiles;
  update of vehicle kilometres driven by heavy-duty trucks;
  emissions from non-road mobile machinery have been recalculated using a new methodology for the determination of the energy use in this sector;
  final fuel consumption data for 2006 to the present day for national fisheries

These recalculations affected the total time series for all relevant pollutants.

10.2 Improvements

10.2.1 Included improvements

- Incomplete CO, Pb and Hg time series from earlier submissions, in the industrial processes are improved.
- F-gasses have been included in the NMVOC data for 1990 to 2004; they were erroneously not included in the last submission.
- The 2009 emission figures were updated on the basis of environmental reports from individual (EPRTR) companies and improved 2009 statistics.
- As a result of the planned improvement from last submission the allocation of emissions is improved. Some sources and thus the corresponding emission data in the 2G and 6 categories were not properly allocated in the previous submissions. In general, these reallocations mainly occurred from the industrial categories (2G) to the combustion sectors (1A). Please note that the above reallocations do not change the national emission total.

10.2.2 Planned improvements

For the coming submission the following improvements are envisaged:

Transport:

- New average annual mileages are being derived for motorcycles by Statistics Netherlands, 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). Unfortunately, the NAP register did not contain enough odometer readings to estimate average annual mileages for several vehicle types. Therefore a survey will be held among motorcycle owners next year to complement the NAP-data.
- TNO is preparing a study on the average load factors for heavy-duty trucks, using data from the '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 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.

IP:

In coming submissions incomplete TSP and Cd time series will be repaired..

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.

Almost all changes shown in table 10.1 originate from the improvements made in the estimation methods for the transport category. Changes in the 2009 figures are also the result of using improved activity data for that year.

Emissions from the metals Cu, Pb and Zn changed as a result of methodological improvements in the transport category. Hg emissions increased due to the inclusion of missing estimates. Changes in the 2009 figures are also the result of using improved activity data for that year.

Almost all changes shown in table 10.3 originate from the improvements made in the estimation methods for the transport category. Changes in the 2009 figures are also the result of using improved activity data for that year.

Table 10.1 Differences in National total emission levels between current and previous submission for the years 1990, 2000, 2005 and 2009.

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 2011**	**566.4**	**464.5**	**191.6**	**355.1**	**44.0**	**67.4**	**89.6**	**1119.4**
	IIR 2012	**566.3**	**477.3**	**191.6**	**355.1**	**44.4**	**67.7**	**89.9**	**1124.4**
Difference	**absolute**	**-0.1**	**12.8**	**0.0**	**0.0**	**0.3**	**0.3**	**0.3**	**5.0**
	%	0.0%	2.8%	0.0%	0.0%	0.8%	0.5%	0.4%	0.4%
2000	**IIR 2011**	**397.8**	**232.6**	**73.0**	**161,5**	**24.1**	**38.6**	**45.3**	**754.9**
	IIR 2012	**398.3**	**237.9**	**73.0**	**161,5**	**24.2**	**38.8**	**45.6**	**756.0**
Difference	**absolute**	**0.5**	**5.4**	**0.0**	**0,0**	**0.2**	**0.2**	**0.2**	**1.1**
	%	0.1%	2.3%	0.0%	0.0%	0.7%	0.5%	0.5%	0.1%
2005	**IIR 2011**	**344.3**	**178.2**	**64.5**	**140.4**	**19.4**	**33.1**	**39.9**	**668.8**
	IIR 2012	**345.6**	**177.5**	**64.5**	**140.5**	**19.5**	**33.3**	**40.0**	**659.0**
Difference	**absolute**	**1.3**	**-0.7**	**0.0**	**0.1**	**0.1**	**0.1**	**0.2**	**-9.8**
	%	0.4%	-0.4%	0.0%	0.1%	0.5%	0.4%	0.4%	-1.5%
2009	**IIR 2011**	**279.3**	**155.5**	**38.1**	**125.5**	**16.0**	**29.8**	**35.0**	**599.5**
	IIR 2012	**280.3**	**152.2**	**37.4**	**125.1**	**15.9**	**29.7**	**35.0**	**579.5**
Difference	**absolute**	**1,0**	**-3.2**	**-0.6**	**-0.5**	**0.0**	**0.0**	**0.0**	**-19.9**
	%	0.4%	-2.1%	-1.7%	-0.4%	-0.1%	-0.1%	0.0%	-3.3%

Table 10.2 Differences in National total emission level between current and previous submission for the years 1990, 2000 and 2009 (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 2011	336.2	2.1	3.5	1.5	9.9	67.7	75.3	0.4	220.6
	IIR 2012	336.4	2.1	3.5	1.5	9.9	69.2	75.3	0.4	220.7
Difference	absolute	0.3	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.1
	%	0.1%	0.0%	0.1%	0.0%	0.0%	2.2%	0.0%	0.0%	0.1%
2000	IIR 2011	33.6	0.9	0.9	1.1	3.1	74.9	18.8	0.5	90.9
	IIR 2012	33.1	0.9	1.0	1.1	3.1	70.7	18.7	0.5	91.0
Difference	absolute	-0.4	0.0	0.1	0.0	0.0	-4.2	0.0	0.0	0.1
	%	-1.2%	0.0%	16.2%	0.0%	0.0%	-5.6%	0.0%	0.1%	0.1%
2005	IIR 2011	35.9	1.7	0.8	1.5	2.2	79.3	10.7	2.4	84.0
	IIR 2012	35.5	1.7	0.9	1.5	2.3	74.8	10.7	2.6	84.2
Difference	absolute	-0.4	0.0	0.0	0.0	0.0	-4.5	0.0	0.2	0.2
	%	-1.2%	0.0%	5.2%	0.0%	0.5%	-5.7%	0.1%	7.5%	0.2%
2009	IIR 2011	37.8	1.7	0.8	0.8	1.5	84.0	2.9	0.9	89.4
	IIR 2012	37.4	1.8	0.6	0.8	1.5	79.8	3.0	0.9	91.6
Difference	absolute	-0.4	0.0	-0.2	0.0	0.0	-4.2	0.0	0.0	2.2
	%	-1.0%	2.6%	-22.5%	1.9%	0.4%	-5.0%	0.8%	0.3%	2.4%

Table 10.3 Differences in National total emission level between current and previous submission for the years 1990, 2000 and 2009 (PCDD/F and PAHs)

National total for the entire territory		PCDD/ PCDF (dioxines/ furanes)	PAHs				
			benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3 -cd) pyrene	Total 1-4
		g I-Teq	Mg	Mg	Mg	Mg	Mg
1990	IIR 2011	742.8	5.2	8.0	4.0	2.8	20.0
	IIR 2012	742.5	5.2	8.0	4.0	2.8	20.0
Difference	absolute	-0.3	0.0	0.0	0.0	0.0	0.0
	%	0.0%	0.2%	0.1%	0.1%	0.1%	0.1%
2000	IIR 2011	30.0	1.3	1.2	0.7	0.6	3.8
	IIR 2012	29.8	1.3	1.2	0.7	0.6	3.8
Difference	absolute	-0.2	0.0	0.0	0.0	0.0	0.0
	%	-0.7%	0.1%	0.3%	-0.2%	-0.5%	0.0%
2005	IIR 2011	37.9	1.4	1.2	0.7	0.6	3.9
	IIR 2012	30.8	1.4	1.2	0.6	0.6	3.8
Difference	absolute	-7.1	0.0	0.0	0.0	0.0	0.0
	%	-18.8%	-0.5%	-0.3%	-1.3%	-1.5%	-0.7%
2009	IIR 2011	29.3	1.3	1.5	0.7	0.7	4.2
	IIR 2012	29.2	1.3	1.4	0.7	0.7	4.1
Difference	absolute	-0.1	0.0	0.0	0.0	0.0	-0.1
	%	-0.2%	-1.6%	-2.2%	-2.5%	-3.7%	-2.3%

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 the Energy research Centre of the Netherlands (Reference projection, ECN, 2010) 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.

With regard to Dutch policy developments, the policy programme Clean and Efficient (Schoon en Zuinig) on energy and climate, introduced in 2007, plays an important role. To assess the effects of the policy measures from the Clean and Efficient policy programme on air pollutants, ECN's Reference projection explores only the policy variant with post-2007 policies already implemented (with measures; WM scenario). In this report, policies refer to Dutch, as well as European policies.

The WM scenario in the IIR that was used for the latest emission projections 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, ECN estimated the number of additional power plants and CHP installations,

Table 11.1 Historical and projected emissions from the Netherlands (PBL, 2010; RIVM, 2012).

		Historical (RIVM, 2012)					*NEC*	Projected (PBL, 2010)		
Pollutant/year		1990	2000	2005	2009	2010	*2010*	2015	2020	2030
SO_2	Gg	192	73	65	37	34	*50*	45	46	45
NO_x	Gg	566	398	346	280	276	*260*	230	185	161
NH_3	Gg	355	161	140	125	122	*128*	122	118	119
NMVOC	Gg	477	238	177	152	151	*185*	146	149	162
PM_{10}	Gg	68	39	33	30	29	*NA*	30	29	29
$PM_{2.5}$	Gg	44	24	19	16	15	*NA*	14	13	13

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

Activity	Reference Year 2000	2008	2010	2015	2020	2030	Units (energy units are in NCV)	Notes on Measures included excluded.
Assumptions for general economic parameters:								
1. Gross Domestic Product (GDP)	498	579	558	604	662	763	10^9 €	Euro2007
2. Population	15864	16405	16536	16779	17014	17380	Thousand People	
3. International coal prices	60	46.64	45.35	47.16	48.29	48.88	€ per tonne or GJ (Gigajoule), Other please specify	Euro2000/ton
4. International oil prices	5.3	7.52	7.02	7.02	7.02	7.02	€ per barrel or GJ	Euro2000 per GJ
5. International gas prices	0.1163	0.1615	0.154	0.1615	0.1707	0.1767	€ per m^3 or GJ	Euro2000 per m^3
Assumptions for the energy sector:								
Total gross inland consumption								
1. Oil (fossil)	715.9	786.3	772.2	769.6	799.0	828.6	Petajoule (PJ)	energetic use
2. Gas (fossil)	1334.3	1359.1	1320.6	1252.4	1279.0	1202.2	Petajoule (PJ)	energetic use
3. Coal	254.1	254.2	304.5	542.4	470.1	391.8	Petajoule (PJ)	energetic use
4. Biomass without liquid biofuels (e.g. wood)	28.2	58.1	68.2	51.3	34.3	26.9	In tonnes or %: Mton	biomass without liquid biofuels for transport, avoided primary use
5. Liquid biofuels (e.g. bio-oils)	0.0	12.0	18.6	29.1	39.3	39.3	Petajoule (PJ)	liquid biofuels transport
6. solar	0.49	1.19	1.69	2.44	2.60	4.76	Petajoule (PJ)	solar PV + thermal, avoided primary
7. Other renewable (wind, geothermal etc.)	8.8	41.4	43.4	115.7	137.7	194.4	Petajoule (PJ)	avoided primary energy
Total electricity production by fuel type								
8. Oil (fossil)	395	257	1060	1143	1111	979	GWh	
9. Gas (fossil)	52493	64723	69190	63941	78584	81632	GWh	
10. Coal	23428	22495	26194	54250	46361	37944	GWh	
11. Renewable	2992	9492	10647	17194	18017	23853	GWh	

