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
1990-2009**

Informative Inventory Report 2011

Netherlands Informative Inventory Report 2011

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Subsequently, the emissions and activity data of the Inventory are translated into the NFR source categories and contained in the excel files. The description of the various sources, the analysis of trends and uncertainty estimates (see Chapters 2 to 9) were made in cooperation with the following emission experts: Gerben Geilenkirchen (transport), Peter Coenen and Rianne Dröge (energy), Kees Peek (fugitive emissions, industrial processes), Jan Vonk and Sietske van der Sluis (agriculture). We are particularly grateful to Marian Abels, Bert Leekstra and Dirk Wever, for their contributions to data processing, chart production and quality control. For their continued support we acknowledge Jan Wijmenga and Johan Sliggers in particular, from the Directorate for Climate Change and Air Quality of the Dutch Ministry of Infrastructure and the Environment. For the design and lay-out of this report we thank the RIVM's graphics department, in particular Martin Middelburg. We greatly appreciate all the contributions to this Informative Inventory Report, as well as the external reviewers that provided comments on its draft.

Rapport in het kort

Emissies van luchtverontreinigende stoffen in Nederland, 1990-2009. Toelichting op jaarlijkse reeks emissiecijfers.

Tussen 1990 en 2009 is in Nederland de uitstoot van luchtverontreinigende stoffen gedaald. Het betreft zwaveldioxide, stikstofoxiden, niet-methaan vluchtige organische stoffen (NMVOS), koolmonoxide, ammoniak, zware metalen en persistente organische vervuilende stoffen (POP's). Deze neerwaartse trend is vooral toe te schrijven aan schonere brandstoffen en auto's, en aan emissiebeperkende maatregelen voor industriële sectoren.

Dit blijkt uit de toelichting van het RIVM op de Nederlandse emissiecijfers van grootschalige luchtverontreinigende stoffen, het Informative Inventory Report (IIR) 2011. Deze cijfers worden jaarlijks – onder regie van het RIVM – door het Emissieregistratieteam aan de overheid geleverd vanwege verplichtingen voor de Verenigde Naties (UNECE) en de Europese Commissie. De emissiecijfers zijn data van een reeks jaren, vanaf 1990 tot de meest recent aangeleverde gegevens.

Dit keer is de ammoniakemissiereeks met een nieuw model berekend, waarmee beter in kaart is gebracht wat maatregelen om deze emissie te verminderen opleveren. Hieruit blijkt dat in 1990 meer ammoniak is uitgestoten ten opzichte van de vorige reeks en na 1991 minder. Voor 2008 scheelt dat 7,6 kiloton ammoniak. Deze daling komt vooral doordat het vanaf 1991 verplicht is de mest niet over het land te verspreiden, maar in de bodem te injecteren (onderwerken). Hierdoor komt minder ammoniak in de lucht terecht.

Verder zijn nieuwe bronnen van stikstofoxiden onderscheiden en zijn methoden ontwikkeld om deze emissies te berekenen. Het gaat om emissies uit mest van landbouwbodems en uit mest in opslagsilo's. Uit de berekeningen blijkt dat voor het jaar 2009 zo'n 25,5 kiloton stikstofoxiden afkomstig is van landbouwbodems. Dit is circa tien procent van de maximaal toegestane hoeveelheid uitgestoten stikstof-oxiden in Nederland, het zogenoemde NEC-plafond (National Emission Ceiling). Deze hoeveelheid telt echter niet mee in de berekening voor dit plafond (en staan vermeld onder memo-item 'natuurlijke emissies' 11C in de rapportage). De methoden waren namelijk niet bekend toen de plafonds werden bepaald.

Trefwoorden: emissies/emissiecijfers, IIR, grootschalige luchtverontreiniging, emissieregistratie

Abstract

Emissions of transboundary air pollutants in the Netherlands, between 1990 and 2009. Explanation on the annual set of emission data.

Emissions of air pollutants in the Netherlands decreased between 1990 and 2009. 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 may be attributed in particular to cleaner fuels, cleaner car engines and to emission reductions in the industrial sectors.

This has become apparent in the RIVM's explanation of the emission data submission, the Informative Inventory Report (IIR) 2011. Every year the Emission Inventory team – under direction of the RIVM - submits emission data to the government, for it to meet its obligations to the United Nations Economic Commission for Europe (UNECE) and the European Commission. The emission data set consists of data on a series of years, from 1990 up to the most recently submitted data.

For this submission, the ammonia emission data series was calculated using a new model, which includes improved emission reduction measures, more in line with actual measurements. Results of the new model give rise to considerably higher NH_3 emissions in the base year 1990. After 1991 they turned out to be lower. For the year 2008 the difference was 7.6 Gg. The reduction is mostly due to the change in manure application method (i.e. incorporation in the soil instead of surface spreading). Consequently less ammonia is volatilized.

Furthermore, new sources of nitrogen oxides were distinguished and methods were developed to calculate their emissions. These emissions come from manure on agricultural soils and from manure storage. Emissions from agricultural soils for the year 2009 are calculated to amount to 25.5 Gg NO_x. This is about 10% of the maximum allowed emissions of NO_x in the Netherlands, the 'NEC-ceiling' (National Emission Ceiling). The amount is, however, not included for compliance to this ceiling (they are reported under memo-item 11C 'Natural emissions' in the submission). This is because, the methods were not known, when the ceilings were determined.

Key words: emissions, emission data, IIR, transboundary air pollution, emissions 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, PM, 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 2011 is based on data from the national Pollutant Release and Transfer Register (PRTR). The IIR contains information on the Dutch emission inventories for the years from 1990 to 2009, including descriptions of methods, data sources, QA/QC activities and a trend analysis. The inventory covers all anthropogenic emissions to be reported in the Nomenclature for Reporting (NFR), including individual polycyclic aromatic hydrocarbons (PAHs), which are to be reported under persistent organic pollutants (POPs) in Annex IV.

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 default values 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 for 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 the Environment (IenM) has the overall responsibility for the emission inventory and submissions to CLRTAP. A Pollutant Release and Transfer Register (PRTR) 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 an annual (project) cycle (PBL, 2009; RIVM, 2010). Various external agencies contribute to the PRTR by performing calculations or submitting activity data (see next section). In addition to the RIVM, the following institutes contribute to the PRTR:

- PBL Netherlands Environmental Assesment Agency;
- 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 coordinates annual environmental reporting (AER) by companies.

Each of the contributing institutes has its own responsibility and role in the data collection, emission calculations and quality control. These are laid down in general agreements with RIVM and in annual project plans.

1.3 The process of inventory preparation

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 recalculations 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 '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 Enterprices (SMEs).

About 400 companies, representing even more facilities, are legally obligated to submit an Annual Emission Report (AER) as part of an Annual Environmental Report. As from 1 January 2010, AERs can only be submitted, 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 the property of the companies involved.

Data on point-source emissions in the AER database are checked for consistency by the task forces. The result is a selection of validated data on individual 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).

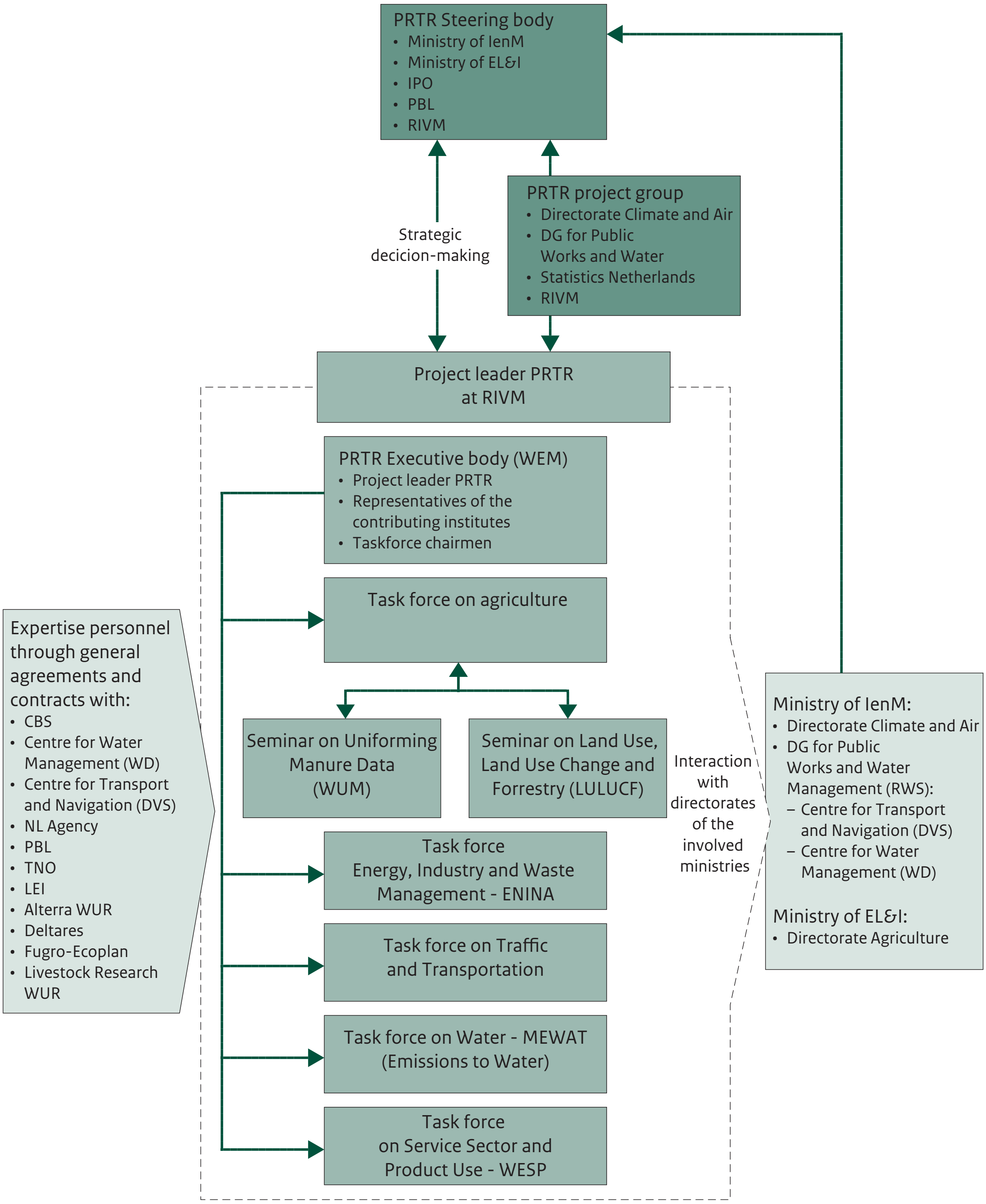
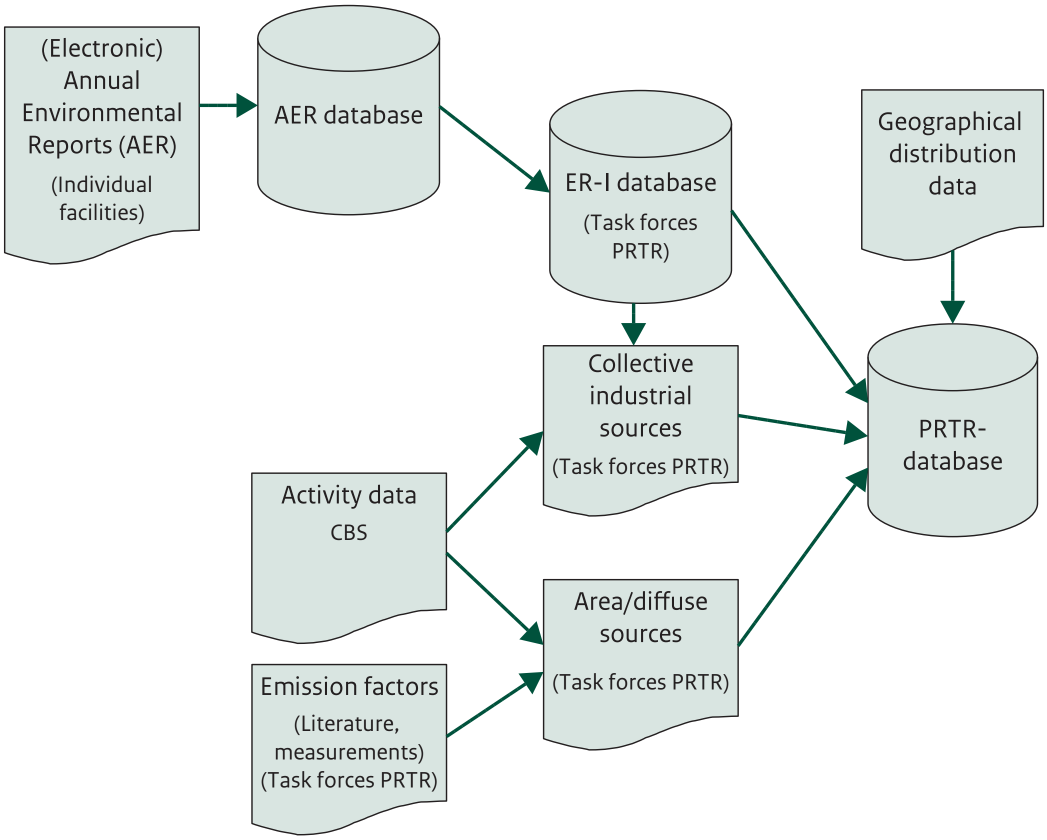


Figure 1.2 The data flow in the Netherlands Pollutant Release and Transfer Register.



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 spread 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 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 sectoral emission inventory studies in the Netherlands (e.g. SPIN documents produced by the 'Cooperation project on industrial emissions').

1.5 Key source analysis

Following recommendations 9 and 10 from the Stage 3 in-depth review report for the Netherlands (UNECE, 2010), a trend assessment was carried out for the emission inventory of all components, in addition to a level assessment, to identify key source categories. In both approaches key source categories were identified using a cumulative threshold of 80%. Key categories are those which, when summed together in descending order of magnitude, add up to more than 80% of the total level (EEA, 2009). The level assessments were performed for both the latest inventory year 2009, as well as for the base year of the inventory, 1990. The trend assessments aim to identify categories for which the trend is significantly different from that of the overall inventory. See Appendix 1 for the actual analysis.

1.6 Reporting, QA/QC and archiving

1.6.1 Reporting

The Informative Inventory Report is prepared by the RIVM, with contributions by experts from the PRTR task forces.

1.6.2 QA/QC

As of 1 January 2010, PRTR project and management are transferred from the PBL to the RIVM Centre for Environmental Monitoring (CMM). The RIVM has an ISO 9001:2000 based QA/QC system in place. Additionally, CMM has a NEN-EN-ISO/IEC 17025:2005 based quality system in place, and with regard to the centre's task of the accredited to perform tests with a limited scope. The quality systems combined serve the complete scope of the CMM, and documentation and archiving are done according to procedures in the quality manual. Arrangements and procedures for the contributing institutes are described in an annual project plan (RIVM, 2010).

In 2010, the adaptation of the PRTR project to the quality system of CMM was initiated, as the CMM had to conclude that it was necessary to change the combined quality system primarily to the ISO 9001:2000 system. In May 2011 the centre is planned to undergo its initial audit in the certification process. As a result of this change, the transition of the PRTR project to the CMM quality system has yet to be completed.

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 CMM quality system, internal audits are performed at the CMM, as part of the ISO certification;
- Furthermore, there are annual external QA checks in 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 2010 inventory, the PRTR task forces filled in a standard format database containing emission data from 1990 to 2009. 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).

Table 1.1 Main items of the verification actions related to data processing 2010 and for the NRF/IIR.

Item	Date	Who	Result	Documentation *
Automated initial check on internal en external data consistency	Up to 29-11-2010	Data Exchange Module (DEX)	Acceptation or rejection of uploaded sector data	Upload event and result logging in the ER-database
Error and outlier checking uploaded and processed data	Up to 1-12-2010	Task Forces and ER team	Action list	historische reeksen vergeleken LUCHT versie 30 nov 2010.xls, Verschiltabel definitieve emissiecijfers 30 nov 2010 LUCHT actueel.xls, Actiepunten trendanalyse T-1 2010 definitief v 1 dec 2010.xls and e-mail communications
Checking result from error correction	Up to 7-12-2010	Sector specialists and ER team	Updated action list	historische reeksen vergeleken LUCHT versie 6 dec 2010.xls, Verschiltabel definitieve emissiecijfers 6 dec 2010 LUCHT actueel.xls, Actiepunten trendanalyse T-1 2010 definitief v 7 dec 2010.xls and e-mail communications
Trend analysis	08-12-2010	Task Forces and ER team	Updated Action list Explanation of trends and differences with previous inventories	Actiepunten trendanalyse T-1 2010 definitief v 10 dec 2010.xls and email communications Documentation sheets (text and tables) on relevant sub sectors.
Checking result of resolved issues	Up to 22-12-2010	Sector specialists and ER team	Updated action list	Actiepunten trendanalyse T-1 2010 definitief v 22 dec 2010.xls and e-mail communications
Check allocations in Draft NRF (v5)	16-12-2010	NIC/IIR team	Allocation table with couplings emission sources to NFR sub sectors	NFR-koppellijst-Kees.xls

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

Text box 1.1 Trend verification workshops

About a week in advance of a trend analysis meeting, a snapshot from the database is made available by the RIVM in a web-based application (Emission Explorer, EmEx) for checks by the institutes involved, sector and other experts (PRTR task forces), and the RIVM ER team. In this way, 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 against the previous year's data set. Where significant differences are found, the task forces evaluate the emission data in more detail. The results from these checks form the subject of discussion at the trend analysis workshop and are subsequently documented. Furthermore, the ER team provides the task forces with time series of emissions per substance, for the individual subsectors. The task forces examine these time series. During the trend analysis for this inventory report, the emission data were checked in two ways: 1) emissions from between 1990 and 2008 from the new time series were compared against the time series of previous year's inventory, and 2) the data for 2009 were compared with the trend development per compound since 1990. Checks of outliers are performed on the more detailed level of subsources in all sector background tables, and relate to:

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

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

1.6.3 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 at the PBL, including the documentation/archiving of QC checks. As of 2010, sector experts can store relating documents (e.g. interim results, model runs) 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 and 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 from 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 will be done during 2011, so that the results may be presented in de IIR of 2012. At that time, also more detailed uncertainty analyses, as suggested by the ERT in their Stage 3 in-depth review, will be provided (UNECE, 2010)

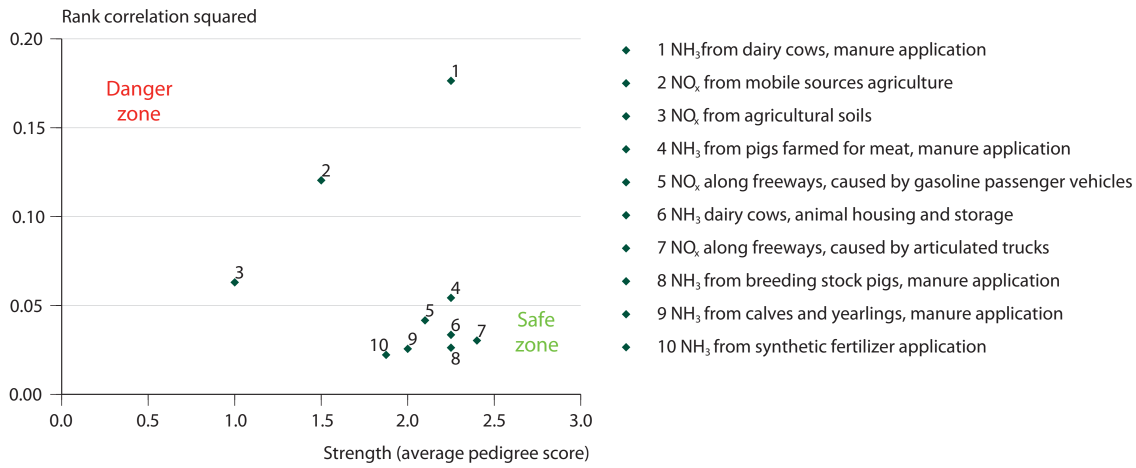
1.7.1 Quantitative uncertainty

Uncertainty estimates on national total emissions have been reported in the Dutch Environmental Balances since 2000 (PBL, 2009a). 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 of NMVOC emissions showed an uncertainty range of about 25%. Van Gijlswijk et al. (2004) assessed the uncertainty in the contribution from the various emission sources to total acidification (in acidification equivalents) according to the Tier-2 methodology (estimation of uncertainties per source category, using Monte Carlo analysis). See Table 1.2 for results. A comparison was also made between the Tier-1 and Tier-2 methodologies. This was not straightforward, as the two studies used a different knowledge collection. The 2000 Tier-1 analysis used CLRTAP default uncertainties for several NO_x processes, which explains the difference with the 1999 Tier-1 results. For NH_3, the difference between the 2000 Tier 1 and Tier 2 can be explained by taking non-normal distributions and dependencies between individual emission sources for each animal type into account (both are violations of the Tier-1 assumptions: effects encapsulated in the 1999 Tier-1 analysis). The differences for SO_2 and total acidifying equivalents are small. The conclusion drawn from this comparison is that focusing on the order of magnitude of the individual uncertainty estimates, as in the RIVM (2001) study, provides a reasonable first assessment of the uncertainty of source categories.

Table 1.2 Uncertainty (95% confidence ranges) in acidifying compounds and for total acidifying equivalents for emissions in 1999 (RIVM, 2001) and 2000 (Van Gijlswijk et al., 2004).

Component	Tier 1 for 1999	Tier 1 for 2000	Tier 2 for 2000
NH_3	± 17%	± 12%	± 17%
NO_x	± 11%	± 14%	± 15%
SO_2	± 8%	± 6%	± 6%
Total acid equivalents	± 9%	± 8%	± 10%

Figure 1.3 NUSAP diagnostic diagram indicating strong and weak elements in the available knowledge on acidifying substances in the 2004 emission inventory.



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) that 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)	NH_3	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	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
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(ii)	All	1A3a ii(i)
1B2c	All	1B2b, 1B2aiv
4B1b	NO_x	4B1a
1A3e	All	1A2fi, 1A4cii, 1B2 b
2A2	All	2A7d
2A5	NMVOC	2A7d
2A6	All	2A7d
2B1	NMVOC, NH_3	2B5a
2B2	NH_3	2B5a
2B4	NMVOC	2B5a
2C2	All	1A2a
2C5f	All	1A2b
4B3	NO_x	4B1b
4B4	NO_x	4B1b
4B6	NO_x	4B1b
4B8	NO_x	4B1b
4B9a	NO_x	4B1b
4B9b	NO_x	4B1b
4B9b	TSP, PM_{10}, $PM_{2.5}$	4B9a
4B9c	NO_x	4B1b
4B9c	NH_3	4B9b
4B9c	TSP, PM_{10}, $PM_{2.5}$	4B9a
4B9d	NO_x	4B1b
4B9d	NH_3	4B9b
4B9d	TSP, PM_{10}, $PM_{2.5}$	4B9a
4B13	NO_x	4B9a
4D1a	NO_x	4B9a
4D2 c	NH_3	4B
1B1a	TSP, PM_{10}, $PM_{2.5}$	2G
3C	NMVOC	2B5a

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 in industries not reported elsewhere, machineries, services, product making activities.
1A5a		Combustion gas from landfills
1A5b		NO/NA
1B1c		NO/NA
1B3		NO/NA
2A7d		Processes, excl. combustion, in building activties, production of building materials
2B5a		Production of chemicals, paints, pharmaceutics, soaps, detergents, glues and other chemical products.
2B5b		NO/NA
2C5e		Production of non-ferrous metals
2C5f		Production of non-ferrous metals
2G		Manufacturing of wooden, plastic, rubber, metal, textile and paper products.
3A3		NO/NA
4B13	NH_3	Pets
4G	NH_3, TSP, PM_{10}, $PM_{2.5}$	Handling agricultural base materials and products
6D		Handling waste
7A		Smoking tobacco products (all substances, excl. NMVOC); transpiration, breathing, manure application to private domains and nature (NH_3)
7B		NO/NA
11C		NO/NA

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 over the 1990-2009 period (see Table 2.1). The major overall drivers for this trend were:

- emission reductions in the industrial sectors;
- cleaner fuels;
- cleaner vehicle engines.

Road transport emissions have decreased by 80% since 1990 for NMVOC, 51% for PM, 55% for NO_x and 98% for SO_2, despite a growth in traffic of 35%. 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 Dutch implementation of the 'EU Large Combustion Plants Directive'(LCP), related to the extent of emissions from stocks of heating installations. In meeting these requirements, Dutch industrial plants have realised a reduction of 87% in PM emissions and 59% in NO_x emissions, since 1990. The drivers for the downward emission trend for specific substances are elaborated in more detail in the next section. For heavy metals and dioxins, information on division of sectors and trends has not been included, as information from the IIR2010 is still current.

Table 2.1 Total national emissions, 1990-2009.

	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	1119	464	192	355	90	67	44	336	2.1	3.5
1995	472	911	328	130	208	67	50	33	160	1.1	1.2
2000	398	755	232	73	161	45	39	24	34	0.9	0.9
2005	344	669	176	65	140	40	33	19	36	1.7	0.8
2008	303	649	164	51	126	38	32	17	37	1.9	0.8
2009	279	599	154	38	125	35	30	16	38	1.7	0.8
1990–2009 period [1]	-287	-520	-310	-154	-230	-55	-38	-28	-298	-0.3	-2.7
1990 -2009 period [2]	-51%	-46%	-67%	-80%	-65%	-61%	-56%	-64%	-89%	-17%	-77%

[1] Absolute difference in Gg

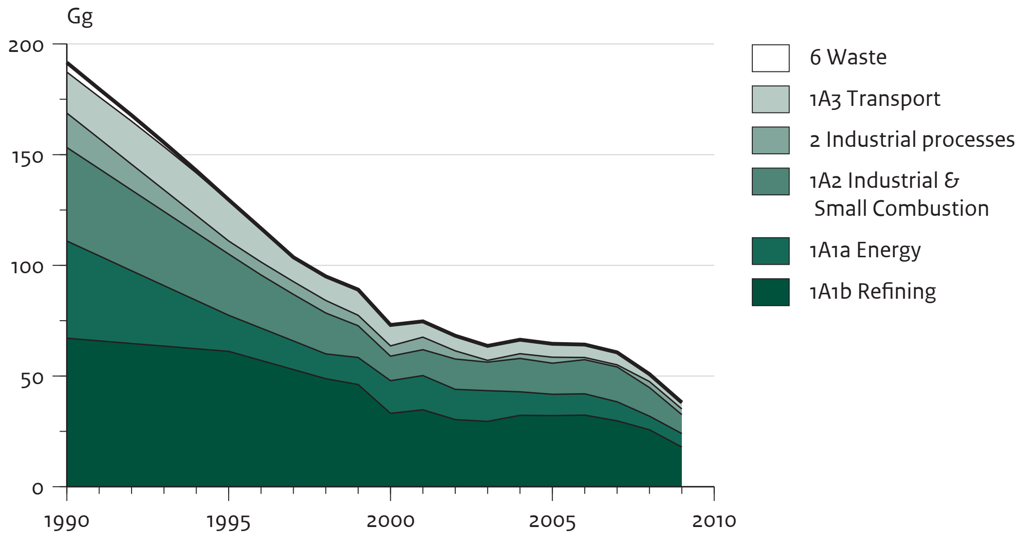
[2] Relative difference to 1990 in %

	POPs		Other Heavy Metals					
	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	743	20.0	1.5	9.9	67.7	75.3	0.4	220.6
1995	69	9.7	1.0	6.6	70.4	86.6	0.3	141.8
2000	30	3.8	1.1	3.1	74.9	18.8	0.5	90.9
2005	38	3.8	1.5	2.2	79.3	10.7	2.4	84.0
2008	28	4.5	0.8	2.1	82.7	9.0	2.5	87.4
2009	29	4.1	0.8	1.5	84.0	2.9	0.9	89.4
1990–2009 period [1]	-714	-15.9	-0.7	-8.4	16.3	-72.3	0.5	-131.2
1990–2009 period [2]	-96%	-79%	-46%	-85%	24%	-96%	134%	-59%

[1] Absolute difference in Gg

[2] Relative difference to 1990 in %

Figure 2.1. SO_2 emission trend, 1990-2009.



2.2 Trends in sulphur dioxide (SO_2)

The Dutch SO_x emissions (reported as SO_2) decreased by 154 Gg, in the 1990-2009 period, corresponding to 80% of the national total of 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 fluegas desulphurisation plants. The sulphur content in fuels used in the (chemical) industry and in transport was also reduced. At present, the industry, energy and refining sector (IER) are responsible for 90% of 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 287 Gg, in the 1990–2009 period, corresponding to 51% of the national total of 1990 (Figure 2.2). Main contributors to this decrease were the road-transport and energy sectors. The emissions per vehicle decreased significantly during this period, but the effect on total emissions was partially counterbalanced by an increase in number and mileages of vehicles. The share of the different NFR categories in the national total did not change significantly.

Figure 2.2 NO_x emission trend, 1990–2009.

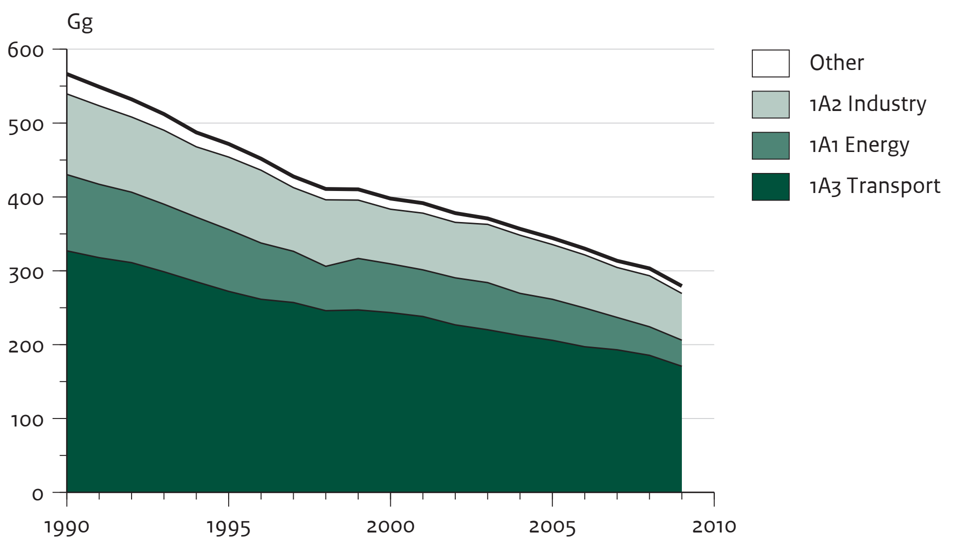
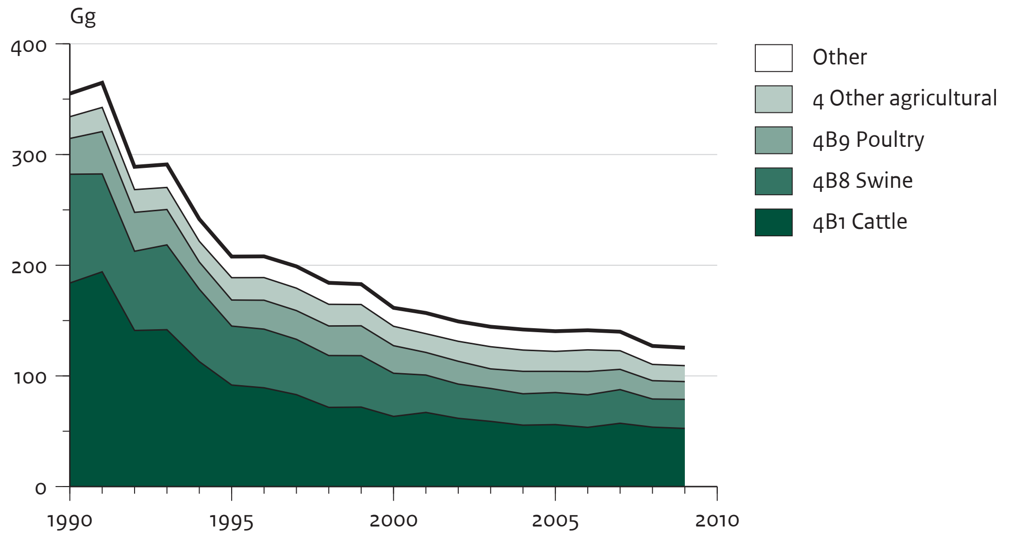


Figure 2.3 NH_3 emission trend, 1990–2009.



2.4 Trends in ammonia (NH_3)

The Dutch NH_3 emissions decreased by 230 Gg, in the 1990–2009 period, corresponding to 65% of the national total of 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 populations 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 310 Gg, in the 1990–2009 period, corresponding to 67% of the national total of 1990 (Figure 2.4). All major source categories contributed to this decrease, for example, transport (introduction of catalysts and cleaner engines), product use (intensive programme to reduce NMVOC content in consumer products and paints) and industry (introducing emission abatement specifically for NMVOC).

Figure 2.4 NMVOC emission trend, 1990–2009.

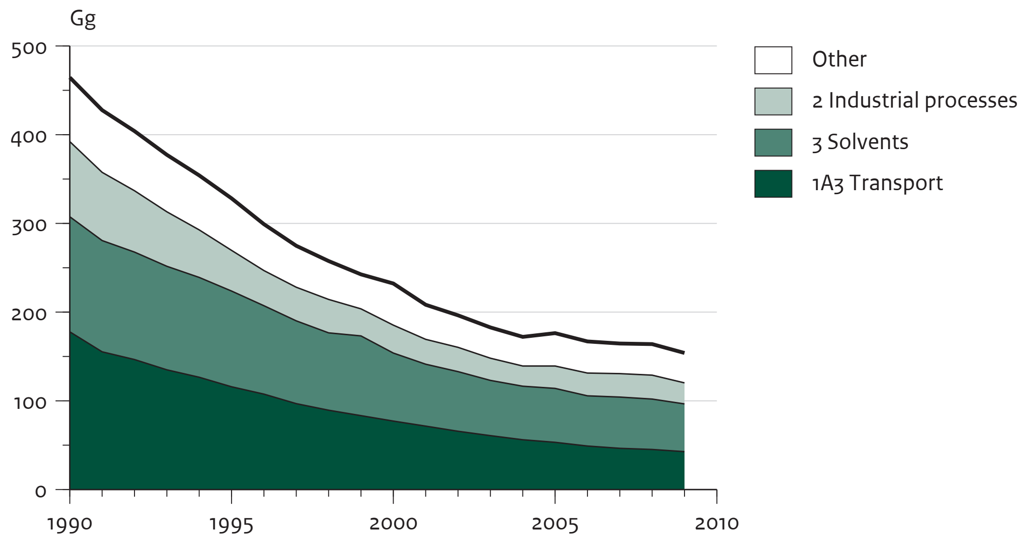
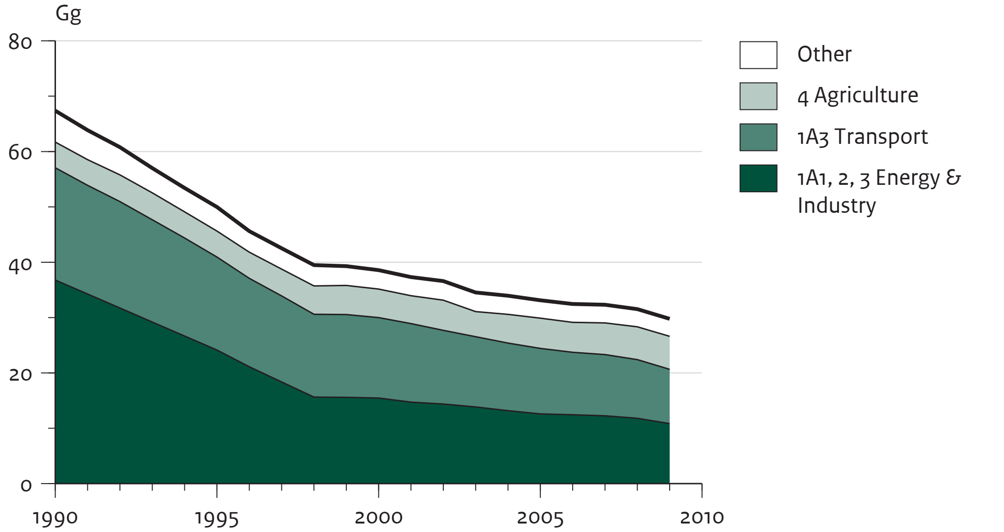


Figure 2.5 PM_{10}, emission trend, 1990–2009.