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 long-term average oil price of 70 USD per barrel from 2010 onwards, and uses the mid 2008 exchange rate of 1.53 US dollars per euro. The direct impact from higher energy and CO_2 prices on final and primary energy use is projected to be relatively low. In 2008 the Energy research Centre of the Netherlands (ECN), on the basis of an analysis of the electricity market, concluded that in the coming decade strong climate policies and high CO_2 prices would be likely to improve the internationally competitive position of Dutch electricity generation (See http://www.ecn.nl/docs/library/report/2008/e08026.pdf). Higher CO_2 prices, paradoxically, are thought to increase the share of coal in Dutch electricity generation and limit the share of renewable energy in electricity production. The capacity of wind power is assumed to increase from 2000 MW in 2005 to the government target of 15400 MW by 2020. This includes the introduction of a wind farm of 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.

Table 11.3 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	2025	2030	2020	2025	2030	2020	2030
	[GW]	[GW]	[GW]	[%]	[%]	[%]	[%]	[%]
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

After the economic dip in 2009 and 2010, a moderate growth rate of 1.7 % 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 11.3 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 of relatively few new developed plants 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).

Germany is a neighbouring country to which the Netherlands have a high and still increasing degree of interconnection. Although, at the moment, the Netherlands are still a net importer of German electricity, the new ECN Reference projection confirms anew that, from 2012 onwards, the switch of the Netherlands to becoming a net exporter of electricity is a robust one (ECN, 2010).

The Netherlands, from their geographical location, have some 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 consequently are 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 German power 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 German nuclear plants would be substantially phased out before 2020, this would lead to approximately 6 TWh in additional export to Germany.

11.1.1 NO_x

Stationary sources

Development emission of nitric oxides (NO_x) fromstationary sources
Based on implemented policy, the decrease in NO_x emissions from stationary sources will continue in the coming years. The BEMS (the Dutch implementation of the EU Large Combustion Plants Directive; LCP) of December 2009 has also been taken into account. This new BEMS legislation will have its effect between 2015 and 2020, and under this legislation, gas engines also will have to comply with more strict emission standards (VROM, 2009). After 2020 emissions will more or less stabilise. Replacing the

Table 11.4 Development of the NO_x emission of stationary sources per sector.

NO_x emission in [kton]	1990	2000	2005	2008	2010	2015	2020
Industry	78.7	34.0	34.2	30.1	26.4	28.5	30.6
Refineries	18.8	10.3	9.1	8.6	7.0	6.0	5.8
Energy sector	85.0	55.6	46.2	30.2	31.7	34.3	32.7
Waste treatment	7.1	4.5	3.8	3.8	2.9	2.8	2.7
Agriculture	9.8	13.1	12.3	12.5	12.1	9.9	3.9
Households	20.3	18.4	15.2	13.0	9.9	7.1	5.8
TSG and construction	11.8	12.7	11.7	13.1	8.1	6.5	5.0
Total	232.0	148.6	132.5	111.3	98.2	95.2	86.4

old installations with new ones that have lower emissions is expected to largely compensate for the increase in fuel consumption.

Table 11.4 presents the historical and projected NO_x emissions per sector.

The following developments can be noted with regard to specific emissions of installations:

- In 2005 it was still assumed that the emission requirement of 80 g/GJ for new gas engines according to the GothenburgProtocol would apply. Eventually, this standard was not implemented in the Netherlands. Since then, BEMS legislation was implemented instead. At about 28 g/GJ for engines larger than 2.5 PMth, this standard is stricter than under the Gothenburg Protocol. Smaller engines and biogas engines must comply with the new BEMS standard of about 95 g/GJ. Moreover, a major difference is that the standards, for existing installations, will enter into force before 2020.
- The number of gas engines used in greenhouse horticulture has increased significantly over the last 5 years (ECN, 2010). Most of these engines are equipped with flue gas cleaning to enable CO_2 fertilization. Despite the fact that costs are relatively low, flue gas cleaning systems are often switched off if CO_2 fertilization is not required (Dueck, 2008). Therefore, the standard emissions from this type of engine have increased. As these engines are covered by BEMS legislation, this adjustment no longer will be visible in 2020. Due to this adjustment (a higher emission without BEMS), the effect of the BEMS legislation will increase. In 2020 emissions will amount to about 7.5 Gg, with about 6 Gg from greenhouse horticulture.
- The inventory of NO_x emissions from the new high efficiency central heating boiler shows a favourable development. The emissions are significantly lower than the Dutch emission requirement. Due to these lower emission levels, the household emissions are lower than in earlier calculations (Gastec, 2007).

The NO_x trading system, which entered into operation in mid 2005, for installations with a capacity of more than 20 MWth (unless exempted) and installations with high process emissions, deserves special attention. Since its implementation in 2005, there has been a surplus of emission allowances (NEA, 2008). The allowed amounts ces will be lowered step by step, over the course of time. For 2010, the maximum emission level for incineration installations has been set at 40 g/GJ fuel. This is the performance standard rate (PSR). Process emissions carry a reduction target. In 2008 the average incineration emission level was 44 g/GJ. This was already lower than the PSR for 2009 of 46 g/GJ, but higher than the PSR for 2010.

Around 2013 the PSR will be gradually tightened to 37 g/GJ. In the 2010[1]–2013 period, emission allowances could, for the first time, reach a trading value that corresponds with the costs of additional emission reduction.

Table 11.5 shows the distribution of emissions in 2020 under implemented policy. About 80% of emissions are covered by the NO_x emissions trading system. This percentage is higher than that of today, because the

[1] In the various years it is possible to save about 5% on the emission allowances for (or borrow from) a subsequent year. The surplus of 2008, via 2009, thus could be used for covering a deficit in 2010. Businesses may also buy additional allowances, for instance in 2011, and use them in the same year. This may result in a trade market with a certain equilibrium between supply and demand. The explanation of the legislation for the emissions trading system states: 'As a result of this mechanism, the emission curbing measures that contribute in the most cost-effective manner to realising the total emission target will be taken'. This mechanism could become operational in 2011 (temporarily, see text below). The underlying aim of the system, that is, to realise ambitious reduction targets for NOx by 2020, is being realised quite successfully in terms of pace. Partly because of the pressure of the trading system, but also due to local policy addressing, for example, NOx removal from coal-fired plants, and because NOx emissions in the energy and industrial sectors have decreased rapidly and significantly.

reduction under BEMS legislation will occur in smaller installations. For this report, the emissions from installations under the trading system were established by multiplying the fuel use with a PSR of 37 g/GJ. Process emissions were established by multiplying historical emissions with the physical increase and the reduction target for process emissions under the trading system.

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

Assuming the trade system to be in balance in 2012 (companies with excess emissions are exactly compensated by companies that have surplus emission allowances to sell), this may lead to another surplus in 2013. It seems likely that maximum allowed emission levels will be realised in 2012 by adjusting the installations. Reductions in NO_x emissions will mainly be realised through investments, and substantial variable costs may only occur in a very limited number of instances. Once installations have been adjusted they will remain at a lower emission level.

A large number of electricity plants are planned to be built between 2013 and 2020. Given the environmental requirements for these new installations, their emissions will remain far below the PSR. As a result the electricity sector is expected to have a surplus of emission allowances in 2020 of about 3 to 5 Gg. If the PSR will not be tightened further after 2013, there will hardly be a market for the sale of surplus allowances among the existing installations in 2013. Assuming the purchase of maximum emission allowances by existing, expanded and new businesses, the unmarketable surpluses are expected to amount to between 0 and 1 Gg. It is more likely that, over time, businesses will have lower emissions (because of renovations). Therefore, a surplus of 2 to 3 Gg would be more likely. See also Section 1.7 on uncertainties with regard to the emission estimate for 2020.

Emission factors. About 19 Gg of NO_x emissions from stationary sources are expected to be outside the NO_x emissions trading system by 2020. To determine the uncertainty of this emission amount, each type of installation was examined to establish how much higher or lower its emission factor would be. Subsequently, the emission amount was calculated with the other factors, and the possible deviation in emissions was determined per type of installation. After that the total uncertainty of emissions being higher or lower was established per sector. The main uncertainties are linked to gas engines; whether the emission will be close to the maximum standard or will be significantly lower. For households, the main uncertainties involve the actual emissions from central heating boilers. For new central heating boilers (high-efficiency boilers), these are on average significantly lower than the emission standard, but the question remains how these developments will evolve. The emission from gas heaters used for local heating in this sector, for which there are no emission standards, is still a source of uncertainty.

Energy prices. The effect of different energy prices was derived from the uncertainty in CO_2 emissions, linked to the energy prices for the various sectors. In the electricity sector this is mainly about the price difference between coal and gas. Here, the average CO_2 effect is applied and is assumed to go into the same direction as in the other sectors. There may be some shifts in large-scale CHP. As these shifts occur mainly in the NOx emissions trading system, they were not included here. What is more, in the basic calculation, the actual emissions may (partly) occur in a different sector than indicated here, due to emissions trading. As higher or lower prices in all sectors are taking effect simultaneously, the total was established by means of addition.