2.6 Trends in PM_{10}

Dutch PM_{10} emissions decreased by 38 Gg, in the 1990–2009 period, corresponding with 56% of the national total of 1990 (Figure 2.5). The major source categories contributing to this decrease were:

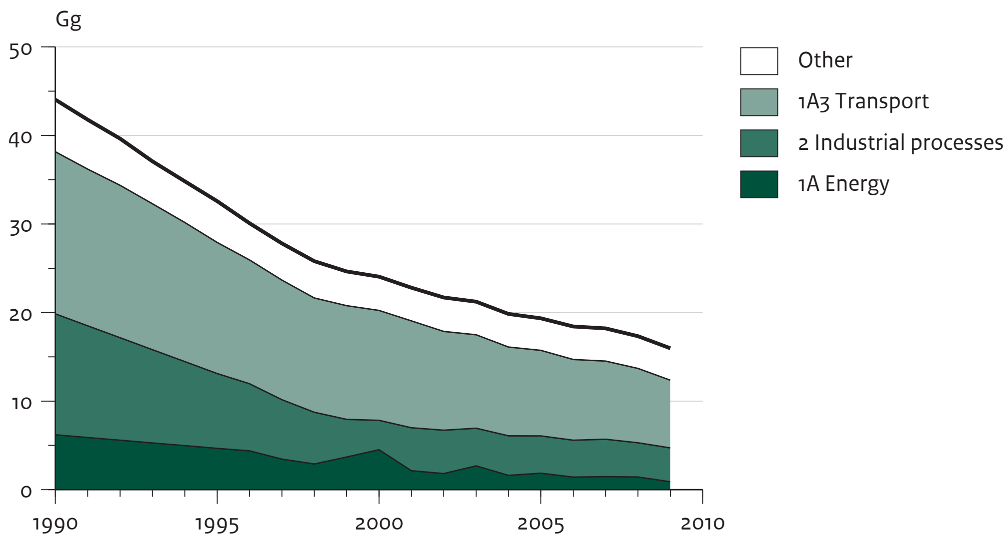
- industry (combustion and process emissions), due to cleaner fuels in refineries and the side effect of emission abatement for SO_2 and NO_x , and
- traffic and transport.

The 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 2011 submission to UNECE. These emissions are calculated as a specific fraction of PM_{10} per sector (based on Visschedijk et al., 2007). $PM_{2.5}$ emissions in the Netherlands decreased by 28 Gg, in the 1990–2009 period, corresponding with 64% of the national total of 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, 1990–2009.



3
Energy

3.1 Overview of sector emissions

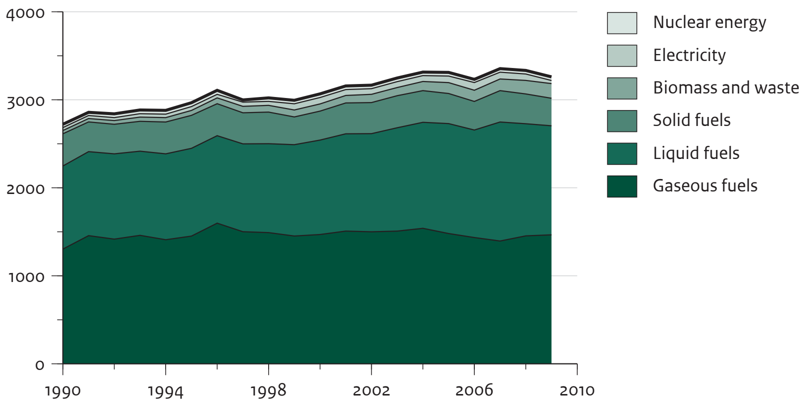
Emissions from this sector include all energy-related emissions from industrial activities and transport. Furthermore, they include fugitive emissions from the energy sector.

About 80% to 100% of the NO_x, SO_2, PM_{10} and NH_3 emissions from stationary combustion (categories 1A1, 1A2, 1A4 and 1A5) are based on environmental 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.

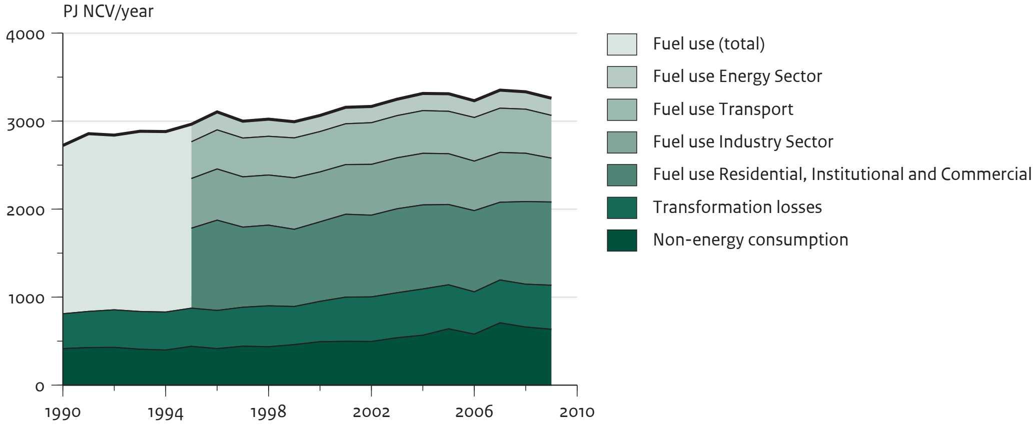
As for most developed countries, the energy system in the Netherlands is largely driven by the combustion of fossil fuels. In 2009, natural gas supplied about 45% of the total primary fuels used in the Netherlands, followed by liquid fuels (38%) and solid fossil fuels (9.6%). The contribution of non-fossil 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, between1990 and 2009, only total fuel use is shown.

Energy supply



Energy demand



3.2 Public Electricity and heat production (1A1a)

3.2.1 Source category description

In this sector, one source category is included: Public Electricity and Heat Production [1A1a]. This sector consists mainly of coal-fired power stations and gas-fired cogeneration plants, with many of the latter being operated as joint ventures with industries. Compared to other countries in the EU, nuclear energy and renewable energy (biomass and wind) provide a small amount of the total primary energy supply in the Netherlands.

3.2.2 Key sources

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 of 2009 (%)
1A1a Public electricity and heat production	SO_x	16.1
	NO_x	8.6
	Hg	15.1

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 2009, while fuel consumption increased by 50% over the same period. The emissions from the main pollutants decreased by 45% to 86%, while emissions from other pollutants decreased by 67% to 99%. The only pollutant for which the emissions have increased is mercury. The decrease in emissions has partly

Table 3.2 Overview of trends in emissions of 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	76	5	0.5	44	0.00	1.70	1.45	1.18	3.38	0.11	0.01
1995	59	7	0.6	16	0.00	0.89	0.56	0.34	0.28	0.00	0.00
2000	50	15	2.1	15	0.01	0.30	0.30	0.25	0.00	0.00	0.08
2005	41	7	0.5	10	0.21	0.78	0.50	0.42	0.07	0.00	0.18
2008	25	4	0.3	6	0.07	0.61	0.30	0.22	0.05	0.01	0.17
2009	24	3	0.3	6	0.03	0.56	0.33	0.24	0.04	0.03	0.12
1990 -2009 period [1)]	-52	-2	-0.2	-38	0.03	-1.14	-1.13	-0.94	-3.34	-0.08	0.11
1990 -2009 period [2)]	-69%	-45%	-47%	-86%		-67%	-78%	-80%	-99%	-70%	929%

[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	1.01	0.17	0.43	0.24	0.74	1.48	0.00	7.04
1995	0.00	0.05	0.12	0.08	0.16	0.71	0.00	0.79
2000	0.00	0.00	0.00	0.02	0.05	0.00	0.37	0.14
2005	0.00	0.01	0.12	0.20	0.17	1.86	1.40	0.42
2008	0.02	0.00	0.05	0.12	0.20	1.18	0.77	2.24
2009	0.19	0.01	0.04	0.06	0.08	0.10	0.83	1.07
1990 -2009 period [1)]	-0.82	-0.16	-0.39	-0.18	-0.66	-1.38	0.83	-5.96
1990 -2009 period [2)]	-81%	-92%	-90%	-76%	-90%	-93%		-85%

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

been caused by a shift from coal to gas consumption.

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 provides 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.

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

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-I_SBI_emission $_{(SBI\ category,\ fuel\ type)}$ **= EF ER-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 high enough quality (see Section 1.3 on QA/QC), the information is used.

3.2.8 Source-specific recalculations

There were no source-specific recalculations in this submission.

3.2.9 Source-specific planned improvements

There are no source-specific planned improvements.

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

3.3.1 Source category description

This source category consists of the following categories:
- 1A1b 'Petroleum refining'
- 1A1c 'Manufacture of solid fuels and other energy industries'
- 1A2a 'Iron and Steel'
- 1A2b 'Non-ferrous Metals'
- 1A2c 'Chemicals'
- 1A2d 'Pulp, Paper and Print'
- 1A2e 'Food Processing, Beverages and Tobacco'
- 1A2fi 'Other'

The sector 1A2fi includes industries for mineral products (cement, bricks, other building materials, glass), textiles, wood and wood products, machinery.

3.3.2 Key sources

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 2009 (%)
1A1b Petroleum refining	SO_x NMVOC	47.1 3.7
1A1c Manufacture of solid fuels and other energy industries	-	-
1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	SO_x CO	6.2 10.6
1A2b Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	Dioxins	5.7
1A2c Stationary combustion in manufacturing industries and construction: Chemicals	SO_x NO_x Cd Dioxins	5.9 4.0 37.9 4.7
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	-	-
1A2fi Stationary combustion in manufacturing industries and construction: Other	SO_x	5.9

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. Reduction in emissions of main pollutants has been

Table 3.4 Overview of trends in emissions in 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	94	230	22.0	105	0.58	8.95	8.12	5.01	1.89	0.14	0.18
1995	74	182	17.4	87	0.32	7.00	6.67	4.32	4.27	0.20	0.08
2000	46	116	9.1	43	0.05	6.37	6.26	4.26	0.04	0.01	0.20
2005	49	106	12.2	45	0.06	2.09	1.88	1.44	0.01	0.00	0.00
2008	45	144	10.1	38	0.76	2.14	1.63	1.21	1.27	0.78	0.02
2009	38	96	8.6	26	0.57	1.19	0.91	0.65	1.69	0.67	0.02
1990 -2009 period [1]	-56	-133	-13.5	-79	0.00	-7.75	-7.21	-4.36	-0.20	0.53	-0.16
1990 -2009 period [2]	-59%	-58%	-61%	-76%	-1%	-87%	-89%	-87%	-11%	386%	-90%

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

	POPs		Other Heavy Metals					
	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	0.01	1.06	0.17	2.49	1.39	64.63	0.04	2.95
1995	1.02	0.42	0.23	3.14	2.82	79.44	0.05	58.96
2000	1.75	0.04	0.00	0.51	0.15	17.42	0.00	24.28
2005	7.87	0.13	0.78	0.08	0.09	6.51	0.08	0.49
2008	2.39	0.20	0.02	0.31	1.07	5.76	0.00	4.84
2009	5.16	0.21	0.01	0.10	1.07	1.40	0.01	9.11
1990 -2009 period [1]	3.11	-0.85	-0.16	-2.39	-0.32	-63.23	-0.04	6.17
1990 -2009 period [2]		-80%	-94%	-96%	-23%	-98%	-87%	209%

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

caused by improvement in used techniques. Increases in some other pollutants have been caused by increases in fuel use.

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.

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

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.

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

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

3.4.2 Key sources

Key sources in this sector are presented in Table 3.5.

Table 3.5 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	4.4
1A4bi	Residential, stationary	NO_x	4.8
		NMVOC	6.1
		CO	9.4
		TSP	9.9
		PM_{10}	5.5
		$PM_{2.5}$	9.7
		Dioxins	19.5
		PAH	69.9
1A4ci	Agriculture/forestry/fishing, stationary	NO_x	3.9
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 only slightly (4%).

Table 3.6 Overview of trends in emissions in Small 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	14	3	1.1	2	0.37	0.34	0.30	0.63	0.03	0.09	0.09
1995	14	3	1.1	1	0.08	0.07	0.06	0.03	0.00	0.00	0.00
2000	13	2	0.9	1	0.03	0.03	0.03	0.00	0.00	0.00	0.00
2005	12	3	1.1	0	0.10	0.09	0.07	0.01	0.00	0.00	0.00
2008	12	3	1.3	0	0.08	0.06	0.05	0.00	0.00	0.00	0.00
2009	12	3	1.3	0	0.06	0.06	0.05	0.00	0.00	0.00	0.00
1990–2009 period [1]	-1	0	0.1	-2	-0.31	-0.29	-0.25	-0.63	-0.03	-0.09	-0.09
1990–2009 period [2]	-10%	12%	9%	-92%	-83%	-83%	-82%	-100%	-99%	-99%	-99%

	POPs		Other Heavy Metals					
	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
Year	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	100.02	0.47	0.01	3.53	0.39	2.94	1.14	1.14
1995	0.20	0.06	0.01	0.05	0.03	0.83	0.04	0.04
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	0.01	0.01	0.00	0.01	0.01	0.31	0.02	0.02
2008	0.01	0.01	0.00	0.00	0.00	0.06	0.01	0.01
2009	0.01	0.01	0.00	0.00	0.00	0.12	0.01	0.01
1990–2009 period [1]	-100.01	-0.46	-0.01	-3.52	-0.39	-2.82	-1.13	-1.13
1990–2009 period [2]	-100%	-98%	-92%	-100%	-99%	-96%	-99%	-99%

[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.

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)

Combustion emissions from (wood) stoves and fireplaces have been calculated by multiplying the fuel consumption per apparatus type and fuel type (Statistics Netherlands) by emission factors per house (Hulskotte et al., 1999).

Agriculture/forestry / fishing (1A4ci)
Stationary combustion emissions have been based on fuel consumption obtained from CBS, 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 for wood consumption for wood stoves in category 1A4bi has been revised. The results from the latest survey (winter 2006–2007) have been interpreted and combined with surveys from previous years to re-calculate the complete time series. This new method caused minor changes in data on wood consumption for the 1990–2003 period. For the 2004–2008 period, the new method caused an increase in wood consumption of 11% to 28%. The latest survey showed that wood consumption had increased during the last few years, while this was not yet included in the wood consumption data for these years. Furthermore, emission factors for this sector have been revised (mainly for heavy metals).

3.4.9 Source-specific planned improvements

There are no source-specific planned improvements.

3.5 Fugitive emissions (1B)

3.5.1 Source category description

This source category includes fuel-related emissions from non-combustion activities in the energy production and transformation industries:
- 1B2ai Oil and gas production
- 1B2aiv Refining
- 1B2b Gas transport and gas distribution

3.5.2 Key sources

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	4.1
1B2a.v Refining	NMVOC	2.6
1B2b Gas transport and gas distribution	-	-

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 2009.

Table 3.10 Overview of trends in fugitive emissions.

	NMVOC	PAH
Year	Gg	Mg
1990	32.0	0.01
1995	23.3	0.02
2000	22.5	0.00
2005	11.4	0.04
2008	11.4	0.00
2009	11.8	0.03
1990–2009 period [1]	-20.1	0.02
1990–2009 period [2]	-63%	356%

[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 aeroplane 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 source categories: 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 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 and national fishing. The emissions from non-road mobile machinery are 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 use, using for the most part national activity data and emission factors. Emissions from fisheries are reported under 1A4c iii 'National fishing' and were also calculated using a Tier-3 method.

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.

Table 4.1 Source categories and methods for transport related sources.

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

NS = National Statistics
CS = Country-specific

Table 4.2 Key source analysis for transport related sources.

NFR code	Source category description	SO_2	NO_x	NMVOC	CO	TSP	PM_{10}	$PM_{2.5}$	Pb
1A3bi	Passenger cars	3.8%	25.8%	14.5%	26.8%				44.1%
1A3bii	Light duty trucks		5.6%	2.0%	6.2%	3.7%	3.7%	9.5%	
1A3biii	Heavy duty vehicles	6.7%	11.9%	2.5%		5.2%	7.6%	10.4%	
1A3biv	Motorcycles and mopeds			5.4%	13.4%				
1A3bv	Gasoline evaporation			9.8%					
1A3bvi	Tyre and brake wear					4.6%	5.1%		9.6%
1A3bvii	Road abrasion					3.6%	3.9%		
1A3di(ii)	International inland waterways		3.0%					2.4%	
1A3dii	National navigation		5.5%	2.2%	6.1%			3.4%	
1A4bii	Residential household gardening (land-based mobile machinery)				8.6%				
1A4cii	Agriculture/forestry/fishing: off-road vehicles and other machinery		2.7%						

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 Schiphol Amsterdam Airport, 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) has increased by 88% between 1990 and 2009, from 4.9 to 9.2 PJ. Schiphol Amsterdam Airport is responsible for over 90% of fuel consumption in civil aviation in the Netherlands. Fuel consumption (LTO) at Schiphol Amsterdam Airport has more than doubled between 1990 and 2008, but decreased by 8% in 2009 compared to 2008. This decrease can be attributed to the economic crisis and the resulting decline in air travel. The number of passengers at Schiphol Amsterdam Airport also decreased by 8% and the number of flights (LTO cycles) decreased by 9%, according to Statistics Netherlands.

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 2009, 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, and for Eindhoven Airport it has more than tripled.

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,

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
2008	2.86	4.05	0.25	0.10	0.055	0.055	0.042	2.43	0.0060	0.0007
2009	2.67	4.05	0.24	0.09	0.051	0.051	0.039	2.61	0.0056	0.0007
1990 -2009 period [1)]	1.31	-0.20	-0.16	-0.02	0.016	0.016	0.009	-1.02	-0.0037	-0.0005
1990 -2009 period [2)]	96%	-5%	-41%	-18%	47%	47%	31%	-28%	-38%	-41%

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

TSP, PM_{10} and $PM_{2.5}$. NO_x and PM_{10} emissions at Schiphol Amsterdam Airport show similar trends to the fuel consumption time series, with NO_x emissions increasing from 1.3 to 2.5 Gg between 1990 and 2009. Emission levels at regional airports have increased much faster than levels of fuel consumption, with NO_x emissions more than doubling between 2004 and 2009 (from 80 Mg in 2004 to 180 Mg in 2009).

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., 2011). 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 USEPA (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 Takeoff and Climbout. 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. The emissions reported under 1A3aii ‘Domestic aviation’ consists of the actual emissions at regional airports, whereas the emissions reported under 1A3ai ‘International aviation’ are the emissions at Schiphol Amsterdam Airport.

4.2.6 Uncertainties and time-series consistency

There was no recent and accurate information available for assessing the uncertainties about the emissions from civil aviation. Currently, a research project on uncertainties in the emission inventory has been started by TNO. 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, flights and passenger numbers at Schiphol Amsterdam Airport and regional airports, see also Subsection 4.2.3.