Volume gas engine park. There is significant movement in the number of these installations. Moreover, the small engines and the biogas engines have relatively high emissions. An additional uncertainty percentage of 35% of the capacity was used for this report. A decreasing capacity would lead to emission reductions ranging from 30% to 50%. The 35% used here was derived from the largest possible changes in gas engine deployment between 2010 and 2020, taking into account the lifetime and age structure of the machinery. The introduction of BEMS legislation and the subsequent lower gas engine emissions have significantly reduced the uncertainty in this area. It is assumed that the effect may work both ways.

11.1.2 SO_2

The SO2 emissions in the industry, refineries and energy sectors combined are expected to increase by several kilotons between 2010 and 2020, rising from 42 to 45 Gg SO_2, accounting for more than 90% of SO_2 emissions in the Netherlands.

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

Table 11.6 The development of the SO_2 emission of stationary sources per sector.

SO_2 emission [in kton]	1990	2000	2005	2008	2010	2015	2020
Industry	51.1	13.4	14.9	14.3	13.6	15.0	16.7
Refineries	67.1	33.1	32.2	25.7	15.0	15.0	14.8
Energy sector	45.6	15.1	9.9	6.3	10.1	13.5	13.5
Waste processing	4.6	0.2	0.2	0.2	0.2	0.2	0.2
Agriculture	1.0	0.1	0.4	0.1	0.0	0.0	0.0
Households	1.1	0.5	0.5	0.5	0.3	0.3	0.3
TSG and construction	2.7	1.3	0.5	0.6	0.3	0.3	0.3
Total	232.0	63.7	58.6	47.7	39.4	44.3	45.7

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.
The SO_2 emissions in the various sectors are listed in Table 11.6. Relevant developments 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.
- Several years ago, an agreement was made with refineries that they would stop burning heavy fuel oil, with the aim of keeping emission levels of 2020 under those when gas firing. A further agreement was made about limiting the maximum emission amount to 16 Gg in 2010 and subsequent years, and establishing the emission level per company, in the permit. 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.
- An agreement was entered into with the electricity sector 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 SO2 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 according to new insights into transport volumes and emission factors. Main drivers for growth in passenger and freight transport are demographic, economic and price developments.

11.2.1 Projected transport volumes

The projected growth in passenger car traffic in the Netherlands was derived from pre-existing model runs with the LMS model, the Dutch National Model System for Traffic and Transport. The LMS is a strategic model used for calculations for passenger transport in the Netherlands (excluding air transport). Previously, this model has been used to derive projections of future passenger car traffic according to scenarios in the study 'Welfare, Prosperity and Quality of the Living Environment' (CPB *et al.*, 2006). The results from these model runs were corrected for different assumptions used in the ECN Reference projections on economic growth and future oil and fuel prices, using price elasticities of demand derived from international literature (Hoen *et al*., 2010). This resulted in a projected annual increase in passenger car traffic of approximately 0.9%, for the 2008–2020 period. This is slightly lower than the average annual growth in the 2000–2008 period, of 1.2%. The difference between these two periods is being caused by lower expected economic growth and higher fuel prices.

The future composition of the Dutch national passenger car fleet was derived from Dynamo, the Dutch dynamic auto-mobile market model (Meurs *et al*., 2006; MuConsult, 2008). Dynamo models the effect of general developments (e.g. related to demographics and fuel prices) and government policies on the size, composition and use of the Dutch national passenger car fleet, for the period up to 2040. The model runs performed for the ECN Reference projections show a projected increase in the number of passenger cars from 7.4 to 8.5 million between 2008 and 2020. The share of diesel cars in the national car fleet is expected to increase from 17% to 19% over the same time period. This share of diesel cars in the Dutch car fleet remains fairly small in the Netherlands, compared to other EU countries, due to the Dutch fiscal system for passenger cars. 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 ECN Reference projections this model was only used to model freight transport in the Netherlands. The results from the model runs show an increase in road transport of approximately 13%, between 2007 and 2020, both in tonnage transported and in vehicle kilometres driven. The average annual growth in this period of approximately 1% is slightly lower than that in previous years, mainly due to the economic crisis and the resulting drop in road transport in 2009 and 2010.

The projected average annual growth between 2011 and 2020 is comparable to the growth between 2000 and 2008. The future composition of the fleet of light-duty and heavy-duty trucks in the Netherlands was derived from trend extrapolation, taking into account the 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).

Freight rail transport is expected to increase by 26%, between 2007 and 2020 (total tonnage), but diesel fuel consumption by rail transport is expected to remain fairly constant due to the further electrification of rail transport in the Netherlands. Inland shipping of freight is expected to increase by 12%, between 2007 and 2020. Also in inland shipping, the average annual growth is lower than in previous years, due to the economic crisis.
Volume growth in other transport related categories has been derived from different existing studies or by extrapolating the historical trends of the 2000–2008 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 ECN 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 fleet of aircraft 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 9%, between 2008 and 2020. Energy use by fisheries is expected to further decrease, up to 2020.

11.2.2 Policy measures and emission projections

All relevant policy measures that were agreed upon by 2009 in the EU or in the Netherlands are taken into account in the Reference projections. For road traffic, emissions of NO_x PM and NMVOC are expected to reduce further due to the further tightening of EU emission standards for road vehicles, e.g. the Euro-6 standards for light duty vehicles. Furthermore, there has been agreement within the EU on stricter NO_x and PM_{10} standards for heavy duty vehicles (Euro-VI). The Euro-VI standard applies to new vehicle types from 1-1-2013 and to all new sales from 1-1-2014. These standards are incorporated in the NO_x and PM emission projections and lead to a decrease in NO_x emission of approximately 13 Gg in 2020.

Total NO_x emissions from road transport are expected to decrease by 65 Gg (59%), between 2009 and 2020, whereas NMVOC and PM_{10} emissions are expected to decrease by 7 Gg (38%) and 1 Gg (16%), respectively. Emission reductions in PM_{10} will be relatively small, because those from 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 72% 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 66%, between 2009 and 2020.

NO_x emissions from inland shipping are expected to remain fairly stable, with the effects of the expected volume growth 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. At the end of 2008, the EU agreed on the revision of the fuel quality directive, which constrains the sulphur content of fuels used for inland shipping, rail transport and mobile machinery to a maximum of 10 ppm, from 2011 onwards. As a consequence of the tightening of the standard, the entire transport sector (except for sea shipping) will use virtually sulphur-free fuels from 2011 onwards. This leads to a further decrease in projected SO_2 emissions from the transport sector. SO_2 emissions from transport (road and non-road) are expected to decrease from 1.3 Gg in 2010 to 0.3 Gg by 2020

11.3 Industry

In 2007, industry, energy and refineries (IER) emitted 10.6 Gg PM_{10}, which is a share of 30% 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 emissions from industry are dominated by process emissions (about 75%). In 2008, industrial NMVOC emissions amounted to 38 Gg.

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 these sectors with about 65%, between 1990 and 2007. Agreements with the refineries about switching to oil-firing instead of gas-firing will further decrease the PM_{10} emissions in this sector. PM_{10} emissions from IER are expected to amount to 10.3 Gg in 2020, and emissions from storage and handling of dry bulk to 1.2 Gg.

11.3.2 NMVOC

No new policy developments have been reported since 2007. The measures of the ‘National Reduction Plan NMVOC’ were still taking effect at the time of this projection. Industrial activities are expected to continue to decrease due to the credit crisis, and, in 2010, NMVOC emissions have decreased to 36 Gg. The NMVOC emissions from industry are expected to rise again, up to 38 Gg by 2020. The NMVOC emissions from refineries look to develop according to a similar trend; after a decrease from 8 Gg in 2008 to 7 Gg in 2010, emissions are expected to rise again to 8 Gg in 2020. The energy sector emitted 8 Gg NMVOC in 2008, but is expected to decrease emissions over the coming years, to 6 Gg in 2010, and to 4 Gg by 2020.

11.4 Solvents and Product use

Relevant developments until 2020

NMVOC emissions from households, for the most part, are caused by 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 fire places and wood-burning stoves, however, is increasing less rapidly.
Volume developments can be found in Table 11.7 and Table 11.8.

According to CPB, disposable income and consumption have decreased in 2009 and 2010, as a result of the credit crisis. In the 2010–2011 period, disposable income has lagged somewhat behind economic growth, because other expenditure that had to be financed from economic growth increased more rapidly. Over the last decades, annual consumer expenditure increased 0.3% more rapidly than disposable income. As for the 2011–2020 period, this annual growth is assumed to be 0.3% higher than that of disposable income.

The credit crisis mainly affects the industry. The industrial shrinkage in 2009 and 2010, therefore, was much larger than the shrinkage of the entire economy. The public sector and the government were less affected by the credit crisis; they still experienced growth in 2009 and 2010. In the 2011–2020 period, the growth differences in the various sectors are expected to be smaller than during the crisis years 2009 and 2010. Tertiary services and industry, in 2011–2020, will grow more than average. Chemical industry is expected to grow the most. Base metal industry will also grow more than the average for the entire industry. The foods industry is expected to have a somewhat lower growth. Growth in the other sectors will lag far behind the average economic growth, which is mainly due to mineral extraction, which is expected to shrink significantly between 2011 and 2020 because of the decreasing gas extraction. No new policy developments have taken place since 2007. The measures of the ‘National Reduction Plan NMVOC’ were still taking their effect at the time of this projection.

Table 11.7 Annual economic growth, disposable income and consumer expenditure.

	Growth per capita [%]			Growth Dutch economy [%]		
	2009	2010	2011-2020	2009	2010	2011-2020
Economic growth (GDP)	-3.8	-0.8	1.4	-3.5	-0.3	1.7
Disposable income	-0.6	-0.8	1.3	-0.3	-0.5	1.6
Consumer expenditures	-0.6	-0.8	1.7	-0.3	-0.5	1.9

Table 11.8 Annual growth of the value added tax, per sector.

	2009 [%]	2010 [%]	2011-2020 [%]
Agriculture	-3.4	0.8	1.5
Industry	-7.9	-0.7	1.9
Tertiary Services	-4.0	-0.4	2.3
Public Services and Government	1.4	0.9	1.7
Other	-3.1	-0.8	0.3
Total	-3.5	-0.3	1.7

Between 2008 and 2010, NMVOC emissions from households have increased from 32 Gg to 33 Gg, despite the credit crisis. From 2010 onwards, NMVOC emissions from households are expected to continue to increase, up to 40 Gg. Because of this relatively large increase, the household share in total NMVOC emissions will increase from 20% to 27%.