4.2.8 Source-specific recalculations

There were no source-specific recalculations for civil aviation.

4.2.9 Source-specific planned improvements

The allocation of fuel consumption in civil aviation will be corrected in next year's submission. In the current submission, the reported emissions under domestic aviation consisted of the actual emissions at regional air-ports, and the emissions at Schiphol Amsterdam Airport were reported under international aviation. There was no information on the division of total emissions in those from national and international aviation, although most of the emissions are expected to be from international aviation, since national aviation is smaller as it is limited to the Netherlands. In next year's submission, all aviation emissions will be reported under international 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 passengers cars (1A3bi), light-duty trucks (1A3bii), heavy-duty vehicles (1A3biii), 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 NO_x, NMVOC, CO and Pb. 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 NO_x, NMVOC, 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}. Road vehicle tyre and brake wear is also a key source of emissions of 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 2009, due to the tightening of the EU fuel quality standards regulating the maximum allowed 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	693	163.6	13	0.90	15.14	15.14	13.42	245.88	0.03
1995	187	521	100.4	12	1.89	12.04	12.04	10.27	83.11	0.03
2000	155	425	62.3	3	2.50	10.18	10.18	8.29	5.47	0.04
2005	130	356	41.3	0	2.46	8.57	8.57	6.56	5.83	0.04
2008	118	337	35.1	0	2.47	7.87	7.87	5.76	6.12	0.04
2009	110	327	33.4	0	2.49	7.36	7.36	5.26	6.09	0.04
1990 -2009 period [1)]	-133	-366	-130.2	-12	1.59	-7.78	-7.78	-8.16	-239.79	0.01
1990 -2009 period [2)]	-55%	-53%	-80%	-98%	178%	-51%	-51%	-61%	-98%	33%

[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	2.50	1.48	0.16	0.17	50.45	0.24	0.01	29.45
1995	1.57	1.03	0.17	0.18	51.35	0.26	0.01	30.85
2000	0.99	0.70	0.20	0.21	54.64	0.28	0.01	34.25
2005	0.67	0.45	0.21	0.23	58.33	0.31	0.01	36.52
2008	0.58	0.39	0.22	0.24	61.23	0.32	0.01	38.25
2009	0.56	0.38	0.22	0.24	60.92	0.32	0.01	38.04
1990 -2009 period [1)]	-1.95	-1.10	0.06	0.06	10.46	0.08	0.00	8.59
1990 -2009 period [2)]	-78%	-74%	35%	36%	21%	34%	23%	29%

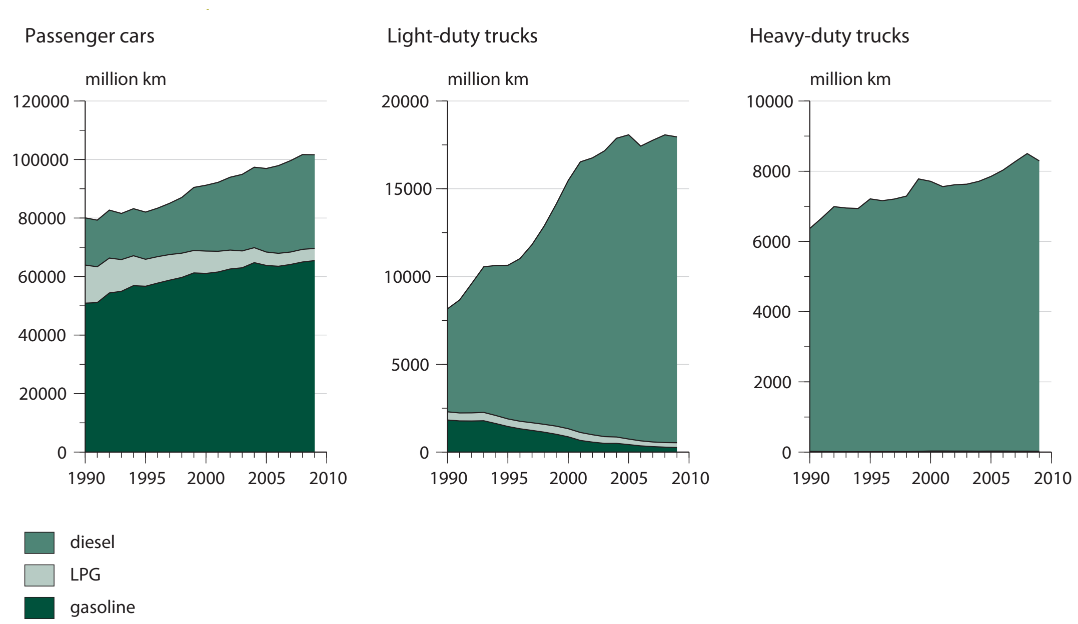
[1)] Absolute difference in Gg [2)] Relative difference to 1990 in %

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). In 2009 the total kilometres driven by passenger cars did not increase further compared to 2008. This can be attributed to the economic crisis. Diesel kilometres have 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 98% between 1995 and 2009. In comparison: gasoline mileages have increased by 15% 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 68% between 1990 and 2009. NO_x emissions from passenger cars have decreased by 75% between 1990 and 2009, from 138 to 35 Gg. This decrease has mainly been caused by the introduction of the (closed loop) three-way catalyst (TWC) for gasoline-powered cars, which has led to a major decrease in NO_x emissions from these cars (84% between 1990 and 2009). 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). The average NO_x emission factor for the national diesel-powered car fleet in the Netherlands has shown a decreasing trend, with an average annual decrease of approximately 2% between 1990 and 2009.

NMVOC exhaust emissions from passenger cars have decreased significantly, from 97 Gg in 1990 to 20 Gg in 2009 (80% decrease). This decrease was primarily caused by the introduction of the TWC for gasoline passenger cars, leading to a decrease in NMVOC exhaust emissions, from 80 Gg in 1990 to 18 Gg in 2009. NMVOC exhaust emissions from diesel and LPG-powered passenger cars have also decreased significantly. CO emissions from passenger cars have decreased by 58%, between 1990 and 2009. Gasoline passenger cars were responsible for over 90% of total CO emissions from passenger cars. Introduction of the

Figure 4.1 Kilometres driven per fuel type, for different types of road transport in the Netherlands.



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 2009. CO emissions from diesel and LPG passenger cars have also decreased significantly, but the share of both fuel types in total CO emissions was small.

With the introduction of unleaded gasoline, Pb emissions from passenger cars decreased from 0.2 Gg in 1990 to 0 Gg in 1997. Since then, Pb is no longer present in exhaust emissions from road traffic.

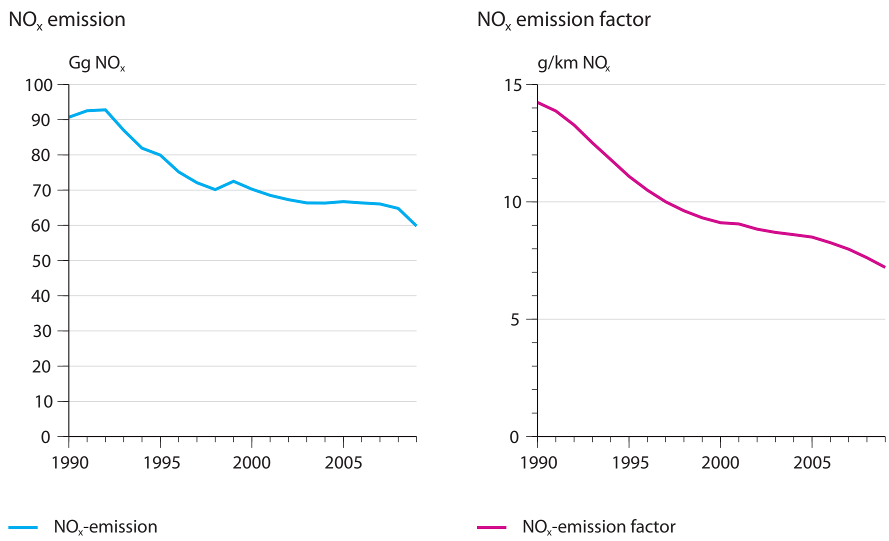
1A3bii Light duty trucks

The national light-duty truck fleet in the Netherlands has grown significantly since 1990, leading to a major, 120% 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 and of the kilometres driven is diesel-powered. NO_x emissions from light-duty trucks have increased between 1995 and 2000, and have slowly decreased since. NO_x emissions in 2009 were approximately at the same level as in 1990 (14.5 Gg v. 14.9 Gg), even though the vehicle kilometres have doubled in the same time period. 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 NO_x emission factor for diesel light-duty trucks has decreased by approximately 4% annually, over 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 2009, 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 average fleet emission factors for both gasoline and diesel vehicles of 70 to 80%, between 1990 and 2009. Gasoline-powered trucks emit far more NMVOC and CO than diesel-powered trucks; therefore, the decreasing trend 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

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



series, but was offset during the earlier years by the increase in diesel kilometres driven. Diesel-powered trucks are dominant in the total PM_{10} emissions from lightduty 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 2009. Combined with the stabilisation of the amount of vehicle kilometres driven since 2005, this has led to a decrease in emissions.

1A3biii Heavy duty vehicles including buses

The vehicle kilometres driven by heavy-duty trucks and buses in the Netherlands have increased by approximately 30%, between 1990 and 2009 (see Figure 4.1). The economic crisis has led to a decrease in total vehicle kilometres of 3% between 2008 and 2009. 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 91 Gg in 1990 to 60 Gg in 2009 (see Figure 4.2). The fleet average NO_x emission factor decreased by 50% in this period, from 14 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 77%, from 10 Gg in 1990 to 2 Gg in 2009, whereas PM_{10} exhaust emissions decreased by 82%, from 5 Gg to 1 Gg. These dereases have also been caused by EU emission legislation.

1A3biv Motorcycles and mopeds

The kilometres driven by motorcycles and mopeds have increased by 27%, between 1990 and 2009. The increase in kilometres driven by motorcycles was caused only by the growth in the number of vehicles, as the average annual mileages of motorcycles had not been updated, recently. NMVOC emissions from motorcycles and mopeds decreased from 12.5 to 9.0 Gg, between 1990 and 2009, due to the introduction of European emission standards for two wheelers. CO emissions increased by 33% during this time period, mainly due to the increase in the kilometres driven. The emission factors for regulated two-wheelers had not been updated, recently, therefore emission estimates for recent years are highly uncertain.

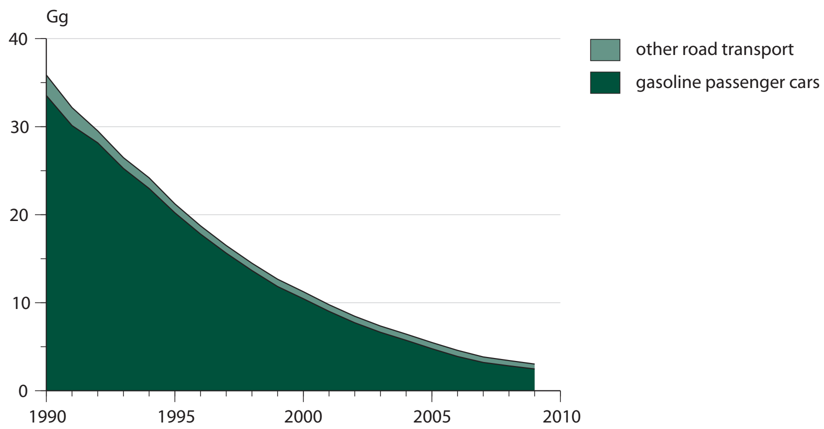
1A3bv Gasoline evaporation

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 in the Netherlands. Total evaporative NMVOC emissions decreased from 36 Gg in 1990 to 3 Gg in 2009 (see Figure 4.3). Evaporative emissions from motorcycles and mopeds have increased by 27%, from 0.4 Gg in 1990 to 0.5 Gg in 2009.

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 22%, between 1990 and 2009, 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.

Figure 4.3 Evaporation of NMVOC emissions from road transport in the Netherlands.



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 in grams per vehicle kilometre (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 allowed 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. Next year, the Netherlands plans to use NAP data for motorcycles to improve annual mileages data on Dutch motorcycles.

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 category of kilometres driven per vehicle were also sub-divided by road types. The road type distributions for different vehicle types were recently re-estimated (Goudappel Coffeng, 2010). For this study, a national tran-sport 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. (2011).

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 kilometre driven). These figures on specific fuel consumption (litre/kilometre) were derived from surveys among owners of passenger cars, heavy-duty trucks and motorcycles.

Emission factors

The CO, NMVOC, NO_x and PM exhaust emission factors for road transport were calculated by TNO 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 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 and De Lange, 2009) was used to de-rive 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 measure-ments, 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. (2011). 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). For 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).

4.3.5 Methodological issues

The fuel consumption figures (litre/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 about the emissions from road transport. Currently, a research project is performed by TNO on uncertainties in the emission inventory. 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

Compared to last year's submission, several new methods and insights have been applied in the emission inventory for road transport in the Netherlands:

- The road type distribution of different vehicles types has been re-estimated by Goudappel Coffeng (2010).
- TNO has derived new VOC and PAH species profiles (Ten Broeke and Hulskotte, 2009).
- The vehicle kilometres driven for heavy-duty trucks and buses have been recalculated by Statistics Netherlands using NAP-register data.
- The emission factors for different types of road vehicles have been recalculated using a new version of VERSIT+ LD (Ligterink and De Lange, 2009) and results from recent emission measurements on light-duty and heavy-duty vehicles.

4.3.9 Source-specific planned improvements

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

- New average annual mileages will be 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).
- The emission factors for motorcycles and mopeds will be updated, based on a survey of international literature by TNO.
- 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 traffic 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.

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 22%, between 2007 and 2009 (Rail Cargo, 2007; 2009).

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 decreased from 1.6 Gg in 2008 to 1.2 Gg in 2009, whereas PM_{10} emissions decreased from 43 to 34 Mg. Emissions of heavy metals are very low and therefore not shown in the table.

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

PM_{10} emissions due to 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.

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
2008	1.62	0.24	0.07	0.05	0.0003	0.06	0.05	0.05	0.27
2009	1.16	0.19	0.05	0.02	0.0002	0.05	0.04	0.04	0.28
1990 -2009 period [1]	-0.45	-0.07	-0.02	-0.08	-0.0001	-0.01	-0.01	-0.01	0.06
1990 -2009 period [2]	-28%	-27%	-26%	-80%	-28%	-17%	-20%	-20%	28%

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

Based on the NS-CTO study, the percentage of particulate matter in the total quantity of wear debris was estimated at 20%. Because of their low weight, these particles probably remain airborne. It is estimated that approximately 65% of the wear debris ends up in the immediate vicinity of the railway, while 5% enters the ditches alongside the railway line (Coenen and Hulskotte, 1998). According to the NS-CTO study, the remainder of the wear debris (10%) does not enter the environment, but attaches itself to the train surface and is captured in the train washing facilities.

4.4.5 Methodological issues

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

4.4.6 Uncertainties and time-series consistency

There was no recent and accurate information available for assessing the uncertainties about the emissions from rail-ways. Currently, a research project is performed by TNO on uncertainties in the emission inventory. Consistent methodologies were used throughout the time series for railways.

4.4.7 Source-specific QA/QC and verification

Trends in fuel sales data from NS have been compared with trends in traffic volumes. The trends in both time series show good agreement, as reported in Subsection 4.4.3.

4.4.8 Source-specific recalculations

There are no source-specific recalculations for railways.

4.4.9 Source-specific planned improvements

In the coming year, the Netherlands plans to improve the fuel sales data for railways. Fuel sales to railways are currently obtained from Railways Netherlands (NS). The NS operates the fuel stations for trains in the Netherlands. In a recent research project by ECORYS (2010), the amount of fuel sold to railways was estimated to be higher than reported by the NS. Next year, these new insights will be compared with the data from NS to try to explain the differences and, if necessary, to make a new estimate of fuel sales to the railways sector.

4.5 Waterborne navigation

4.5.1 Source-category description

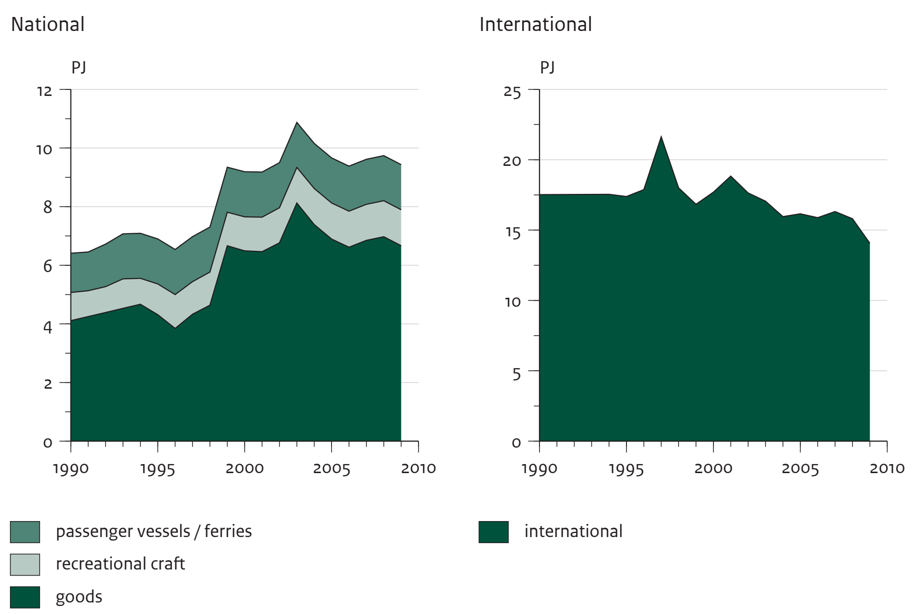
The source category 1A3d 'Waterborne navigation' includes emissions from national (1A3di(ii)) and international (1A3dii) inland navigation in the Netherlands and from international maritime navigation (1A3di(i)).

4.5.2 Key sources

The source category 1A3di(ii) 'International inland waterways' is a key source of emissions of NO_x and $PM_{2.5}$, whereas the source category 1A3dii 'National inland waterways' is a key source of emissions of NO_x, NMVOC, CO and $PM_{2.5}$.

4.5.3 Overview of emission shares and trends

Figure 4.4 Fuel consumed by 3 different types of inland shipping types in the Netherlands.



Fuel consumption by international inland navigation decreased slightly between 2001 and 2008. The year 2009 saw a major drop in fuel consumption of 11%,which may be attributed to the economic crisis and the resulting drop in freight transportation. Fuel consumption for national inland navigation, including recreational craft, passenger vessels and ferries, has decreased slightly in recent years from 10,9 PJ in 2003 to 9,4 PJ in 2009 (see Figure 4.4).