NMVOC emissions from the services and construction sectors have decreased slightly from 28 to 27 Gg, between 2008 and 2010. From 2010 onwards, NMVOC emissions in the services sector are expected to rise again, up to 31 Gg by 2020. In 2020, the emissions from construction are expected to be at about the same level as that of 2008. NMVOC emissions from the services and construction sectors are expected to increase from 17% to 21%, between 2008 and 2020.

11.5 Agriculture

Stocks of dairy cattle and laying hens, in 2020, are expected to be only slightly greater than in 2007. It is assumed that the dairy sector will produce about 15% more milk in 2020. An annual productivity increase of well over 1%, would be possible with roughly the same number of dairy cows as that of today. Numbers of young cattle stock are, however, assumed to be reduced by some 15%. Numbers of swine and broilers are also assumed to decrease by about 10% and 5%, respectively. Cattle stocks for meat production are expected to be about halved, except for meat calves, for which numbers will remain at the 2007 level (Silvis *et al.*, 2009).

Milk quota legislation and manure and ammonia policies are expected to limit the increase in livestock, up to 2015. The ECN Reference projection has taken into account the release of the milk quota as of April 2015, as well as the abolishment of the system of animal rights in intensive farming by 2015. The manure production ceiling that is in effect for the Netherlands, following agreements with the European Commission cannot limit livestock increases, since it is not implemented at farm level.

Nevertheless, livestock numbers are not assumed to increase strongly up to 2020, as developments will depend on trade policy and market developments: sale prices are expected to go down (as a consequence of free world trade), while cattle farmers pay higher prices for manure management and low emission housing (as a consequence of manure and ammonia policies).

Table 11.9 Projected animal numbers in the Netherlands. (in 1,000 heads)

Activity	2000	2008	2010	2015	2020	2030
Beef Cattle	2,566	2,489	2,443	2,337	2,046	2,046
Dairy cows	1,504	1,491	1,490	1,490	1,439	1,439
Sheep	1,486	1,490	1,988	2,047	2,106	2,106
Swine	13,118	12,290	12,026	11,303	10,579	10,579
Poultry	53,078	53,519	52,342	53,071	53,799	53,799
Broilers	53,439	46,384	46,466	45,148	43,829	43,829
Horses	318	431	444	436	428	428
Rabbits and mink	641	881	890	812	735	735

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

face high costs and consequently run out of business. Scaling in the agricultural sector is anticipated to continue.

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

11.5.1 Policy measures

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

12 Spatial distributions

12.1 Background for reporting

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

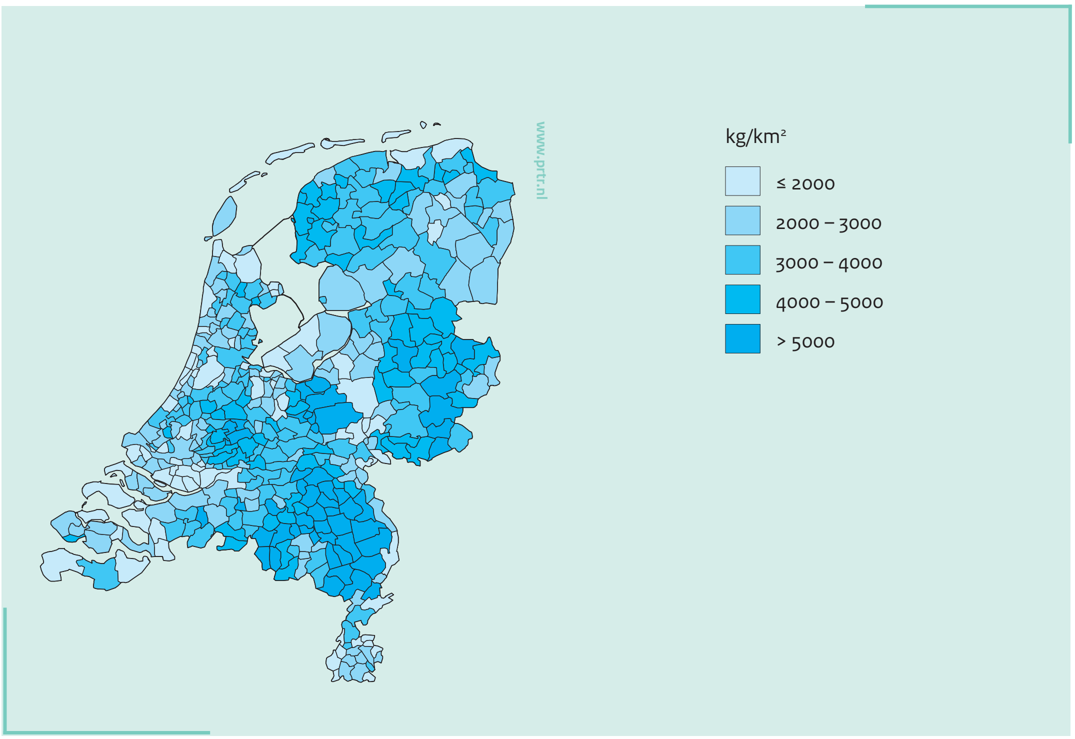
The gridded emission data of the 2012 reporting is available at the Central Data Repository (CDR) at the EIONET website.

12.2 Methodology for disaggregation of emission data

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

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

Figure 12.1 Geographical distribution of NH_3 emissions in the Netherlands in 2010



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

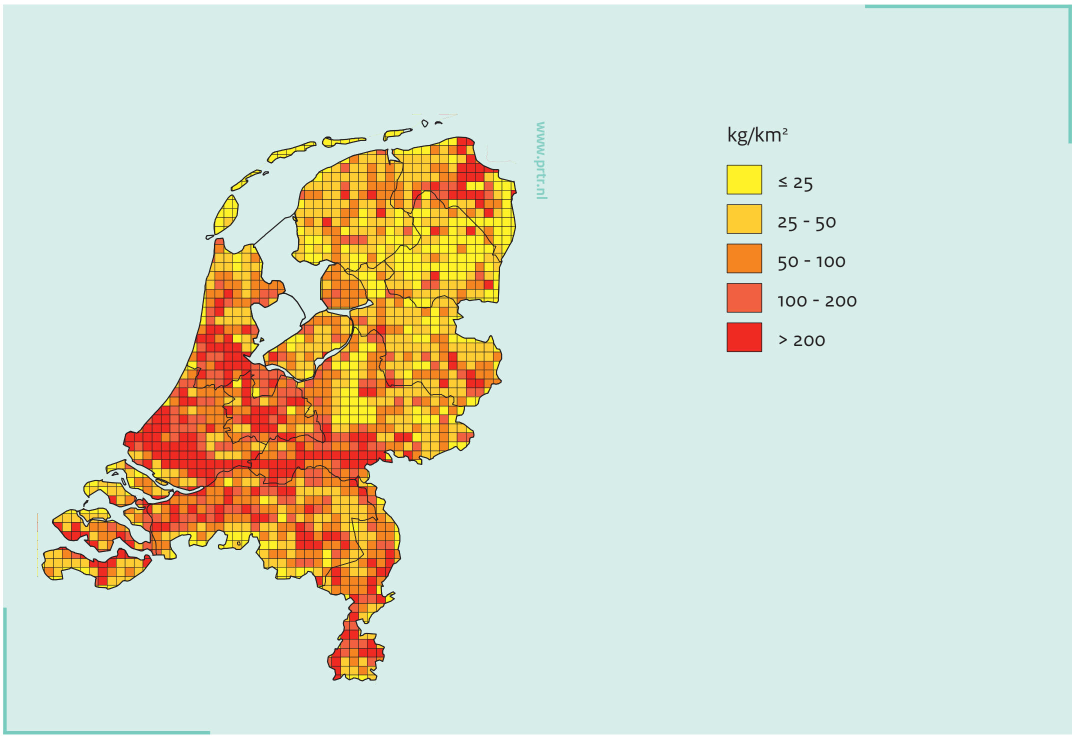
Finally, the third and largest group of emissions is spatially allocated by proxy data. Examples of these allocation keys are population and housing density, vehicle kilometres (roads, shipping routes, railways), land cover and number of employees per facility.

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.

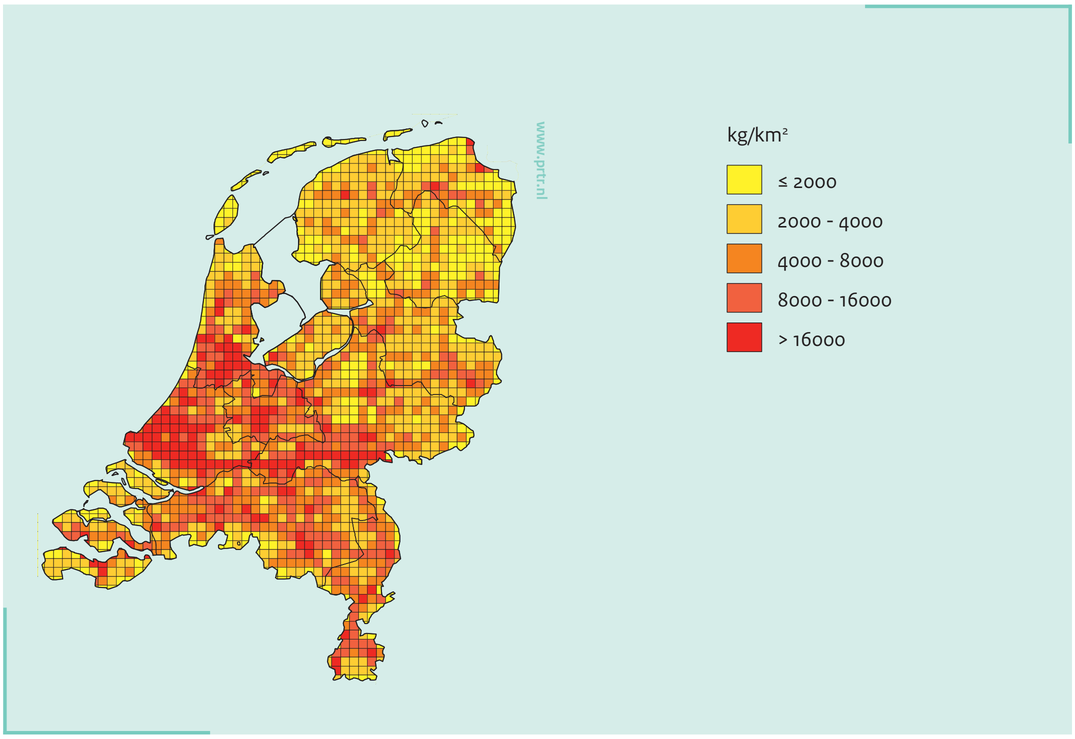
The agricultural sector is the major contributor to the national total NH_3 emission. Emissions of NH_3 are mainly related to livestock farming and especially to the handling of manure from the animals. Emissions of NH_3 are therefore related to storage and spreading of manure as well as emissions from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