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.

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 unloaded vessels. In addition, the average speed, of the

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	31	22	5,3	2	0.01	1.36	1.36	1.29
1995	27	23	5,5	2	0.01	1.37	1.37	1.30
2000	30	26	5,6	2	0.01	1.36	1.36	1.30
2005	29	28	4,9	2	0.01	1.21	1.21	1.15
2008	29	27	4,2	1	0.01	1.09	1.09	1.09
2009	26	27	3,9	1	0.01	0.99	0.99	0.99
1990 -2009 period [1]	-5	5	-1,4	-1	0.00	-0.37	-0.37	-0.30
1990 -2009 period [2]	-15%	21%	-27%	-44%		-27%	-27%	-24%

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

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 en 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., 2003). 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 by passenger ships and ferries, therefore the fuel consumption data on 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. (2011).

4.5.5 Methodological issues

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

4.5.6 Uncertainties and time-series consistency

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

There was no recent and accurate information available for assessing the uncertainties about the emissions from inland waterborne navigation. Currently, a research project is performed by TNO on uncertainties in the emission inventory. 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

There are no source-specific recalculations for waterborne 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 is used in many different kinds of activity. 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 a non-mobile machine 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 leafblowers.

Emissions from non-road mobile machinery are reported under 1A2fii 'Mobile combustion in manufacturing industries and construction', 1A4aii 'Commercial/industrial 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, whereas the source category 1A4bii 'Residential: household and gardening (mobile)' is a key source of emissions of CO.

4.6.3 Overview of shares and trends in emissions

Fuel consumption by non-road mobile machinery has fluctuated between 38 and 40 PJ throughout most of time series. Figure 4.5 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 90% of energy use in 2009 coming from diesel fuel. Both gasoline and LPG have a share of 5% in total energy use. LPG is used in the industrial sector (forklift trucks) and gasoline in the agricultural, construction and commercial/institutional sectors.

The trends in emissions from non-road mobile machinery in the Netherlands are shown in Table 4.7. 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 4.6). With the introduction of EU emissions standards for non-road mobile machinery in 1999 and the subsequent tightening of these emission

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	33	38	7.5	3	0.01	3.30	3.30	3.14
1995	35	58	8.0	3	0.01	2.86	2.86	2.72
2000	38	60	7.7	3	0.01	2.47	2.47	2.35
2005	31	56	5.9	3	0.01	1.68	1.68	1.60
2008	26	55	4.9	1	0.01	1.33	1.33	1.27
2009	23	55	4.5	1	0.01	1.19	1.19	1.14
1990 -2009 period [1]	-10	17	-3.0	-2	0.00	-2.10	-2.10	-2.00
1990 -2009 period [2]	-30%	46%	-40%	-60%	3%	-64%	-64%	-64%

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

Figure 4.5 Fuel consumed by 5 different types of non-road mobile machinery in the Netherlands.

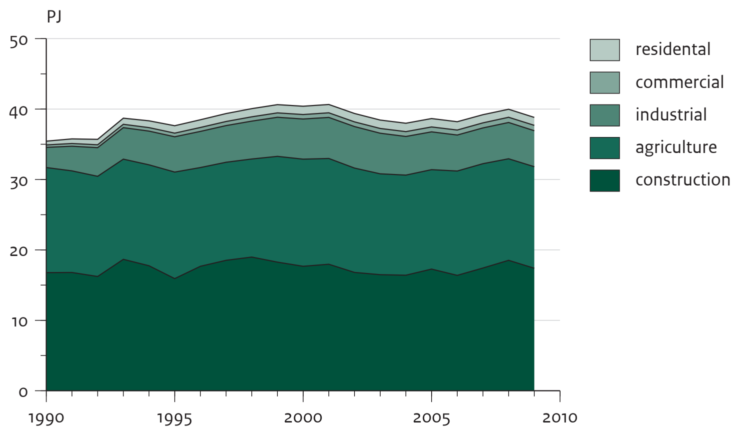
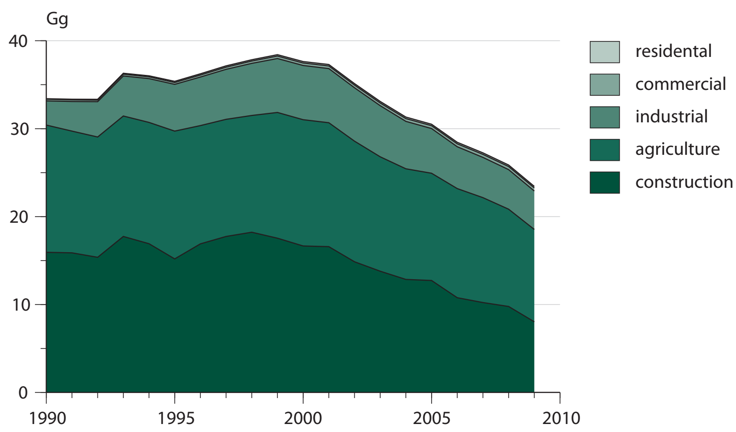


Figure 4.6 NO_x emissions from 5 different types of non-road mobile machinery in the Netherlands.



standards in later years, NO_x emissions have steadily decreased. Since 1999, NO_x emissions from non-road mobile machinery have decreased by 39%, whereas fuel consumption has only decreased by 5%. 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 2009, gasoline and LPG machinery had a combined share of 15% in total NO_x emissions, whereas in 1990 their combined share was only 4%.

Emissions from most other substances have also decreased significantly throughout the time series. For CO and NMVOC, this was also mainly caused by EU emissions standards. SO_2 emissions have decreased due to the EU fuel quality standards reducing the maximum allowed sulphur content for 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 has been 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.

4.6.5 Methodological issues

Since there were no reliable data available on fuel sales specifically on 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 about the emissions from non-road mobile machinery. Currently, a research project is performed by TNO on uncertainties in the emission inventory.

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.

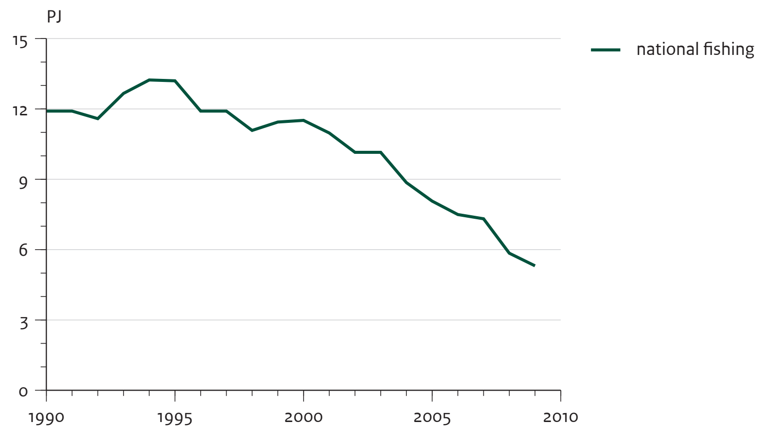
4.6.7 Source-specific QA/QC and verification

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 greenhouse gas emissions from non-road mobile machinery have been recalculated using a new methodology. In last year's submission, total energy use by non-road mobile machinery in different sectors was calculated with the EMMA model. The results from the EMMA model were subsequently adjusted to make sure total energy use was consistent with national energy statistics from Statistics Netherlands. However, the national energy statistics for non-road mobile machinery showed rather large fluctuations from year to year that did not seem consistent with economic activity data for the different sectors. Therefore, a research project was performed by Statistics Netherlands and TNO to improve fuel consumption data for non-road mobile machinery.
The project resulted in a new methodology to calculate

Figure 4.7 Fuel consumed by the fishing fleet in the Netherlands.



fuel consumption by non-road mobile machinery. Total fuel consumption is now calculated solely with the EMMA model, as described above. 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 conjunctural effects that cannot only lead to fluctuations in the sales data, but also in the use of machinery (hours per year). The latter effect is not included in the model, therefore the EMMA results were corrected based on economic indicators from Statistics Netherlands for the specific sectors where the machinery is used. The adjusted EMMA results were used for the total energy use by non-road mobile machinery. The resulting energy use was also used in the national energy statistics.

The new methodology led to a more consistent time series for the total energy use by non-road mobile machinery. In the old time-series total energy use by mobile machinery fluctuated between 29 and 39 PJ, whereas in the new time-series total energy use fluctuates between 33 and 37 PJ. The differences between new and old time series fluctuate from year to year.

4.6.9 Source-specific planned improvements

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

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 by national fishing has shown a decreasing trend (see Figure 4.7). Since 1995, fuel consumption by national fishing has decreased by 7.9 PJ (60%). This is in line with the decrease in the number of cutter vessels (32%) and the installed engine power in the cutter fleet (50%) over this same time period, as reported by Statistics Netherlands.

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 for the entire time series. NO_x emissions decreased from 16.5 to 7.3 Gg between 1990 and 2009, whereas PM_{10} emissions decreased from 0.39 to 0.17 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 by 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

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
2008	8.1	1.1	0.4	0.3	0.19	0.19	0.18
2009	7.3	1.0	0.3	0.1	0.17	0.17	0.17
1990 -2009 period [1]	-9.1	-1.2	-0.4	-0.8	-0.22	-0.22	-0.21
1990 -2009 period [2]	-55%	-55%	-55%	-0.9	-55%	-55%	-55%

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

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 about the emissions from national fishing. Currently, a research project is performed by TNO on uncertainties in the emission inventory. 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 by 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 Subsection 4.3.3.

4.7.8 Source-specific recalculations

For last year's submission, provisional fuel consumption figures were used for the years 2006, 2007 and 2008, since definitive data had not been released by LEI. Since then, LEI has reported definitive figures for the years 2006, 2007 and 2008 and provisional figures for 2009. These data have been applied in this year's submission. Table 4.9 shows the old and new fuel consumption data. Reported fuel con-sumption is lower than in last year's submission. Because the same emission factors were used for the entire time series, NO_x and PM_{10} emission have decreased by the same percentages for these years compared to last year's submission.

Table 4.9 Fuel consumption (PJ) by national fishing as reported in IIR 2010 and IIR 2011.

	2006	2007	2008	2009
IIR2010	8.0	7.7	7.4	
IIR2011	7.5	7.3	5.8	5.3
	-7%	-5%	-21%	

4.7.9 Source-specific planned improvements

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

5 Industry

5.1.1 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:
2.A Mineral Industry
2.B Chemical Industry
2.C Metal Industry
2.D Other Production Industry
2.E Production of POPs
2.F Consumption of POPs and Heavy Metals
2.G Other production, consumption, storage, transportation or handling of bulk products

Since 1998, the production and consumption of POPs have been banned in the Netherlands. Emissions from the consumption of heavy metals are considered to be insignificant.

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

Table 5.1 Overview of total emissions from the Industrial Processes (NFR 2) sector.

	Main Pollutants					Particulate Matter		
	NO_x	CO	NMVOC	SO_x	NH_3	TSP	PM_{10}	$PM_{2.5}$
Year	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg
1990	13	45	84.7	16	4.13	44.41	26.16	13.31
1995	7	36	45.8	6	3.85	30.01	15.87	8.10
2000	5	46	31.5	5	2.65	12.48	7.70	2.91
2005	1	50	25.3	3	2.30	13.42	9.08	3.83
2008	1	12	26.9	3	1.25	12.50	8.55	3.42
2009	1	23	23.8	3	1.11	11.14	8.36	3.41
1990 -2009 period [1]	-12	-21	-60.9	-13	-3.02	-33.27	-17.81	-9.90
1990 -2009 period [2]	-93%	-47%	-72%	-83%	-73%	-75%	-68%	-74%

	Priority Heavy Metals			POPs	
	Pb	Cd	Hg	DIOX	PAH
Year	Mg	Mg	Mg	g I-Teq	Mg
1990	67.10	0.90	1.47	37.73	10.69
1995	66.20	0.62	0.85	29.21	3.47
2000	24.39	0.77	0.20	1.80	0.36
2005	27.22	1.50	0.35	10.81	0.29
2008	26.22	0.88	0.40	2.26	0.91
2009	26.66	0.80	0.51	2.04	0.50
1990 -2009 period [1]	-40.44	-0.10	-0.96	-35.47	-10.19
1990 -2009 period [2]	-60%	-11%	-66%	-94%	-95%

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

5.1.2 Key sources

The key sources from this sector are presented in Table 5.2.

Because some sources and thus the corresponding emission figures in the 2G category have not been properly allocated, this category is a key source in this submission. In the next submission, these sources and the corresponding emission data will be reallocated. These reallocations will have effect on the emissions in several industrial (sub) categories. Other key sources are discussed in Sections 4.2 to 4.5. Because TSP, CO and the priority heavy metals (Pb, Hg and Cd) time series of most key sources are incomplete they will not be discussed in Sections 4.2 to 4.5. 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 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 production process

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

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

Category / Sub-category		Pollutant	Contribution to total in 2009 (%)
2A1	Cement Production	Hg	12.1
2A7	Other, specified in categories a-c and d further specified	TSP / PM_{10} / $PM_{2.5}$ Hg	3.4 / 3.9 / 2.7 12.0
2B5	Other Chemical Industry	NMVOC TSP / PM_{10} / $PM_{2.5}$	3.3 5.0 / 3.8 / 5.3
2C1	Iron and Steel Production	TSP / PM_{10} / $PM_{2.5}$ Pb Cd Hg DIOX PAH	8.8 / 4.5 / 5.4 64.7 39.5 32.9 7.0 1.5
2C3	Aluminum Production	CO PAH	3.2 10.6
2D2	Food and Drink	NMVOC TSP / PM_{10}	3.2 6.2 / 6.1
2.G	Other production, Consumption, storage, transportation or handling of bulk products	NMVOC TSP / PM_{10} / $PM_{2.5}$	8.0 6.5 / 7.6 / 4.6

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 individual registration
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.

Uncertainties and time-series consistency
No accurate information was available for assessing the uncertainties about the emissions from the sources tof this sector. Consistent methodologies –except for CO, TSP, Pb, Cd and Hg– were used throughout the time series for the sources in this sector.

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.

Source-specific recalculations
Only the data on particulate matter in the 2D2 sector were recalculated and reduced for the complete time series.

Source-specific planned improvements
In subsequent submissions, incomplete CO, TSP, Pb, Cd and Hg time series will be repaired, as far as possible. In addition, some sources and thus the corresponding emission figures in the 2G category will be properly allocated in the next submission.

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 2A2 Lime production are included in 2D2; those from 2A5 Asphalt roofing and 2A6 Road paving with asphalt have not been estimated, since no activity data was available.

Because of allocation problems, total emissions from mine-ral products (2A) have been reported in category 2A7d. Only emissions in the category 2A1 Cement production could be reported separately, because emissions in this category were derived from the environmental reports by the corresponding companies.

5.2.2 Key sources

2A1 Cement clinker production and 2A7d Other are identified as key sources of Hg emissions. 2A7d Other is also a key source of PM_{10} and $PM_{2.5}$.

5.2.3 Overview of emission shares and trends

Because the Hg time series for both key sources were incomplete they are not discussed in this section. From 1990 to 2009, PM_{10} emissions from 2A7d decreased from 2.64 to 115 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 both key sources.

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
Adapic acid (2B3) and calcium carbide (included in 2B4) are not produced in the Netherlands. Emissions are not reported under 2B1 and 2B2 (only the greenhouse gases CO_2 and N_2O are reported here). Because of allocation problems, all emissions from the chemical industry (2B) have been reported in category 2B5a.

5.3.2 Key sources

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

5.3.3 Overview of emission shares and trends

From 1990 to 2009, NMVOC emissions decreased from 33.82 to 7.56 Gg, and PM_{10} emissions from 4.42 to 0.84 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 from both key sources.

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
2C5 Other Metal Production

5.4.2 Key sources

Category 2C1 Iron and Steel Production describes key sources of TSP, PM_{10}, $PM_{2.5}$, Pb, Cd, Hg, DIOX and PAH, and 2C3 Aluminum Production does the same for CO and PAH.

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. For the purpose of the inventory, emissions from integrated steelworks were estimated for these three processes, as well as for some other minor processes. Emissions from sintering are included in 1A. A portion of the coke oven gas and blast/oxygen furnace gas produced during these processes is sold to a nearby power plant to be used as

Table 5.3 Overview emissions of 2C1Iron and Steel production.

Pollutant	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
PM_{10}	8.90	4.56	0.35	1.68	1.52	1.61	1.64	1.61	1.56	1.68	1.46	1.33
$PM_{2.5}$	5.66	2.81	0.23	1.07	0.97	1.01	1.02	1.02	0.99	1.07	0.93	0.85
Pb	55.74	57.46	18.84	23.01	26.93	24.65	25.42	22.95	22.39	28.84	23.38	24.45
Cd	0.69	0.41	0.41	0.63	0.92	0.71	0.69	0.66	0.69	0.91	0.73	0.69
Hg	0.39	0.35		0.12	0.12	0.12	0.21	0.21	0.20	0.28	0.29	0.27
DIOX	23.00	26.50	1.75	1.47	2.10	1.74	1.87	8.40	1.91	2.25	2.26	2.04
PAH	1.64	1.62	0.08	0.06	0.06	0.06	0.06	0.06	0.06	0.12	0.20	0.06

Table 5.4 Overview PAH emissions of 2C3 Aluminium production.

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

fuel. These emissions are reported by Tata Steel in AERs and are included in category 1B. Table 5.3 gives an overview of the emissions of 2C1.

The 2005 dioxin emission level of 8.4 gr TEQ is not correct. In the next submission, this value will be replaced by 1.4 gr TEQ. 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)

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 2C3.

PAH emissions orginate from ‘Producing anodes’ and the ‘Use of anodes’ during primary aluminium production. Emission fluctuations have mainly been caused by the vary-ing process conditions combined with a measure-ment inaccuracy of 43% in the PAH measurements during the production of anodes. Between 1990 and 2000, PAH emissions decreased from 6.91 Mg in 1990 to less than 1 Mg in 2000. These reductions were mainly caused by the implementation of technical measures.

Emissions, Activity data and (implied) emission factors

Part of the PAH emissions were obtained from the environ-mental reports by the above mentioned plants.

Methodological issues

Method 3 was used for estimating the emissions from both key sources.

5.5 Other Production Industry (2D)

Source-category description

This category comprises emissions related to the following sources:

2D1 Pulp and Paper
2D2 Food and Drink
2D3 Wood processing Category

5.5.1 Key sources

2D2 Food and Drink is a key source for NMVOC, TSP, PM_{10} and $PM_{2.5}$.

5.5.2 Overview of emission shares and trends

From 1990 to 2008, NMVOC emissions decreased from 7.56 to 5.67 Gg, and PM_{10} emissions from 7.17 to 2.77 Gg. These reductions were mainly caused by the imple-menta-tion of technical measures.

5.5.3 Emissions, Activity data and (implied) emission factors

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

Methodological issues

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

Source-specific recalculations

Based on new research, emissions of particulate matter from the food and drink [2D2] sector (drying of animal feed) were recalculated and reduced for the complete time series.

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) are included in 2B (Chemical Industry).

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	129.7	0.98	1.05	1.05	0.35	25.0	2.48
1995	108.0	1.04	1.03	1.03	0.34	23.0	1.05
2000	76.6	1.06	1.21	1.21	0.40	20.0	0.06
2005	60.8	1.11	1.14	1.14	0.38	18.0	0.05
2008	56.8	1.11	1.33	1.33	0.44	16.0	0.04
2009	53.7	1.09	1.24	1.24	0.41	15.5	0.04
1990 -2009 period [1]	-76.0	0.10	0.19	0.19	0.06	-9.5	-2.44
1990 -2009 period [2]	-59%	11%	18%	18%	17%	-38%	-98%

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

6.1.1 Key sources

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 (%)
3A2 Industrial coating application	NMVOC	9.8
3D1 Printing	NMVOC	2.6
3D2 Domestic solvent use including fungicides	NMVOC	12.5
3D3 Other product use.	NMVOC $TSP/PM_{10}/PM_{2.5}$ DIOX	5.9 3.5 / 4.2 / 2.6 53.2

The key sources are discussed in Sections 6.2 and 6.3.

Source-specific QA/QC and verification
The source categories are covered by the general QA/QC procedures as discussed in Chapter 1.

Source-specific recalculations
There were no source-specific recalculations in this submission.

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

6.2 Paint Application (3A)

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 emissions from Total Paint Consumption in the Netherlands and NMVOC contents

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

Table 6.1 shows a decrease in the NMVOC content of 30% in 1990 to almost 10% in 2006. After 2006 the NMVOC content remained rather stable.

Key sources
Category 3A2 Industrial Coating application has been identified as a key source of NMVOC.

Overview of shares and trends in emissions
NMVOC emissions from industrial paint use decreased from 67.2 Gg in 1990 to 21.8 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 2009. For that reason, the emissions decreased to 17.4 Gg in 2009.

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).

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 (3D)

Source-category description
This category comprises emissions related to the following sources:
3D1 Printing
3D2 Domestic solvent use including fungicides
3D3 Other product use

6.3.1 Key sources

Categories 3D1, 3D2 and 3D3 have been identified as key sources of NMVOC and 3D3 is also identified as a key source of dioxin.

6.3.2 Overview of emission shares and trends

Printing [3.D.1]
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 2009. For that reason, emissions also decreased in 2009.

Domestic solvent use including fungicides [3.D.2]
The most important sources are Cosmetics (and personal care), Cleaning agents and Car products. The NMVOC emissions increased from 11.3 Gg in 1990 to 19.2 Gg in 2009. These extra emissions were caused by the increased consumption of Cosmetics, Cleaning agents and Car products during the period 1990–2009 period.

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 2009. 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 from ca 25 g I-TEQ in 1990 to ca 16 g I-TEQ in 2009.

6.3.3 Emissions, Activity data and (implied) emission factors

Printing [3D1]
The Dutch Government has an agreement with the printing industry from which data become available for the emission inventory.

Domestic solvent use including fungicides [3D2]
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]
For NMVOC see **[3D2]**
Dioxin emissions by wooden house frames are determined for 1990 based on Bremmer et al. (1993). Since PCP has been banned from 1989, a linear reduction of dioxin emission has been assumed.

Methodological issues

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

Domestic solvent use including fungicides [3.D.2]
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 [3.3]
For NMVOC see **[3D2]**
For dioxin see ***Emissions, Activity data and (implied) emission factors***, **[3D3]**

7 Agriculture

7.1 Overview of the sector

Included in this chapter 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.

TThe Intergovernmental Panel on Climate Change (IPCC) distinguishes several categories for emissions in the agricultural sector. Of these categories, the following are of interest to the Informative Inventory Report (IIR):

- 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, acti-vities belonging to the category 4F are negligible, in actual practive. Emissions of the greenhousegases 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, with manure being 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 top key source of NH_3, followed by swine (4B8). Synthetic N fertilizers (4D1a), non-dairy cattle (4B1b), laying hens (4B9a) and broilers (4B9b) are key sources for NH_3, too.

Laying hens (4B9a) are the top key source of PM_{10} and TSP emissions, and also key source of $PM_{2.5}$.
Swine (4B8) are also key source of PM_{10} and TSP.

7.1.2 Trends

NH_3 emissions decreased sharply between 1990 and 2009, and although last year animal numbers increased, the whole period showed a decreasing trend. Main reason for the decrease in emissions, is the ongoing improvement in diets, leading to lower N excretions per animal. Since the national total is dominated 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 1990–2009 period, 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 an increase from 2008 to 2009, 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, 4B9d and 4B13 are small and, therefore, have not been estimated.

7.2.2 Key sources

Dairy cattle (4B1a) is the largest contributor to NH_3 emissions, at 27.8% of the national total. Second is swine (4B8) with 20.9%, and non-dairy cattle (4B1b) is third, adding 14.1%. Laying hens (4B9a; 7.3%), Broilers (4B9b; 6.9%) and animals in 'Other' (4B13; 1.8%) are also key sources for NH_3.

Laying hens (4B9a) are the largest contributor to the national total PM_{10} emissions, with 11.7%. At 9.9%, it is also the second most important source of TSP, while adding 1.7% to the emissions of $PM_{2.5}$. Swine (4B8) is responsible for 4.6% of the emissions of PM_{10} and 3.9% of TSP.

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	320.24	3.87	3.87	0.44
1995	7.8	174.76	3.94	3.94	0.44
2000	6.8	132.79	4.40	4.40	0.47
2005	6.2	109.13	4.69	4.69	0.45
2008	6.6	100.29	5.13	5.13	0.47
2009	6.7	99.18	5.19	5.19	0.47
period 1990-2009, abs	-1.2	-221.05	1.31	1,31	0.04
period 1990-2009, %1990	-15%	-69%	34%	34%	8%

Between 1990 and 2009 NH_3 emissions were reduced by 69%, with a sharp decrease in 1995. Different from the reporting category in the NIR (4D), emissions resulting from the application of animal manure here are reported in category 4B. The initial decrease in emissions was mainly from changes in application methods (i.e. incorporation into soil instead of surface spreading). More recently,a decrease in N excretions per animal due to dietary improvements has been seen, counteracting the slight increase in animal numbers.

Since NO emissions from agriculture form a new source not accounted for in the National Emission Ceiling (NEC), most of these emissions are reported as memo items under category 11C 'Other natural' emissions. 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 EmissionModel for Ammonia (NEMA), developed by Statistics Netherlands (CBS). Input data included animal numbers as determined by the annual agricultural census (see Table 7.2), and

Table 7.2 Animal numbers 1990-2009 (in 1,000 heads).

Animal type	1990	1995	2000	2005	2007	2008	2009
Cattle	4,926	4,654	4,070	3,799	3,763	3,890	3,968
- Adult dairy cattle	1,878	1,708	1,504	1,433	1,413	1,466	1,489
- Adult non-dairy cattle	120	146	163	152	144	127	123
- Young Cattle	2,929	2,800	2,403	2,214	2,206	2,297	2,355
Sheep	1,702	1,674	1,308	1,363	1,369	1213	1,117
Goats	61	76	179	292	324	355	374
Horses	370	400	418	433	434	444	445
Pigs (*1000)	13.9	14.4	13.1	11.3	11.7	12.0	12.2
Poultry (*1000)	95.6	92.2	107.2	95.9	96.0	99.7	100.0

Source: CBS, 2010.

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

	1990	1995	2000	2005	2007	2008	2009	Change 2009 - 1990 (%)
Nitrogen fertilizer consumption	412	406	339	279	258	238	238	-42
Nitrogen excretion by animals	710	696	565	495	495	506	499	-30
Nitrogen excretion in animal houses	514	516	433	394	406	413	418	-19
- of which in solid form	102	104	95	88	90	94	95	-7
- of which in liquid form	412	412	338	305	316	319	323	-22
Nitrogen in manure exported abroad/incinerated	6	22	18	26	31	38	39	563
Available manure for application	410	400	336	299	310	302	300	-27
(N-excretion in animal houses - total N-emissions in animal houses - export)								
Nitrogen excretion on pasture	196	180	133	101	89	93	81	-59
Nitrogen in sewage sludge on agric. land	5	2	2	1	1	1	1	-80
Total nitrogen supply to soil	1122	1081	888	749	722	707	699	-38
(manure + fertilizer + sewage sludge - export)								
N_2O-N emission fertilizer application	5.4	5.3	4.4	3.6	3.3	3.1	3.1	-42
N_2O-N emission animal houses	2.4	2.4	2.1	1.9	2.0	2.0	2.0	-15
N_2O-N emission manure application	1.6	3.5	3.1	2.8	2.9	2.8	2.8	69
N_2O-N emission pasture	6.5	5.9	4.4	3.3	2.9	3.1	2.7	-59
N_2O-N emission sewage sludge	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-80

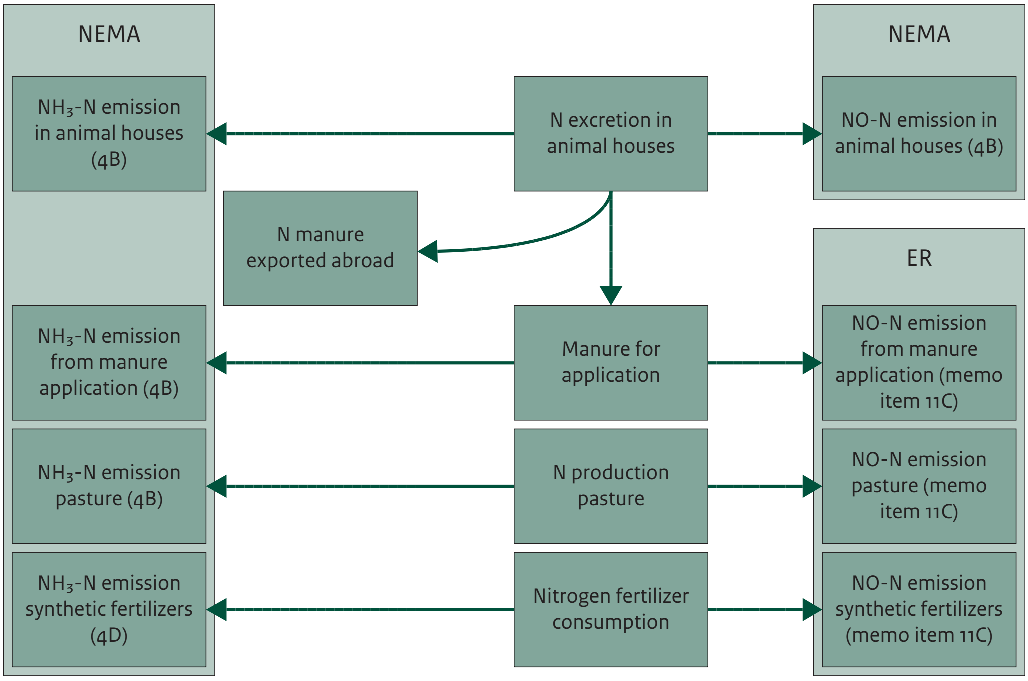
N-excretion per animal was calculated annually by the Working group for Uniform calculations of Manure and mineral data (WUM).

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., in preparation). For N_2O the default emission factors were used from the IPCC Guidelines 1996 and Good Practice Guidance 2001. They were also used for NO following research carried out by Oenema et al. (2000), setting the ratio at 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 application techniques and emission factors involved the manure practice leads to emissions of NH_3. 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. In table 7.3 a summary of associated N-flows is given for the 1990-2009 period in the inventory. While synthetic fertilizer use and N-excretion by animals decreased considerably in the 1990-2009 period, export of manure increased by a factor of six. These developments result in less nitrogen (N) to the soil and therefore overall lower emissions. For manure application, incorporation into the soil is mandatory since the early 90s, leading to much lower NH3 emissions. On the other hand, N_2O

Figure 7.1 Nitrogen flows in relationship to NH_3 and NO_2 emissions



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 pos-sibly outdated and not very precise, thus between 2007 and 2009 a measurement programme was conduct-ed by Wageningen UR Livestock Research. For a range of live-stock 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 nitrogen and phosphate excretions in 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 is taken into account. 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. Some other smaller sources include applications of synthetic fertilizer and pesticides, supply of concentrates, hay making and harvesting of arable crops. The general input data used for calculating emissions from animal housing systems are animal numbers taken from the annual agricultural census. For several animal categories country-specific emission factors are available (see Subsection 7.2.4).

7.2.6 Uncertainties and time-series consistency

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

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

7.2.7 Source-specific QA/QC and verification

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

7.2.8 Source-specific recalculations

For this submission, the NEMA model was used (see Subsection 7.2.5 for a description). Its results give rise to considerably higher NH_3 emissions in the base year, more in line with actual measurements.

For this submission, NO_x emissions from manure management were assessed for the first time. Previously, only emissions in the category stable and storage were included in the inventory (see Subsection 7.2.9)).

7.2.9 Source-specific planned improvements

With regards to NO_x, emissions related to the application of animal manure and manure produced in the meadow currently are reported under natural emissions. 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' and
- 4G 'Agriculture other'.

Within the category 4D1a, emissions of NH_3 and particulate matter from the application of synthetic fertilizer 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. Categories 4D2a and 4D2b are small and therefore not estimated, and activities included in categories 4F and 4G do not occur in the Netherlands.

7.3.2 Key sources

Synthetic N fertilizers (4D1a) are a key source of NH_3 emissions, at 8.1% of the national total. Arable crops (4D2a) contribute 2.6% to PM_{10}, 2.2% to TSP and 0.7% to $PM_{2.5}$ emissions.

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	13.91	0.76	0.76	0.11
1995	13.98	0.75	0.75	0.11
2000	12.05	0.76	0.76	0.11
2005	13.00	0.77	0.77	0.11
2008	10.13	0.78	0.78	0.12
2009	10.13	0.77	0.77	0.11
Period 1990-2009, abs	-3.78	0.00	0.00	0.00
Period 1990-2009, %1990	-27%	1%	1%	1%

Data presented for NH_3 solely reflects emissions caused by synthetic fertilizer use, which has decreased over the years in response to policy measures. For particulate matter, use Netherlands Informative Inventory Report 2011 | 67 of pesticides and the harvesting of crops also contribute to emissions.

Since NO 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 from synthetic fertilizer is also included in that category (see also Subsection 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 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 Subsection 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 un-certainty of the calculations. 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

For this submission the NEMA-model was used. As the model was also used for calculating NH_3 emission from synthetic fertilizer use,this value ensured data consistency. For this submission, NO_x emissions caused by synthetic fertilizer use were assessed for the first time.
However, results have not yet been included in the inventory (see Subsection 7.3.9).

7.3.9 Planned improvements

With regards to NO_x, emissions related to the application of synthetic fertilizer currently are 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 (NFR 6) sector consists of the following categories:
6A Solid waste disposal on land
6B Waste-water handling
6C Waste incineration
6D Other waste

Table 8.1 gives an overview of emissions in the Waste sector.

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

Year	Main Pollutants					Particulate Matter			Priority Heavy Metals		
	NO_x**	CO	NMVOC	SO_x**	NH_3	TSP	PM_{10}	$PM_{2.5}$	Pb	Cd	Hg
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Mg	Mg	Mg
1990	5.6	3.1	1.6	4	NE	0.77	0.76	0.76	12.95	0.84	1.73
1995	2.5	0.6	1.8	1	0.32	0.11	0.08	0.08	1.28	0.16	0.28
2000	2.4	0.9	1.2	0	0.33	0.03	0.03	0.01	0.18	0.08	0.37
2005	1.9	0.5	0.9	0	0.31	0.04	0.04	0.04	0.13	0.08	0.25
2008	2.2	0.5	0.7	0	0.30	0.05	0.04	0.04	0.22	0.12	0.14
2009	2.3	0.5	0.7	0	0.29	0.14	0.03	0.03	0.22	0.15	0.15
1990 -2009 period [1]	-3.2	-2.5	-1.0	-4	-0.04*	-0.63	-0.73	-0.73	-12.73	-0.68	-1.59
1990 -2009 period [2]	-58%	-83%	-58%	-95%	-11%*	-82%	-96%	-96%	-98%	-82%	-92%

Year	POPs		Other Heavy Metals					
	DIOX	PAH	As	Cr	Cu	Ni	Se	Zn
	g I-Teq	Mg	Mg	Mg	Mg	Mg	Mg	Mg
1990	567.00	0.00	0.06	0.38	1.32	1.01	0.01	33.63
1995	6.35	0.00	0.08	0.29	0.29	0.76	0.05	2.98
2000	0.36	0.00	0.08	0.17	0.12	0.08	0.08	0.11
2005	0.94	0.00	0.03	0.11	0.09	0.03	0.09	0.02
2008	0.79	0.00	0.03	0.03	0.06	0.03	0.01	1.77
2009	1.55	0.00	0.03	0.03	0.05	0.05	0.00	5.74
1990 -2009 period [1]	-566.21	0.00	-0.03	-0.35	-1.26	-0.96	-0.01	-27.89
1990 -2009 period [2]	-100%		-48%	-92%	-96%	-95%	-68%	-83%

[1] Absolute difference in Gg [2] Relative difference to 1990 in %
* Period 1995-2009
** Emissions from Cremations included in source category 1A4ai.

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

Category / Sub-category	Pollutant	Contribution to total (%)	
		Level 2009	Trend 1990-2009
6Cc Municipal waste incineration	Hg, Cd, Dioxin, SO_2, $PM_{2.5}$	--/8.8/--/--	29.1/34.3/44.3/3.6/2.8
6Cd Cremations	Hg	9.3	--

8.1.1 Key sources

The relevant key sources in this sector are presented in Table 8.2.

8.1.2 Methodological issues

Emissions from waste incineration plants were based on environmental reports and extrapolation to total emissions per SBI category (i.e. Method 1; see Section 4.1). The emissions from 6Cd Crematoria were estimated on the basis of the number of corpses cremated and their average amalgam content.

8.1.3 Uncertainties and time-series consistency

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

8.1.4 Source-specific QA/QC and verification

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

8.1.5 Source-specific recalculations

There were no source-specific recalculations in this sector.