Figure 12.2 Geographical distribution of SO_2 emissions in the Netherlands in 2010



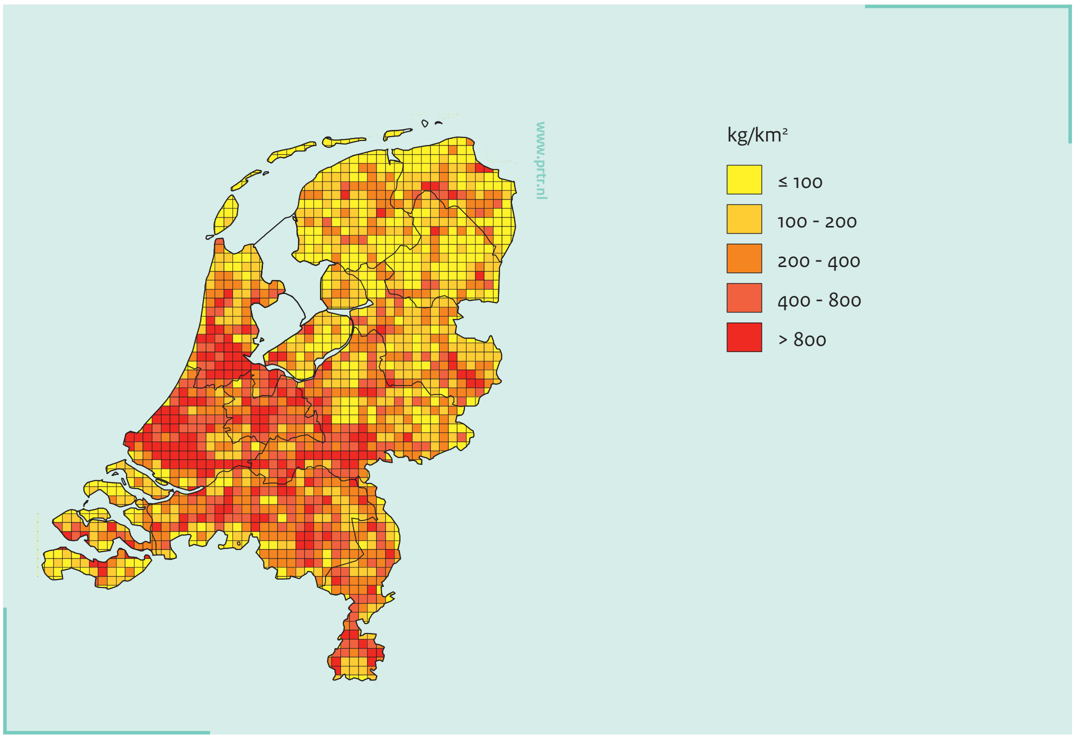
Inland shipping routes are the most striking feature in the geographical distribution of SO_2. During the last 30 years emissions on land decreased sharply due to various measures. Reductions in shipping emissions however have been relatively smaller. As a result, these have become dominant over emissions on land.

Figure 12.3 Geographical distribution of NO_x emissions in the Netherlands in 2010



NO_x emissions are predominantly emitted by the (road) transport sector: cities, main roads and shipping routes are clearly visible.

Figure 12.4 Geographical distribution of $PM_{2.5}$ emissions in the Netherlands in 2010



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.

References

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

Asselt, M.B.A. van (2000). Perspectives on uncertainty and risk-the PRIMA approach to decision-support, PhD thesis, Universiteit Maastricht.

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

Bruggen C. van, C.M. Groenestein, B.J. de Haan, M.W. Hoogeveen, J.F.M. Huijsmans. S.M. van der Sluis and G.L. Velthof (2011). Ammoniakemissie uit dierlijke mest en kunstmest, 1990-2008. Berekeningen met het Nationaal Emissiemodel voor Ammoniak (NEMA) . WOt-werkdocument 250. WOT Natuur & Milieu, Wageningen (in Dutch).

CBS (2010) www.cbs.nl, Statline – Landbouwcijfers. CBS, Voorburg/Heerlen, Nederland.

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

CPB, MNP and RPB (2006). Welvaart en Leefomgeving. Een scenariostudie voor Nederland in 2040. Centraal Planbureau, Milieu- en Natuurplanbureau en Ruimtelijk Planbureau, Den Haag (in Dutch).

DHV (2007), Evaluatie Euro 5 stimulering, DHV, Amersfoort (in Dutch).

Dröge, R., Hensema, A., Broeke, H. ten & Hulskotte, J.H.J. (2011), Emissions of two-wheeled vehicles, TNO-060-UT-2011-01556, TNO, Utrecht.

Dueck, Th. A., C.J. van Dijk, F. Kempes and T. van der Zalm (2008): Emissies uit WKK-installaties in de glastuinbouw. Methaan, etheen en NOx concentraties in rookgassen voor CO2 dosering. Nota 505 Wageningen UR Glastuinbouw, Wageningen (in Dutch).

ECORYS (2010), Tariefdifferentiatie tractoren en mobiele werktuigen, ECORYS, Rotterdam (in Dutch).

ECN (2010), Referentieraming energie en emissies 2010-2020 (in Dutch), ECN-E--10-004, Petten (in Dutch).

EEA (2009), EMEP/EEA air pollutant emission inventory guidebook, Technical report No 9, European Environment Agency (EEA), Copenhagen. http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

ENINA (2007). Emissies van individuele bedrijven in emissieregistratie (ERI). (In Dutch), Bilthoven.

EPA (1985), Compilation of air pollution emission factors, volume 2, Mobile sources, 4th edition, US Environmental Protection Agency, Research Triangle Park, North Carolina.

EPA (2010), Median life, annual activity, and load factor values for non-road engine emissions modeling, EPA-420-R-10-016, United States Environmental Protection Agency, Washington D.C., USA.

Gastec (2007), Inventarisatie van NO_x-emissiegegevens; Een inventarisatie van de NO_x-emissies van huishoudelijke centrale verwarmingstoestellen over de periode 2002 tot en met 2006. VGI/319/LE, Gastec Technology B.V., Apeldoorn (in Dutch).

Gijlswijk, R. van, P.W.H.G. Coenen, T. Pulles, and J.P. van der Sluijs, (2004). Uncertainty assessment of NO_x, SO_2 and NH_3 emissions in the Netherlands, TNO report R2004/100, TNO, Apeldoorn, Available: http://www.rivm.nl/bibliotheek/digitaaldepot/TNOreportRa2004.pdf.

Goudappel Coffeng (2010), Onderzoek naar de wegtypeverdeling en samenstelling van het wegverkeer, Goudappel Coffeng, Deventer (in Dutch).

Hausberger, S., Rodler, J., Sturm, P. and Rexeis, M. (2003), Emission factors for heavy-duty vehicles and validation by tunnel measurements, Atmospheric Environment 37, p. 5237-5245.

Hensema, A. & Verbeek, R. (2010), Update van een aantal grafieken bij 'Achtergrondinformatie over emissies en voertuigen voor de Beleidsbrief Verkeersemissies', TNO-notitie voor het Ministerie van VROM in het kader van Maatwerk Verkeersemissies (in Dutch).

Hoekstra B. (1997). Onderzoek naar kwikemissies van crematoria en beschikbare RGRtechnieken, Report R3517616, Tauw Milieu, Deventer (In Dutch).

Hoen, A., S.F. Kieboom, G.P. Geilenkirchen and C.B. Hanschke (2010), Verkeer en vervoer in de Referentieraming Energie en Emissies 2010-2020, PBL report 500161003, Bilthoven (in Dutch).

Hoogeveen, M.W., H.H. Luesink and P.W. Blokland (2011), Ammoniakemissie uit de landbouw in 2020; Raming en onzekerheden, LEI - Rapport 2010-080, Den Haag (in Dutch).

Hulskotte J.H.J., W.F. Sulilatue, and A.J. Willemsen (1999). Monitoringsystematiek openhaarden en houtkachels, TNO-MEP-R99/170, Apeldoorn (in Dutch).

Hulskotte, J.H.J. and W.W.R. Koch, (2000). Emissiefactoren zeeschepen, TNO-MEP-R2000/221, Apeldoorn (in Dutch).

Hulskotte, J.H.J., J. Oonk and J.C. Roovaart (2005). Emissieschattingen diffuse bronnen, Waterverontreininging door motoremissies uit de recreatievaart, TNO-MEP, Apeldoorn (in Dutch).

Hulskotte, J.H.J. and R.P. Verbeek (2009). Emissiemodel Mobiele Machines gebaseerd op machineverkopen in combinatie met brandstof Afzet (EMMA), TNO-report TNO-034-UT-2009-01782_RPT-ML, TNO, Utrecht (in Dutch).

Jimmink, B.A., P.W.H.G. Coenen, R. Dröge, G.P Geilenkirchen, A.J. Leekstra, C.W.M van der Maas, C.J. Peek, J. Vonk and D. Wever (2011). The Netherlands Informative Inventory Report 2011, RIVM report nr. 680355003, National Institute for Public Health and the Environment. Bilthoven.

Klein, J., Geilenkirchen, G., Hulskotte, J., Duynhoven, N., Lange, R. de, Hensema, A., Fortuin, P., Molnár-in 't Veld, H. (2012), Methods for calculating the emissions of transport in the Netherlands. Task Force traffic and Transport of the National Emissions Inventory, Bilthoven.

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

Ligterink, N.E. and Lange, R. de (2009), Refined vehicle and driving-behaviour dependencies in the VERSIT+ emission model, TNO Science & Industry, Delft.

Ligterink, N.E., Lange, R. de, Vermeulen, R. and Dekker, H. (2009), On-road NO_x emissions of Euro-V trucks, TNO Science and Industry, Delft.

Luesink, H. et al. (2008), Ammoniakemissie uit de landbouw 2006 en 2007, WOT werkdocument 144, Wageningen UR, Wageningen (in Dutch).

Molnár-in 't Veld, H. and Dohmen-Kampert, A. (2010), Methoderapport verkeersprestaties autobussen, Statistics Netherlands, Heerlen (in Dutch).

Morris, K.M. (2007), Emissions from aircraft, airframe sources: tyre and brake wear, British Airways, 12 April 2007, http://www.cate.mmu.ac.uk/saaq/presentations/Morris.pdf

NEA (2009), Nadere analyse NOx -emissiegegevens 2005-2008. Nederlandse emissieautoriteit, Den Haag (in Dutch).

Nijdam, D. S. and Koch, W. R. R (2007). Methoden emissieregistratie; Productgebruik, Consumenten, Bouw en HDO. Milieu en Natuurplanbureau Bilthoven en TNO Apeldoorn (in Dutch).

Nollet, J. (1993), Taxitijden t.b.v. PMMS-werkgroep 4 (herziene versie), NV Luchthaven Schiphol, Amsterdam (in Dutch).

NS-CTO (1992), Project koperemissies spoorwegverkeer (in Dutch), NS-CTO, Utrecht

Ntziachristos, L. and Z. Samaras (2000), COPERT III, Computer Programme to calculate emissions from road transport, methodology and emission factors (version 2.1), European Environmental Agency, Copenhagen.

Oenema, O., G.L. Velthof, N. Verdoes, P.W.G. Groot Koerkamp, G.J. Monteny, A. Bannink, H.G. van der Meer and K.W. van der Hoek (2000), Fortaitaire waarden voor gasvormige stikstofverliezen uit stallen en mestopslagen, Alterra (rapport 107, gewijzigde druk, ISSN 1566-7197), Wageningen.

PBL (2009). Environmental balance 2009, Netherlands Environmental Assessment Agency. Bilthoven (in Dutch).

Peek, C.J. (2010). Protocol NMVOS emissies uit verfgebruik in Nederland, PBL, Netherlands Environmental Assessment Agency, Bilthoven (in Dutch).

Pulles, T., and J. van Aardenne, (2001). Good Practice Guidance for CLRTAP Emission Inventories, Draft chapter for the UNECE CORINAIR Guidebook on Emission Inventories, Available: http://reports.eea.eu.int/EMEPCORINAIR4/en/BGPG.pdf
Rail Cargo (2007), Spoor in Cijfers 2007. Statistisch overzicht railgoederenvervoer (in Dutch), Rail Cargo, Hoogvliet.
Rail Cargo (2009), Spoor in Cijfers 2009 (in Dutch), Rail Cargo, Hoogvliet.
Rail Cargo (2011), Spoor in Cijfers 2011 (in Dutch), Rail Cargo, Hoogvliet.
RIVM (2001). Environmental Balance 2000, RIVM report 251701051, National Institute for Public Health and the Environment RIVM, Bilthoven (in Dutch).
RIVM (2010), Werkplan Emissieregistratie 2010, National Institute for Public Health and the Environment. Bilthoven.
RIVM (2011), Werkplan Emissieregistratie 2011, National Institute for Public Health and the Environment. Bilthoven.
Silvis, H.J., C.J.A.M. de Bont, J.F.M. Helming, M.G.A. van Leeuwen, F. Bunte and J.C.M. van Meijl (2009). De agrarische sector in Nederland naar 2020; Perspectieven en onzekerheden, LEI, 's Gravenhage (in Dutch).
Sluijs, J.P. van der, P. Kloprogge, J. Risbey and J. Ravetz (2003). Towards a synthesis of qualitative and quantitative uncertainty assessment: applications of the numeral, unit, spread, assessment, pedigree (NUSAP) system, Paper for the International Workshop on Uncertainty, Sensitivity, and Parameter Estimation for Multimedia Environmental Modeling, August 19-21, 2003, Rockville, Maryland, USA, Available: http://www.nusap.net.
Sluijs, J.P. van der, M. Craye, S. Funtowicz, P. Kloprogge, J. Ravetz, and J. Risbey (2005). Combining Quantitative and Qualitative Measures of Uncertainty in Model based Environmental Assessment: the NUSAP System, Risk Analysis, 25 (2). p. 481-492
Smit, R., Smokers, R. and Rabé, E. (2007), A new modelling approach for road traffic emissions: VERSIT+, Transportation Research Part D: Transport and Environment 12, p. 414-422, TNO, Delft
Soest-Vercammen, E.L.J. van, J.H.J. Hulskotte and D.C. Heslinga (2002). Monitoringsprotocol Bijschatting Stationaire NO_x-bronnen kleiner dan 20 MWth, TNO report R2002/042, TNO Milieu, Energie en Procesinnovatie, Apeldoorn (in Dutch).
Tak, C. van der (2000). Actualisatie To-emissies, report number 16196.620/2, MARIN, Wageningen (in Dutch).
TML & TNO (2005). Emissies door niet voor de weg bestemde mobiele machines in het kader van internationale rapportering, Transport & Mobility Leuven, Leuven, Belgium & TNO, Apeldoorn (in Dutch).
UNECE (2009). Guidelines for Estimating and Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution. http://www.ceip.at/fileadmin/inhalte/emep/reporting_2009/Rep_Guidelines_ECE_EB_AIR_97_e.pdf.
UNECE (2010) Report for the Stage 3 in-depth review of emission inventories submitted under the UNECE LRTAP Convention an EU National Emissions Ceilings Directive for The Netherlands, CEIP/S3.RR/2010/Netherlands, Centre on Emission Inventories and Projections, Wien.
Velthof, G.L., C. van Bruggen, C.M. Groenestein, B.J. de Haan, M.W. Hoogeveen en J.F.M. Huijsmans (2009), Methodiek voor berekening van ammoniakemissie uit de landbouw in Nederland. WOt-report nr. 70. Wageningen, the Netherlands (in Dutch).
Visschedijk, A., W, Appelman, J. Hulskotte and P. Coenen. (2007). Onderhoud van methodieken Emissieregistratie 2006-2007, TNO report nr. A-R0865/B (in Dutch).
VROM (2008), Milieuverslaglegging en PRTR: veranderingen vanaf het verslagjaar 2009, Ministerie van Infrastructuur en Milieu. Den Haag. http://www.rijksoverheid.nl/documenten-en-publicaties/brochures/2009/10/01/milieuverslaglegging-en-prtr-veranderingen-vanaf-het-verslagjaar-2009.html. (in Dutch).
VROM (2009), Houdende nieuwe regels voor de emissie van middelgrote stookinstallaties, Besluit van 7 december 2009. Staatsblad jaargang 2009, no 547 (in Dutch).
Wageningen UR Livestock Research (2009), Publication series Dust emission from animal houses, Report numbers 275 to 279, 292 to 294 and 296. Wageningen, the Netherlands.
Winkel, R.G. (2002), NH_3 emission results of Dutch car park, TNO-Automotive, Delft.

Appendix 1
Key source analysis results

Results from the key source analysis have been calculated and sorted for every component. Following a 2010 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 2010 level assessment (Emission levels in Gg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
1A1b	1A1b Petroleum refining	12.73	37.57%	37.57%
1A1a	1A1a Public electricity and heat production	6.70	19.77%	57.34%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	3.81	11.25%	68.59%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	2.65	7.83%	76.42%
1A2b	1A2b Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	2.24	6.61%	83.03%

Table 1.1.b SO_x key source categories identified by 2010 level assessment (Emission levels in Gg).

NFR Code	Longname	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 1990-2010 trend assessment (Emission levels in Gg).

NFR Code	Longname	1990	2010	Trend	Trend contribution	Cumulative trend contribution
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	9.14	3.81	1.15%	15.63%	15.63%
1A1a	1A1a Public electricity and heat production	48.37	6.70	0.97%	13.22%	28.85%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	5.91	2.65	0.91%	12.36%	41.21%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	19.95	2.09	0.75%	10.25%	51.45%
1A2b	1A2b Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	4.97	2.24	0.71%	9.70%	61.15%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	6.27	0.04	0.56%	7.59%	68.74%
1A1b	1A1b Petroleum refining	67.09	12.73	0.45%	6.17%	74.91%
1A3bi	1A3bi Road transport: Passenger cars	4.51	0.20	0.31%	4.25%	79,16%
2A7d	2A7d Other Mineral products	7.47	0.81	0.27%	3.66%	82.82%

Table 1.2.a NO_x key source categories identified by 2010 level assessment (Emission levels in Gg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
1A3biii	1A3biii Road transport:, Heavy duty vehicles	58.96	21.37%	21.37%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	58.96	21.37%	21.37%
1A3bi	1A3bi Road transport: Passenger cars	32.54	11.80%	33.17%
1A1a	1A1a Public electricity and heat production	26.25	9.52%	42.68%
1A3di(ii)	1A3di(ii) International inland waterways	14.56	5.28%	47.96%
1A3bii	1A3bii Road transport:Light duty vehicles	13.37	4.84%	52.81%
1A4ai	1A4ai Commercial / institutional: Stationary	13.28	4.81%	57.62%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	12.78	4.63%	62.25%
1A4bi	1A4bi Residential: Stationary plants	12.67	4.59%	66.85%
1A4ci	1A4ci Agriculture/Forestry/Fishing: Stationary	11.53	4.18%	71.02%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	10.92	3.96%	74.98%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	10.09	3.66%	78.64%
1A3dii	1A3dii National navigation (Shipping)	8.52	3.09%	81.73%

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

NFR Code	Longname	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%	40.29%
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%	61.23%
1A3di(ii)	1A3di(ii) International inland waterways	22.34	3.95%	65.17%
1A4bi	1A4bi Residential: Stationary plants	20.23	3.57%	68.75%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	19.99	3.53%	72.28%
1A1b	1A1b Petroleum refining	18.85	3.33%	75.60%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	18.83	3.33%	78.93%
1A4ciii	1A4ciii Agriculture/Forestry/Fishing: National fishing	16.46	2.91%	81.84%