8.1.6 Source-specific planned improvements

Incomplete Hg time series will be repaired. as far as possible.

8.2 Waste incineration

8.2.1 Source-category description

This source category 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 6Ca Clinical waste incineration and 6Cb Industrial waste incineration are included in 6Cc. Because of a ban on Small-scale waste burning (6Ce), this emission source does not apply to the Netherlands. The NO_x and SO_x emissions from 6Cd Cremations are included in the source category 1A4ai 'Commercial/institutional: Stationary'

8.2.2 Key sources

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

The emissions from Municipal waste incineration have been relatively constant from 1996 onwards and were no trend key sources over that period. Therefore, they are not further discussed here.

8.2.3 Overview of shares and trends in emissions

Municipal waste incineration
EEmissions from Municipal waste incineration decreased during the period from 1990 to 1996, due to implementation of technological measures. Table 8.3 gives an overview of the emissions from this source.

Cremations
In the period 1990 to 2002 the Hg emissions from Cremations gradually increase as result of increasing activity (period 1990-2009; 33%). As of 1998 new cremation centers are equipped with technical measures to reduce emissions. In the period 2002 onwards the emissions decrease as result of implementation of technical measures. As of 2013 all cremation centers are equipped with technological measures to reduce emissions. Table 8.4 gives an overview of the emissions from this source.

8.2.4 Emissions, Activity data and (implied) emission factors

The emissions of the Municipal waste incineration are obtained from the EARs.

For calculation of the emission of Cremations activity data are obtained from branch reports. The average amalgam content is constant over time.

8.2.5 Methodological issues

There are no specific methodological issues.

Table 8.3 Overview of the key source emissions from Municipal waste incineration (NFR 6Cc).

Pollutant	Year											
	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cd (Mg)	0.84	0.16	0.08	0.10	0.11	0.05	0.05	0.08	0.08	0.08	0.12	0.15

Table 8.4 Overview of the key source emissions from Cremations (NFR 6Cd).

Pollutant	Year											
	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Hg (Mg)	0.06	0.07	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.08	0.07	0.08

9 Other

Emissions from burning candles, smoking cigarettes and lighting fireworks are reported in this category. This also includes the emissions of NH_3 from human perspiration, from manure, sold and applied to private properties and from manure sold and applied to nature parks. Please note that the Netherlands has included this 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 (8.5%), TSP (4%), PM_{10} (5%) and $PM_{2.5}$ (8.5%) as percentages of national total in 2009.

10 Recalculations and other changes

10.1 Recalculations of the 2010 submission

Compared to the 2010 submission (Jimmink et al., 2010) the following methodological changes were implemented in the PRTR system:

Energy:

- The calculation method for emissions from wood stoves (included in category 1a4bi) was changed. The new model ensures that the emissions from this source can be calculated in the future, based on the few available activity data. The new calculation method was used for the total time series and had minor effects on the emissions of the past.

Transport:

- The emissions in the transport sector were recalculated (as every year) based on the updated VERSIT+ LD model (Ligterink and De Lange, 2009).
- Furthermore, emissions changed due to several (methodological) improvements, such as:
  - road type distribution for different vehicles types;
  - 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.

Industry:

- Based on new research the emissions of particulate matter in the food and drink sector (drying of animal feed) were recalculated and reduced for the complete time series.

Agriculture:

- A new methodology for calculating the nitrogen flows in the agricultural sector was introduced. The emissions of ammonia changed considerably compared to the last submission (+100 Gg in 1990 and 26 Gg in 2008).
- From this new method, revised NO_x emissions from manure management also have been assessed for the first time. In this submission we included emissions from stable and storage.
- Based on extensive new measuring data, the PM emissions from agriculture were recalculated for the total time.

10.2 Improvements

10.2.1 Improvements included in 2011 submission and IIR 2011

- F-gasses have been included in the NMVOC data for 1990 to 2004, they were erroneously not included in the last submission.
- The 2008 emission figures were updated on the basis of environmental reports from individual (EPRTR) companies and improved 2008 statistics.
- Because of further standardisaton of the coding of emission sources in the PRTR system, some emission data were reallocated, compared to the 2010 submission. In general, these reallocations only had a minor effect on the emissions in the industrial categories (combustion and process) and in the navigation sectors. 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 will be 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).
- The emission factors for motorcycles and mopeds will be updated based on a survey of international literature by TNO.
- 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 have a major influence on the fuel consumption and resulting emissions from heavy-duty vehicles.

Industry:
- Some sources and thus the corresponding emission data in the 2G category are not properly allocated. This category is a key source in this submission. In next submission these sources and the corresponding emission figures will be reallocated. These reallocations will have effect on the emissions in several industrial (sub)categories.
- In subsequent submissions, incomplete CO, TSP, Pb, Cd and Hg time series will be repaired, as far as possible.
- In subsequent submissions, incomplete TSP time series will be repaired, as far as possible.

10.3 Effect of recalculations and improvements on 1990 and 2008 emission levels

Table 10.1 gives the changes in national totals emission levels for the different compounds compared to the submission of 2010.

Table 10.1 Differences in National total emission level between current and previous submission for the years 1990 and 2008

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	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF (dioxines/ furanes)	PAHs benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3 -cd) pyrene	Total 1-4	HCB	HCH	PCBs
		Gg NO_2	Gg	Gg SO_2	Gg	Gg	Gg	Gg	Gg	Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg	Mg	g I-Teq	Mg	Mg	Mg	Mg	Mg	kg	kg	kg
1990	IIR 2010	556.6	461.3	191.7	252.6	46.3	74.8	96.4	1093.3	338.5	2.1	3.5	1.5	9.9	71.5	75.3	0.4	224.8	740.4	4.3	4.3	3.3	2.7	14.7	0.0	0.0	0.0
	IIR 2011	563.0	464.5	191.6	355.9	44.0	67.4	89.6	1119.4	336.2	2.1	3.5	1.5	9.9	67.7	75.3	0.4	220.6	742.8	5.2	8.0	4.0	2.8	20.0	NO	NO	NO
Difference	absolute	6.4	3.2	-0.1	103.3	-2.2	-7.5	-6.9	26.2	-2.3	0.0	0.0	0.0	0.0	-3.8	0.0	0.0	-4.2	2.4	0.9	3.6	0.7	0.2	5.3			
	%	1%	1%	0%	41%	-5%	-10%	-7%	2%	-1%	-1%	0%	0%	0%	-5%	0%	0%	-2%	0%	20%	83%	20%	6%	36%			
2008	IIR 2010	292.7	159.8	51.8	134.8	19.5	36.6	43.2	559.2	44.9	1.7	0.9	1.1	2.2	85.3	9.3	1.0	86.8	24.6	1.6	0.7	0.9	0.8	4.0	0.0	0.0	0.0
	IIR 2011	299.9	164.0	50.9	127.1	17.3	31.5	38.2	648.9	36.8	1.9	0.8	0.8	2.1	82.7	9.0	2.5	87.4	28.2	1.4	1.6	0.8	0.8	4.5	NO	NO	NO
Difference	absolute	7.2	4.2	-0.9	-7.6	-2.1	-5.1	-5.0	89.7	-8.1	0.2	-0.1	-0.3	-0.2	-2.5	-0.3	1.5	0.6	3.7	-0.2	0.9	-0.1	0.0	0.5			
	%	2%	3%	-2%	-6%	-11%	-14%	-12%	16%	-18%	11%	-12%	-24%	-8%	-3%	-3%	143%	1%	15%	-15%	127%	-7%	-4%	14%			

11 Projections

The chapter consists of descriptions (per source sector) of general methods (models), data sources and assumptions used for estimating emissions as reported in Annex IV, Table 2a, of the Dutch CLRTAP submission. Where available, references to detailed documentation were included in the IIR. Some sectors were not covered (e.g. because they only emitted greenhouse gases, such as in the Waste sector).

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 CO2 and energy prices, ECN estimated the number of additional power plants and CHP installations, planned for the coming decade, in industry and glasshouse horticulture, as well as the share of renewable energy in electricity production.

Table 11.1 Historical and projected emissions for the Netherlands (ECN, 2010).

Pollutant:		1990	2000	2008	2009	*NEC-2010*	2010	2015	2020	2030
SO_2	Gg	192	73	51	38	*50*	42	45	46	45
NO_x	Gg	563	395	300	276	*260*	264	230	185	161
NH_3	Gg	356	163	127	125	*128*	131	122	118	119
NMVOC	Gg	464	232	164	154	*185*	144	146	149	162
PM_{10}	Gg	67	39	32	30	*NA*	30	30	29	29
$PM_{2.5}$	Gg	44	24	17	16	*NA*	15	14	13	13

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, is 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.

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 11.2. 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 northwestern 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 degree of interconnection, which is increasing even further. 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.

Table 11.2 Growth in **production capacity for north-western Europe. Increease in both conventional and renewable energy were** considered.

	Additional power after 2005			Additional power after 2005			growth demand after 2005	
	2020 [GW]	2025 [GW]	2030 [GW]	2020 [%]	2025 [%]	2030 [%]	2020 [%]	2030 [%]
	12.2	14.2	16.1	61	72	81	34	41
Germany	28.1	32.7	29.2	23	27	24	13	16
Belgium	5.3	6.6	6.9	35	43	45	25	31
France	5	0.2	1.9	4	0	2	15	18
Norway	12.6	15.2	18	42	51	61		
United Kingdom	5.4	12.5	18	6	14	20	14	18
Denmark	-0.8	0	0.2	-6	0	1	13	16

Table 11.3 Assumptions and activity data used for national emission projections.

Activity	Reference year 2000	2008	2010	2015	2020	2030	Units	Notes on Measures included excluded.
Assumptions on general economic parameters:								
1. Gross Domestic Product (GDP)	498	579	558	604	662	763	10^9 €	Euro2007
2. Population	15,864	16,405	16,536	16,779	17,014	17,380	Thousand People	
3. International coal prices	60	46.64	45.35	47.16	48.29	48.88	€ per tonne or gigajoule),	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)	1,334.3	1,359.1	1,320.6	1,252.4	1,279.0	1,202.2	Petajoule (PJ)	energetic use
3. Coal	254.1	254.2	304.5	542.4	470.1	391.8	Petajoule (PJ)	energetic use
4. Solid biomass (e.g. wood)	28.2	58.1	68.2	51.3	34.3	26.9	In tonnes or %: M	solid biomass used in 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 (e.g. wind, geothermal etc)	8.8	41.4	43.4	115.7	137.7	194.4	Petajoule (PJ)	avoided primary energy
Total electricity production per fuel type								
8. Oil (fossil)	395	257	1060	1143	1111	979	GWh	
9. Gas (fossil)	52,493	64,723	69,190	63,941	78,584	81,632	GWh	
10. Coal	23,428	22,495	26,194	54,250	46,361	37,944	GWh	
11. Renewable	2,992	9,492	10,647	17,194	18,017	23,853	GWh	

* (energy units in Net Caloric Value)

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 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 emissions of various sectors. 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.

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

NO_x emission in [Gg]	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
Services 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

Since then, BEMS legislation was implemented instead. At about 28 g/GJ for engines larger than 2.5 PMth, this standard is more strict 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 willamount 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 households 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 about 44 gr/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 20101–2013[1] period, emission allowances, for the first time, could 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 reduction under BEMS legislation will occur in smaller installations. For this report, the emissions frominstallati-ons 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 emissionsunder the trading system

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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

[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 NO_x 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, NO_x removal from coal-fired plants, and because NO_x emissions in the energy and industrial sectors have decreased rapidly and significantly.

Assuming the trade system to be in balance in 2012 (companies with emissionexceedances 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 statio-nary sources is 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 calcu-lated 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 NO_x 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 machi-nery. 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 SO_2 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 signi-ficantly up to 2000, but there has been little change in these emission levels since then. In recent years, emissions have decreased again, due to measures in coal-fired plants, the transition of refineries to gas-firing instead of (a part of) oil, and a decreasing sulphur content of oil products. For government policy, the SO_2 covenant with the electricity sector plays an important role, as does the agreement to enter a maximum emission level of 16 Gg in the permits for refineries, divided over various companies.

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 produc-tion would imply.

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

SO_2 emission [in Gg]	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

- Severalyears 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 SO_2 emissions. On balance, this leaves ample space for new construction plans while remaining below the emission ceiling for 2019.
- In households and the services sector (TSG), emission levels have decreased, due to a decreasing sulphur content of domestic fuel oil, from 0.2% to 0.1%.

11.1.3 Policy measures

For NO_x trading in industry, the performance standard rate of 40 g/GJ has been sharpened to 37 g/GJ. Moreover, emission standards for medium-sized heating systems have been sharpened under BEMS legislation. The refinery sector has agreed to an SO_2 emission cap of 16 Gg. Additional policy envisages 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 slighty 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 natio-nal 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, the industry, energy and refinery (IER) sectors 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. 2008.

In 2009 and 2010 industrial production has decreased due to the credit crisis. Industry has been more severely affected by the credit crisis than other sectors. 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 con-siderably 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. Projected emissions of PM_{10} from the IER sectors by 2020, is expected to amount to 10.3 Gg, 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' werestill taking effect at the time of this projec-tion. 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 development of NMVOC emissions from refineries shows a similar picture, and have decreased from 8 Gg in 2008 to 7 Gg in 2010. However, up to 2020, emissions are expected to rise again to 8 Gg. The energy sector emitted 8 Gg NMVOC in 2008. This emission is expected to decrease over the coming years, to 6 Gg in 2010, and to 4 Gg by 2020.

11.4 Solvents and Product use

In 2008, households were responsible for 20% of total NMVOC emissions in the Netherlands. The main sources of NMVOC emissions from households are the use of cosmetics and other toiletries, paints, car products and cleaning agents, and from the burning of wood in fire places and wood stoves. The services and construction sectors, in 2008, were responsible for an 18% share in the total NMVOC emissions of 2008. In the services sector, emissions are released by a large number of sources. The storage and handling businesses are responsible for an important share of NMVOC emissions. These are released during storage and handling of VOC-containing products. Filling stations and car respraying shops also emit NMVOC. The use of cleaning agents also forms an important contribution. In the construction sector these emissions are mainly caused by the use of paints.

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.

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

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 the government are 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.

Results
Between 2008 and 2010, NMVOC emissions from house-holds have increased from 32 Gg to 33 Gg, despite the credit crisis. From 2010 onwards, NMVOC emissions from house-holds 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. However, for agriculture, no change is expected in NMVOC emission levels during this period

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, followingagreements 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 (including turkeys and ducks)	53,439	46,384	46,466	45,148	43,829	43,829
Horses	318	431	444	436	428	428
Rabbits and mink (in 2000 also foxes)	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.

88 | Netherlands Informative Inventory Report 2011

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Appendix 1 Key source analysis results

Results from the key source analysis have been calculated and sorted for every component. Following a 2009 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 in the 2009 level assessment (Emission levels in Gg).

NFR Code	Long name	2009	Contribution	Cumulative contribution
1A1b	1A1b Petroleum refining	17.92	47.08%	47.08%
1A1a	1A1a Public electricity and heat production	6.11	16.07%	63.15%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	2.34	6.16%	69.31%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	2.25	5.91%	75.22%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	2.25	5.90%	81.12%

Table 1.1.b SO_x key source categories identified in the 1990 level assessment (Emission levels in Gg).

NFR Code	Long name	1990	Contribution	Cumulative contribution
1A1b	1A1b Petroleum refining	67.08	35.01%	35.01%
1A1a	1A1 Public electricity and heat production	43.90	22.91%	57.92%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	19.96	10.42%	68.33%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	9.14	4.77%	73.10%
2A7d	2A7d Other Mineral products	7.47	3.90%	77.00%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	6.27	3.27%	80.28%

Table 1.1.c SO_x key source categories identified in the 1990–2009 trend assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative Trend contribution
1A1b	1A1b Petroleum refining	67.08	17.92	2.40%	25.46%	25.46%
1A1a	1A1a Public electricity and heat production	43.90	6.11	1.36%	14.43%	39.89%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	19.96	2.25	0.90%	9.52%	49.41%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	4.61	2.25	0.70%	7.40%	56.81%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	6.27	0.04	0.63%	6.66%	63.46%
1A3bi	1A3bi Road transport: Passenger cars	4.51	0.20	0.36%	3.85%	67.31%
2C3	2C3 Aluminium production	4.17	1.50	0.35%	3.75%	71.06%
6Cc	6Cc Municipal waste incineration (d)	4.33	0.22	0.33%	3.55%	74.60%
2A7d	2A7d Other Mineral products	7.47	0.92	0.29%	3.12%	77.72%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	3.01	0.04	0.29%	3.09%	80.81%

Table 1.2.a NO_x key source categories identified by 2009 level assessment.

NFR Code	Long name	2009	Contribution	Cumulative contribution
1A 3biii	1A3biii Road transport:, Heavy-duty vehicles	59.94	21.46%	21.46%
1A3bi	1A3bi Road transport: Passenger cars	34.99	12.53%	33.98%
1A1a	1A1a Public electricity and heat production	23.99	8.59%	42.57%
1A3di(ii)	1A3di(ii) International inland waterways	14.87	5.32%	47.89%
1A3bii	1A3bii Road transport:Light duty vehicles	14.32	5.13%	53.02%
1A4bi	1A4bi Residential: Stationary plants	13.37	4.79%	57.81%
1A4ai	1A4ai Commercial / institutional: Stationary	12.30	4.40%	62.21%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	11.16	4.00%	66.21%
1A3dii	1A 3 d ii National navigation (Shipping)	11.11	3.98%	70.18%
1A4ci	1 A4ci Agriculture/Forestry/Fishing: Stationary	10.72	3.84%	74.02%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	10.51	3.76%	77.78%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	8.03	2.88%	80.66%

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

NFR Code	Long name	1990	Contribution	Cumulative contribution
1A3bi	1A3bi Road transport: Passenger cars	137.55	24.29%	24.29%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	90.89	16.05%	40.33%
1A1a	1A1a Public electricity and heat production	76.18	13.45%	53.78%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	28.90	5.1%	58.89%
1A3di(ii)	1A3di(ii) International inland waterways	22.34	3.95%	62.83%
1A4bi	1A4bi Residential: Stationary plants	20.22	3.57%	66.40%
1A2fi	1A2fi Stationary combustion in manufacturing industries and construction: Other	19.77	3.49%	69.89%
1A1b	1A1b Petroleum refining	18.84	3.33%	73.22%
1A4ciii	1A4ciii Agriculture/Forestry/Fishing: National fishing	16.46	2.91%	76.13%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	15.93	2.81%	78.94%
1A3bii	1A3bii Road transport:Light duty vehicles	14.66	2.59%	81.53%

Table 1.2.c NO_x key source categories identified in the 1990-2009 trend assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
1A3b i	1A3bi Road transport: Passenger cars	137.55	34.99	5.80%	25.82%	25.82%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	90.89	59.94	2.76%	11.88%	37.70%
1A1a	1A1a Public electricity and heat production	76.18	23.99	2.40%	10.68%	48.38%
1A3bii	1A3bii Road transport: Light duty vehicles	14.66	14.32	1.25%	5.57%	53.95%
1A3dii	1A3dii National navigation (Shipping)	8.36	11.11	1.23%	5.49%	59.45%
1A4ci	1A4ci Agriculture/Forestry/Fishing: Stationary	8.73	10.72	1.13%	5.05%	64.49%
1A4ai	1A4ai Commercial / institutional: Stationary	13.61	12.30	0.99%	4.39%	68.88%
2B5a	2B5a Other chemical industry	9.84	0.35	0.79%	3.54%	72.42%
1A3di(ii)	1A3di(ii) International inland waterways	22.34	14.87	0.68%	3.03%	75.44%
1A4bi	1A4bi Residential: Stationary plants	20.22	13.37	0.60%	2.67%	78.11%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	14.47	10.51	0.59%	2.65%	80.76%

Table 1.3.a NH_x key source categories identified in the 2009 level assessment (Emission levels in Gg).