Table 1.2.c NO_x key source categories identified by 1990-2010 trend assessment (Emission levels in Gg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	137.55	32.54	6.09%	27.24%	27.24%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	90.60	58.96	2.62%	11.72%	38.95%
1A1a	1A1a Public electricity and heat production	82.71	26.25	2.48%	11.09%	50.05%
1A4ci	1A4ci Agriculture/Forestry/Fishing: Stationary	8.73	11.53	1.28%	5.75%	55.80%
1A4ai	1A4ai Commercial / institutional: Stationary	13.65	13.28	1.17%	5.24%	61.03%
1A3bii	1A3bii Road transport:Light duty vehicles	14.66	13.37	1.10%	4.92%	65.95%
1A3dii	1A3dii National navigation (Shipping)	6.44	8.52	0.95%	4.25%	70.20%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	35.89	12.78	0.83%	3.71%	73.92%
1A3di(ii)	1A3di(ii) International inland waterways	22.34	14.56	0.65%	2.91%	76.82%
1A1b	1A1b Petroleum refining	18.85	5.55	0.64%	2.87%	79.69%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	19.99	6.64	0.55%	2.45%	82.14%

Table 1.3.a NH_x key source categories identified by 2010 level assessment (Emission levels in Gg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
4B1a	4B1a Cattle dairy	36.09	29.64%	29.64%
4B8	4B8 Swine	23.31	19.15%	48.79%
4B1b	4B1b Cattle non-dairy	18.59	15.27%	64.05%
4D1a	4D1a Synthetic N-fertilizers	10.03	8.24%	72.29%
7A	7A Other	9.59	7.88%	80.17%

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

NFR Code	Longname	1990	Contribution	Cumulative contribution
4B1a	4B1a Cattle dairy	120.90	34.05%	34.05%
4B8	4B8 Swine	98.28	27.68%	61.73%
4B1b	4B1b Cattle non-dairy	62.99	17.74%	79.48%
4B9a	4B9a Laying hens	21.34	6.01%	85.49%

Table 1.3.c NH_x key source categories identified by 1990-2010 trend assessment (Emission levels in Gg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
4B8	4B8 Swine	98.28	23.31	2.93%	26.04%	26.04%
4B1a	4B1a Cattle dairy	120.90	36.09	1.51%	13.47%	39.52%
4D1a	4D1a Synthetic N-fertilizers	13.91	10.03	1.48%	13.19%	52.71%
7A	7A Other	14.30	9.59	1.32%	11.75%	64.46%
4B1b	4B1b Cattle non-dairy	62.99	18.59	0.85%	7.56%	72.02%
1A3bi	1A3bi Road transport: Passenger cars	0.84	2.37	0.59%	5.23%	77.24%
4B9a	4B9a Laying hens	21.34	9.07	0.49%	4.38%	81.63%

Table 1.4.a NMVOC key source categories identified by 2010 level assessment (Emission levels in Gg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
3D2	3D2Domestic solvent use including fungicides	19.18	12.74%	12.74%
1A3bi	1A3bi Road transport: Passenger cars	18.48	12.28%	25.02%
3A2	3A2 Industrial coating application	15.18	10.08%	35.10%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	12.42	8.25%	43.35%
1A4bi	1A4bi Residential: Stationary plants	9.39	6.24%	49.59%
3D3	3D3 Other product use	9.07	6.02%	55.61%
1B2a iv	1B2a iv Refining / storage	8.58	5.70%	61.31%
1B2a i	1B2a i Exploration, production, transport	5.33	3.54%	64.85%
2D2	2D2 Food and drink	5.05	3.36%	68.20%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	4.49	2.98%	71.18%
3D1	3D1 Printing	4.05	2.69%	73.87%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	3.67	2.44%	76.31%
2B5a	2B5a Other chemical industry	2.96	1.96%	78.28%
3A1	3A1 Decorative coating application	2.93	1.95%	80.23%

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

NFR Code	Longname	1990	Contribution	Cumulative contribution
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 key source categories identified by 1990-2010 trend assessment (Emission levels in Gg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
3D2	3D2Domestic solvent use including fungicides	11.31	19.18	3.27%	18.16%	18.16%
1A3bi	1A3bi Road transport: Passenger cars	97.07	18.48	2.54%	14.11%	32.27%
1A3bv	1A3bv Road transport: Gasoline evaporation	35.46	2.76	1.77%	9.80%	42.07%
3A2	3A2 Industrial coating application	70.97	15.18	1.51%	8.38%	50.45%
1A4bi	1A4bi Residential: Stationary plants	13.22	9.39	1.09%	6.07%	56.52%
3D3	3D3 Other product use	15.31	9.07	0.89%	4.93%	61.45%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	24.50	3.67	0.85%	4.72%	66.16%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	25.19	4.49	0.72%	4.02%	70.19%
2D2	2D2 Food and drink	7.06	5.05	0.59%	3.29%	73.47%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	30.48	12.42	0.59%	3.26%	76.73%
1A3bii	1A3bii Road transport:Light duty vehicles	8.00	0.93	0.33%	1.85%	78.59%
1A5b	1A5b Other, Mobile (including military, land based and recreational boats)	3.34	2.48	0.30%	1.66%	80.25%

Table 1.5.a CO key source categories identified by 2010 level assessment (Emission levels in Gg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
1A3bi	1A3bi Road transport: Passenger cars	237.26	41.15%	41.15%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	82.41	14.30%	55.45%
1A4bi	1A4bi Residential: Stationary plants	58.60	10.16%	65.61%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	31.82	5.52%	71.13%
1A4bii	1A4bii Residential: Household and gardening (mobile)	28.79	4.99%	76.13%
1A5b	1A5b Other, Mobile (including military, land based and recreational boats)	21.35	3.70%	79.83%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	17.67	3.07%	82.90%

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

NFR Code	Longname	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 1990-2010 trend assessment (Emission levels in Gg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
1A3bi	3D2Domestic solvent use including fungicides	585.88	237.26	5.62%	31.0%	31.05%
1A4bi	1A3bi Road transport: Passenger cars	71.88	58.60	1.93%	10.7%	41.74%
1A4bii	1A3bv Road transport: Gasoline evaporation	14.99	28.79	1.88%	10.4%	52.12%
1A3bii	3A2 Industrial coating application	38.77	5.26	1.30%	7.2%	59.30%
1A5b	1A4bi Residential: Stationary plants	14.12	21.35	1.25%	6.9%	66.24%
1A2a	3D3 Other product use	187.72	82.41	1.23%	6.8%	73.04%
1A4aii	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	7.71	13.15	0.82%	4.5%	77.56%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	44.70	31.82	0.79%	4.4%	81.94%

Table 1.6.a TSP key source categories identified by 2010 level assessment (Emission levels in Gg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
1A4bi	1A4bi Residential: Stationary plants	3.51	10.09%	10.09%
2C1	2C1 Iron and steel production	3.30	9.49%	19.58%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	2.42	6.95%	26.53%
2D2	2D2 Food and drink	2.25	6.48%	33.02%
4B9a	4B9a Laying hens	2.21	6.36%	39.37%
2B5a	2B5a Other chemical industry	2.07	5.95%	45.33%
1A3bi	1A3bi Road transport: Passenger cars	1.85	5.33%	50.66%
1A3bii	1A3bii Road transport:Light duty vehicles	1.61	4.63%	55.29%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.41	4.07%	59.36%
4B9b	4B9b Broilers	1.39	3.99%	63.35%
4B8	4B8 Swine	1.34	3.86%	67.21%
7A	7A Other	1.28	3.67%	70.88%
3D3	3D3 Other product use	1.18	3.41%	74.28%
2A7d	2A7d Other Mineral products	1.17	3.36%	77.64%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	1.14	3.27%	80.91%

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

NFR Code	Longname	1990	Contribution	Cumulative contribution
2G	2G Other production, consumption, storage, transportation or handling of bulk products	17.54	19.51%	19.51%
2C1	2C1 Iron and steel production	9.55	10.62%	30.14%
1A1b	1A1b Petroleum refining	6.47	7.20%	37.33%
2B5a	2B5a Other chemical industry	6.01	6.68%	44.02%
2D2	2D2 Food and drink	5.84	6.50%	50.52%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	5.95%	56.47%
1A4bi	1A4bi Residential: Stationary plants	5.33	5.93%	62.39%
1A3bi	1A3bi Road transport: Passenger cars	5.19	5.77%	68.16%
2A7d	2A7d Other Mineral products	3.40	3.79%	71.95%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	2.80%	74.75%
1A1a	1A1a Public electricity and heat production	2.46	2.74%	77.49%
7A	7A Other	1.86	2.07%	79.55%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.72	1.91%	81.47%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	17.54	19.51%	19.51%

Table 1.6.c TSP key source categories identified by 1990-2010 trend assessment (Emission levels in Gg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
2G	2G Other production, consumption, storage, transportation or handling of bulk products	17.54	2.42	4.86%	21.38%	21.38%
1A1b	1A1b Petroleum refining	6.47	0.40	2.34%	10.30%	31.68%
4B9a	4B9a Laying hens	0.45	2.21	2.26%	9.97%	41.65%
1A4bi	1A4bi Residential: Stationary plants	5.33	3.51	1.61%	7.09%	48.74%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	0.86	1.35%	5.94%	54.68%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.18	1.41	1.07%	4.70%	59.38%
4B9b	4B9b Broilers	1.30	1.39	0.98%	4.32%	63.70%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.87	1.14	0.89%	3.91%	67.61%
3D3	3D3 Other product use	1.05	1.18	0.86%	3.80%	71.41%
4B8	4B8 Swine	1.68	1.34	0.77%	3.39%	74.80%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	1.61	0.71%	3.12%	77.92%
7A	7A Other	1.86	1.28	0.62%	2.73%	80.65%

Table 1.7.a PM_{10} key source categories identified by 2010 level assessment (Emission levels in Gg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
2G	2G Other production, consumption, storage, transportation or handling of bulk products	2.40	8.25%	8.25%
4B9a	4B9a Laying hens	2.21	7.59%	15.84%
1A3bi	1A3bi Road transport: Passenger cars	1.85	6.36%	22.20%
2D2	2D2 Food and drink	1.84	6.31%	28.51%
1A4bi	1A4bi Residential: Stationary plants	1.66	5.70%	34.21%
1A3bii	1A3bii Road transport:Light duty vehicles	1.61	5.53%	39.74%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.41	4.85%	44.59%
2C1	2C1 Iron and steel production	1.41	4.85%	49.44%
4B9b	4B9b Broilers	1.39	4.76%	54.19%
4B8	4B8 Swine	1.34	4.61%	58.80%
2B5a	2B5a Other chemical industry	1.32	4.55%	63.35%
7A	7A Other	1.28	4.38%	67.73%
3D3	3D3 Other product use	1.18	4.06%	71.79%
2A7d	2A7d Other Mineral products (Please specify the sources included/excludedin the notes column to the right)	1.16	3.99%	75.77%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	1.14	3.90%	79.67%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	0.86	2.94%	82.61%

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

NFR Code	Longname	1990	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	8.90	13.14%	13.14%
1A1b	1A1b Petroleum refining	6.46	9.54%	22.69%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	7.91%	30.59%
1A3bi	1A3bi Road transport: Passenger cars	5.19	7.66%	38.25%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	4.92	7.27%	45.52%
2B5a	2B5a Other chemical industry	4.11	6.07%	51.59%
2D2	2D2 Food and drink	3.85	5.69%	57.28%
2A7d	2A7d Other Mineral products	2.64	3.90%	61.18%
1A4bi	1A4bi Residential: Stationary plants	2.53	3.74%	64.91%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	3.72%	68.63%
1A1a	1A1a Public electricity and heat production	2.21	3.26%	71.89%
7A	7A Other	1.86	2.74%	74.64%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.72	2.54%	77.18%
4B8	4B8 Swine	1.68	2.48%	79.66%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.32	1.95%	81.61%

Table 1.7.c PM_{10} key source categories identified by 1990-2010 trend assessment (Emission levels in Gg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
1A1b	1A1b Petroleum refining	6.46	0.29	3.68%	13.7%	13.66%
2C1	2C1 Iron and steel production	8.90	1.41	3.57%	13.3%	26.93%
4B9a	4B9a Laying hens	0.45	2.21	2.98%	11.1%	37.99%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	0.86	2.14%	7.9%	45.92%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.18	1.41	1.34%	5.0%	50.90%
4B9b	4B9b Broilers	1.30	1.39	1.22%	4.5%	55.43%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.87	1.14	1.12%	4.2%	59.60%
3D3	3D3 Other product use	1.05	1.18	1.08%	4.0%	63.60%
1A1a	1A1a Public electricity and heat production	2.21	0.27	1.00%	3.71%	67.31%
4B8	4B8 Swine	1.68	1.34	0.92%	3.4%	70.71%
1A4bi	1A4bi Residential: Stationary plants	2.53	1.66	0.85%	3.1%	73.85%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	1.61	0.78%	2.9%	76.74%
7A	7A Other	1.86	1.28	0.70%	2.6%	79.35%
2B5a	2B5a Other chemical industry	4.11	1.32	0.65%	2.4%	81.78%

Table 1.8.a $PM_{2.5}$ key source categories identified by 2010 level assessment (Emission levels in Gg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
1A3bi	1A3bi Road transport: Passenger cars	1.85	12.1%	12.14%
1A3bii	1A3bii Road transport: Light duty vehicles	1.61	10.5%	22.69%
1A4bi	1A4bi Residential: Stationary plants	1.57	10.3%	32.95%
7A	7A Other	1.26	8.2%	41.19%
2B5a	2B5a Other chemical industry	0.99	6.5%	47.64%
2C1	2C1 Iron and steel production	0.90	5.9%	53.55%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	0.86	5.6%	59.16%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	0.77	5.0%	64.20%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.49	3.2%	67.42%
1A3di(ii)	1A3di(ii) International inland waterways	0.47	3.0%	70.47%
2A7d	2A7d Other Mineral products	0.45	2.9%	73.42%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	0.40	2.6%	76.05%
3D3	3D3 Other product use	0.39	2.6%	78.64%
1A3dii	1A3dii National navigation (Shipping)	0.35	2.3%	80.90%

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

NFR Code	Longname	2010	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	5.66	12.75%	12.75%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	12.06%	24.81%
1A3bi	1A3bi Road transport: Passenger cars	5.19	11.69%	36.50%
1A1b	1A1b Petroleum refining	4.19	9.45%	45.94%
2B5a	2B5a Other chemical industry	3.03	6.83%	52.77%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	5.67%	58.44%
1A4bi	1A4bi Residential: Stationary plants	2.32	5.24%	63.68%
1A1a	1A1a Public electricity and heat production	1.94	4.37%	68.05%
7A	7A Other	1.84	4.15%	72.19%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.64	3.69%	75.88%
2A7d	2A7d Other Mineral products	1.53	3.46%	79.34%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.49	3.37%	82.70%

Table 1.8.c $PM_{2.5}$ key source categories identified by 1990-2010 trend assessment (Emission levels in Gg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
1A1b	1A1b Petroleum refining	4.19	0.24	2.72%	14.2%	14.20%
2C1	2C1 Iron and steel production	5.66	0.90	2.35%	12.3%	26.49%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.35	0.86	2.22%	11.6%	38.07%
1A4bi	1A4bi Residential: Stationary plants	2.32	1.57	1.73%	9.0%	47.09%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	1.61	1.68%	8.8%	55.85%
7A	7A Other	1.84	1.26	1.41%	7.3%	63.20%
1A1a	1A1a Public electricity and heat production	1.94	0.22	1.00%	5.2%	68.43%
3D3	3D3 Other product use	0.35	0.39	0.62%	3.2%	71.65%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.49	0.77	0.57%	3.0%	74.64%
1A3dii	1A3dii National navigation (Shipping)	0.34	0.35	0.52%	2.7%	77.33%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	0.21	0.26	0.42%	2.2%	79.51%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.64	0.40	0.36%	1.9%	81.39%

Table 1.9.a Pb key source categories identified by 2010 level assessment (Emission levels in Mg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	29.86	68.50%	68.50%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	5.59	12.83%	81.33%

Table 1.9.b Pb key source categories identified by 1990 level assessment (Emission levels in Mg).

NFR Code	Longname	1990	Contribution	Cumulative contribution
1A3bi	1A3bi Road transport: Passenger cars	Pb	0.04	66.87%
2C1	2C1 Iron and steel production	Pb	29.86	16.57%

Table 1.9.c Pb key source categories identified by 1990-2010 trend assessment (Emission levels in Mg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	224.99	0.04	8.65%	43.53%	43.53%
2C1	2C1 Iron and steel production	55.74	29.86	6.73%	33.85%	77.37%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	5.17	5.59	1.46%	7.36%	84.73%

Table 1.10.a Hg key source categories identified by 2010 level assessment (Emission levels in Mg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	0.309	45.09%	45.09%
1A1a	1A1a Public electricity and heat production	0.220	32.10%	77.19%
6Cd	6Cd Cremation	0,076	9,27%	81,37%

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

NFR Code	Longname	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 1990-2010 trend assessment (Emission levels in Mg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
2C1	2C1 Iron and steel production	0.388	0.309	6.64%	33.81%	33.81%
1A1a	1A1a Public electricity and heat production	1.923	0.220	4.42%	22.48%	56.29%
2B5a	2B5a Other chemical industry	0.702	0.000	3.90%	19.83%	76.12%
6Cd	6Cd Cremation	0.057	0.089	2.20%	11.21%	87.33%

Table 1.11.a Cd key source categories identified by 2010 trend level assessment (Emission levels in Mg).

NFR Code	Longname	2010	Contribution	Cumulative contribution
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	1.282	51.02%	51.02%
2C1	2C1 Iron and steel production	0.827	32.90%	83.92%

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

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

Table 1.11.c Cd key source categories identified by 1990-2010 trend assessment (Emission levels in Mg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	0.022	1.282	60.09%	50.79%	50.79%
1A1a	1A1a Public electricity and heat production	0.949	0.184	45.87%	38.77%	89.55%

Table 1.12.a Dioxine key source categories identified by 2010 level assessment (Emission levels in g I-Teq).

NFR Code	Longname	2010	Contribution	Cumulative contribution
3D3	3D3 Other product use	15.000	49.29%	49.29%
1A4bi	1A4bi Residential: Stationary plants	5.659	18.59%	67.88%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	3.939	12.94%	80.82%
2C1	2C1 Iron and steel production	1.815	5.96%	86.79%

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

NFR Code	Longname	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 1990-2010 trend assessment (Emission levels in g I-Teq).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
1A1a	1A1a Public electricity and heat production	568.01	1.18	2.98%	43.22%	43.22%
3D3	3D3 Other product use	25.00	15.00	1.88%	27.33%	70.55%
1A4bi	1A4bi Residential: Stationary plants	8.61	5.66	0.71%	10.38%	80.92%

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

NFR Code	Longname	2010	Contribution	Cumulative contribution
1A4bi	1A4bi Residential: Stationary plants	2.909	77.73%	77.73%
1A3bi	1A3bi Road transport: Passenger cars	0.203	5.42%	83.15%

Table 1.13.b PAH key source categories identified by 1990 level assessment (Emission levels in Mg).

NFR Code	Longname	1990	Contribution	Cumulative contribution
2C3	2C3Aluminum 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 1990-2010 trend assessment (Emission levels in Mg).

NFR Code	Longname Pollutants	1990	2010	Trend	Trend contribution	Cumulative trend contribution
1A4bi	1A4bi Residential: Stationary plants	3.550	2.909	11.21%	54.73%	54.73%
2C3	2C3Aluminum production	6.909	0.108	5.90%	28.82%	83.55%

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Emissions of transboundary air pollutants in the Netherlands, 1990-2010. Explanation on the yearly set of emission data.
Between 1990 and 2010 emissions of air pollutants in the Netherlands have decreased. This concerns sulfur dioxide, nitrogen oxides, non-methane volatile organic compounds (NMVOC), carbon monoxide, ammonia, heavy metals and persistent organic pollutants (POP's). The downward trend is in particular attributable to cleaner fuels, cleaner cars and to emission reductions in the industrial sectors.

This was found in the explanation from the RIVM on the emission data submission, the Informative Inventory Report (IIR) 2012. Every year the Emission Inventory team – under direction of the RIVM - submits emission data for the government following obligations to the United Nations (UNECE) and the European Commission. The emission data set is a succession of years, from 1990 till the most recent submitted data.

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