NFR Code	Long name	2009	Contribution	Cumulative contribution
4B1a	4B1a Cattle dairy	34.85	27.76%	27.76%
4B8	4B8 Swine	26.20	20.87%	48.63%
4B1b	4B1b Cattle non-dairy	17.71	14.11%	62.75%
7A	7A Other	10.62	8.46%	71.21%
4D1a	4D1a Synthetic N-fertilizers	10.13	8.07%	79.27%
4B9a	4B9a Laying hens	9.18	7.31%	86.58%

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

NFR Code	Long name	1990	Contribution	Cumulative contribution
4B1a	4B1a Cattle dairy	120.90	34.05%	34.05%
4B8	4B8 Swine	98.28	26.20%	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 in the 1990–2009 trend assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
4B8	4B8 Swine	98.28	26.20	2.41%	19.91%	19.91%
4B1a	4B1a Cattle dairy	120.90	34.85	2.22%	18.40%	38.31%
7A	7A Other	14.30	10.62	1.57%	12.97%	51.28%
4D1a	4D1a Synthetic N-fertilizers	13.91	10.13	1.47%	12.13%	63.42%
4B1b	4B1b Cattle non-dairy	62.99	17.71	1.28%	10.62%	74.04%
4B9b	4B9b Broilers	10.99	6.91	0.85%	7.05%	81.08%

Table 1.4.a NMVOC key source categories identified in the 2009 level assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
1A3bi	1A3bi Road transport: Passenger cars	97.07	19.32	12.54%	12.54%
3D2	3D2 Domestic solvent use including fungicides	11.31	19.17	12.45%	25.00%
3A2	3A2 Industrial coating application	67.22	15.03	9.76%	34.76%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	37.93	12.29	7.98%	42.74%
1A4bi	1A4bi Residential: Stationary plants	13.21	9.35	6.07%	48.81%
3D3	3D3 Other product use	15.31	9.06	5.88%	54.69%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	12.46	8.95	5.81%	60.50%
1B2ai	1B2ai Exploration, production, transport	14.39	6.35	4.13%	64.63%
1A1b	1A1b Petroleum refining	15.32	5.67	3.68%	68.31%
2B5a	2B5a Other chemical industry	33.34	5.15	3.35%	71.66%
2D2	2D2 Food and drink	7.05	4.99	3.24%	74.90%
3D1	3D1 Printing	14.36	4.00	2.59%	77.49%
1B2aiv	1B2aiv Refining / storage	16.35	3.97	2.58%	80.07%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
1A3bi	1A3bi Road transport: Passenger cars	97.07	19.32	20.90%	20.90%
3A2	3A2 Industrial coating application	67.22	15.03	14.47%	35.37%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	37.93	12.29	8.16%	43.54%
1A3bv	1A3bv Road transport: Gasoline evaporation	35.46	3.00	7.63%	51.17%
2B5a	2B5a Other chemical industry	33.34	5.15	7.18%	58.35%
1B2aiv	1B2aiv Refining / storage	16.35	3.97	3.52%	61.87%
1A1b	1A1b Petroleum refining	15.32	5.67	3.30%	65.16%
3D3	3D3 Other product use	15.31	9.06	3.30%	68.46%
1B2ai	1B2ai Exploration, production, transport	14.39	6.35	3.10%	71.56%
3D1	3D1 Printing	14.36	4.00	3.09%	74.65%
3A1	3A1 Decorative coating application	13.52	3.03	2.91%	77.56%
1A4bi	1A4bi Residential: Stationary plants	13.21	9.35	2.84%	80.40%

Table 1.4.c NMVOC key source categories identified in the 1990–2009 trend assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
3D2	3D2 Domestic solvent use including fungicides	11.31	19.17	3.32%	17.34%	17.34%
1A3bi	1A3bi Road transport: Passenger cars	97.07	19.32	2.77%	14.46%	31.80%
1A3bv	1A3bv Road transport: Gasoline evaporation	35.46	3.00	1.88%	9.84%	41.64%
3A2	3A2 Industrial coating application	67.22	15.03	1.56%	8.15%	49.79%
2B5a	2B5a Other chemical industry	33.34	5.15	1.27%	6.63%	56.42%
1A4bi	1A4bi Residential: Stationary plants	13.21	9.35	1.07%	5.58%	62.00%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	12.46	8.95	1.04%	5.42%	67.42%
3D3	3D3 Other product use	15.31	9.06	0.86%	4.48%	71.89%
2D2	2D2 Food and drink	7.05	4.99	0.57%	2.99%	74.88%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	10.61	1.27	0.48%	2.53%	77.41%
1A3dii	1A3dii National navigation (Shipping)	3.91	3.21	0.41%	2.15%	79.56%
1A3bii	1A3bii Road transport:Light duty vehicles	8.00	0.90	0.38%	1.97%	81.53%

Table 1.5.a CO key source categories identified in the 2009 level assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Contribution	Cumulative contribution
1A3bi	1A3bi Road transport: Passenger cars	585.88	248.68	41.48%	41.48%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	187.72	63.73	10.63%	52.11%
1A4bi	1A4bi Residential: Stationary plants	70.60	56.50	9.42%	61.54%
1A3biv	1A 3 b iv Road transport: Mopeds & motorcycles	40.71	54.36	9.07%	70.61%
1A4bii	1 A 4 b ii Residential: Household and gardening (mobile)	14.99	28.94	4.83%	75.44%
1A3dii	1 A3dii National navigation (Shipping)	16.02	23.42	3.91%	79.34%
2C3	2C3 Aluminum production	35.11	18.98	3.17%	82.51%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
1A3bi	1A3bi Road transport: Passenger cars	585.88	248.68	52.34%	52.34%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	187.72	63.73	16.77%	69.11%
1A4bi	1A4bi Residential: Stationary plants	70.60	56.50	6.31%	75.41%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	40.71	54.36	3.64%	79.05%
1A3bii	1A3bii Road transport:Light duty vehicles	38.77	5.86	3.46%	82.51%

Table 1.5.c CO key source categories identified in the 1990–2009 trend assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	585.88	248.68	5.81%	26.85%	26.85%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	187.72	63.73	3.29%	15.18%	42.03%
1A3biv	1A3biv Road transport: Mopeds & motorcycles	40.71	54.36	2.91%	13.44%	55.47%
1A4bii	1A4bii Residential: Household and gardening (mobile)	14.99	28.94	1.87%	8.63%	64.10%
1A4bi	1A4bi Residential: Stationary plants	70.60	56.50	1.67%	7.71%	71.81%
1A3bii	1A3bii Road transport:Light duty vehicles	38.77	5.86	1.33%	6.15%	77.96%
1A3dii	1A3dii National navigation (Shipping)	16.02	23.42	1.33%	6.12%	84.09%

Table 1.6.a TSP key source categories identified in the 2009 level assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
1A4bi	1A4bi Residential: Stationary plants	5.30	3.48	9.94%	9.94%
4B9a	4B9a Laying hens	1.75	3.47	9.91%	19.85%
2C1	2C1 Iron and steel production	9.55	3.09	8.81%	28.66%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	17.51	2.27	6.47%	35.13%
2D2	2D2 Food and drink	5.84	2.15	6.15%	41.28%
1A3bi	1A3bi Road transport: Passenger cars	5.19	2.01	5.74%	47.02%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	1.77	5.04%	52.07%
2B5a	2B5a Other chemical industry	6.01	1.73	4.95%	57.01%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.17	1.42	4.07%	61.08%
4B8	4B8 Swine	1.68	1.37	3.91%	64.99%
7A	7A Other	1.86	1.41	4.04%	69.03%
3D3	3D3 Other product use	1.05	1.24	3.54%	72.57%
2A7d	2A7d Other Mineral products	3.40	1.18	3.37%	75.94%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.89	1.10	3.13%	79.08%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.29	0.98	2.81%	81.89%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
2G	2G Other production, consumption, storage, transportation or handling of bulk products	17.51	2.27	19.55%	19.55%
2C1	2C1 Iron and steel production	9.55	3.09	10.66%	30.21%
1A1b	1A1b Petroleum refining	6.47	0.61	7.22%	37.44%
2B5a	2B5a Other chemical industry	6.01	1.73	6.71%	44.14%
2D2	2D2 Food and drink	5.84	2.15	6.53%	50.67%
1A4bi	1A4bi Residential: Stationary plants	5.30	3.48	5.91%	56.58%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.29	0.98	5.91%	62.49%
1A3bi	1A3bi Road transport: Passenger cars	5.19	2.01	5.79%	68.28%
2A7d	2A7d Other Mineral products	3.40	1.18	3.80%	72.08%
1A3bii	1A3bii Road transport: Light duty vehicles	2.52	1.77	2.81%	74.89%
7A	7A Other	1.86	1.41	2.07%	76.97%
4B9a	4B9a Laying hens	1.75	3.47	1.96%	78.92%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.72	0.51	1.92%	80.85%

Table 1.6.c TSP key source categories identified in the 1990–2009 trend assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
2G	2G Other production, consumption, storage, transportation or handling of bulk products	17.51	2.27	5.12%	21.83%	21.83%
4B9a	4B9a Laying hens	1.75	3.47	3.11%	13.27%	35.10%
1A1b	1A1b Petroleum refining	6.47	0.61	2.15%	9.16%	44.26%
1A4bi	1A4bi Residential: Stationary plants	5.30	3.48	1.58%	6.73%	50.99%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.29	0.98	1.21%	5.18%	56.16%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.17	1.42	1.08%	4.61%	60.77%
3D3	3D3 Other product use	1.05	1.24	0.93%	3.95%	64.72%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	1.77	0.87%	3.73%	68.45%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.89	1.10	0.84%	3.57%	72.02%
4B8	4B8 Swine	1.68	1.37	0.80%	3.40%	75.43%
7A	7A Other	1.86	1.41	0.77%	3.27%	78.70%
2C1	2C1 Iron and steel production	9.55	3.09	0.73%	3.10%	81.80%

Table 1.7.a PM_{10} key source categories identified in the 2009 level assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Contribution	Cumulative contribution
4B9a	4B9a Laying hens	1.75	3.47	11.66%	11.66%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	4.90	2.26	7.60%	19.26%
1A3bi	1A3bi Road transport: Passenger cars	5.19	2.01	6.76%	26.02%
2D2	2D2 Food and drink	3.85	1.81	6.07%	32.08%
1A3bii	1A3bii Road transport:Light duty vehicles	2.52	1.77	5.94%	38.02%
1A4bi	1A4bi Residential: Stationary plants	2.51	1.64	5.52%	43.54%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.17	1.42	4.78%	48.33%
4B8	4B8 Swine	1.68	1.37	4.61%	52.93%
7A	7A Other	1.86	1.41	4.75%	57.68%
2C1	2C1 Iron and steel production	8.90	1.33	4.48%	62.16%
3D3	3D3 Other product use	1.05	1.24	4.17%	66.33%
2A7d	2A7d Other Mineral products	2.64	1.15	3.87%	70.20%
2B5a	2B5a Other chemical industry	4.11	1.14	3.84%	74.04%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.89	1.10	3.69%	77.73%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.29	0.98	3.30%	81.03%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
2C1	2C1 Iron and steel production	8.90	1.33	13.21%	13.21%
1A1b	1A1b Petroleum refining	6.46	0.55	9.58%	22.79%
1A3biii	1A3biii Road transport:, Heavy duty vehicles	5.29	0.98	7.85%	30.65%
1A3bi	1A3bi Road transport: Passenger cars	5.19	2.01	7.70%	38.34%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	4.90	2.26	7.28%	45.62%
2B5a	2B5a Other chemical industry	4.11	1.14	6.10%	51.72%
2D2	2D2 Food and drink	3.85	1.81	5.72%	57.44%
2A7d	2A7d Other Mineral products	2.64	1.15	3.92%	61.35%
1A3bii	1A3bii Road transport: Light-duty vehicles	2.52	1.77	3.73%	65.09%
1A4bi	1A4bi Residential: Stationary plants	2.51	1.64	3.73%	68.82%
7A	7A Other	1.86	1.41	2.76%	71.58%
4B9a	4B9a Laying hens	1.75	3.47	2.60%	74.18%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.72	0.51	2.56%	76.74%
4B8	4B8 Swine	1.68	1.37	2.49%	79.23%
1A1a	1A1a Public electricity and heat production	1.45	0.33	2.16%	81.39%

Table 1.7.c PM_{10} key source categories identified in the 1990–2009 trend assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
4B9a	4B9a Laying hens	1.75	3.47	4.00%	15.09%	15.09%
2C1	2C1 Iron and steel production	8.90	1.33	3.86%	14.54%	29.62%
1A1b	1A1b Petroleum refining	6.46	0.55	3.43%	12.91%	42.54%
1A3biii	1A3biii Road transport: Heavy-duty vehicles	5.29	0.98	2.01%	7.58%	50.12%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	1.17	1.42	1.35%	5.08%	55.19%
3D3	3D3 Other product use	1.05	1.24	1.15%	4.34%	59.53%
1A3bvii	1A3bvii Road transport: Automobile road abrasion	0.89	1.10	1.05%	3.94%	63.47%
2B5a	2B5a Other chemical industry	4.11	1.14	1.00%	3.76%	67.23%
1A3bii	1A3bii Road transport: Light-duty vehicles	2.52	1.77	0.97%	3.67%	70.90%
4B8	4B8 Swine	1.68	1.37	0.93%	3.52%	74.42%
7A	7A Other	1.86	1.41	0.88%	3.32%	77.74%
1A4bi	1A4bi Residential: Stationary plants	2.51	1.64	0.79%	2.98%	80.72%

Table 1.8.a $PM_{2.5}$ key source categories identified in the 2009 level assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Contribution	Cumulative contribution
1A3bi	1A3bi Road transport: Passenger cars	5.19	2.01	12.61%	12.61%
1A3bii	1A3bii Road transport: Light-duty vehicles	2.52	1.77	11.07%	23.68%
1A4bi	1A4bi Residential: Stationary plants	2.31	1.55	9.71%	33.39%
7A	7A Other	1.80	1.36	8.52%	41.91%
1A3biii	1A3biii Road transport: Heavy-duty vehicles	5.29	0.98	6.16%	48.07%
2C1	2C1 Iron and steel production	5.66	0.85	5.36%	53.43%
2B5a	2B5a Other chemical industry	3.03	0.84	5.27%	58.70%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.48	0.74	4.62%	63.31%
1A3di(ii)	1A3di(ii) International inland waterways	0.90	0.54	3.40%	66.72%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.26	0.53	3.32%	70.04%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.64	0.48	3.01%	73.05%
1A3dii	1A3dii National navigation (Shipping)	0.39	0.44	2.78%	75.83%
2A7d	2A7d Other Mineral products	1.53	0.43	2.71%	78.53%
3D3	3D3 Other product use	0.35	0.41	2.59%	81.12%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
2C1	2C1 Iron and steel production	5.66	0.85	12.85%	12.85%
1A3biii	1A3biii Road transport: Heavy-duty vehicles	5.29	0.98	12.01%	24.86%
1A3bi	1A3bi Road transport: Passenger cars	5.19	2.01	11.77%	36.63%
1A1b	1A1b Petroleum refining	4.19	0.41	9.52%	46.15%
2B5a	2B5a Other chemical industry	3.03	0.84	6.88%	53.03%
1A3bii	1A3bii Road transport: Light-duty vehicles	2.52	1.77	5.71%	58.74%
1A4bi	1A4bi Residential: Stationary plants	2.31	1.55	5.24%	63.99%
7A	7A Other	1.80	1.36	4.10%	68.08%
1A2fii	1A2fii Mobile Combustion in manufacturing industries and construction	1.64	0.48	3.71%	71.80%
2A7d	2A7d Other Mineral products	1.53	0.43	3.48%	75.28%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.48	0.74	3.37%	78.64%
1A4cii	1A4cii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.26	0.53	2.85%	81.50%

Table 1.8.c $PM_{2.5}$ key source categories identified in the 1990-2009 trend assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
2C1	2C1 Iron and steel production	5.66	0.85	2.72%	13.33%	13.33%
1A1b	1A1b Petroleum refining	4.19	0.41	2.52%	12.37%	25.70%
1A3biii	1A3biii Road transport: Heavy-duty vehicles	5.29	0.98	2.12%	10.41%	36.11%
1A3bii	1A3bii Road transport: Light-duty vehicles	2.52	1.77	1.94%	9.53%	45.64%
1A4bi	1A4bi Residential: Stationary plants	2.31	1.55	1.62%	7.95%	53.59%
7A	7A Other	1.80	1.36	1.60%	7.87%	61.46%
1A3dii	1A3dii National navigation (Shipping)	0.39	0.44	0.69%	3.39%	64.85%
3D3	3D3 Other product use	0.35	0.41	0.65%	3.18%	68.03%
2B5a	2B5a Other chemical industry	3.03	0.84	0.58%	2.86%	70.89%
6Cc	6Cc Municipal waste incineration (d)	0.76	0.02	0.57%	2.79%	73.68%
1A3di(ii)	1A3di(ii) International inland waterways	0.90	0.54	0.49%	2.40%	76.08%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.48	0.74	0.45%	2.22%	78.30%
4B9a	4B9a Laying hens	0.20	0.27	0.45%	2.22%	80.52%

Table 1.9.a. Pb key source categories identified in the 2009 level assessment (Emission levels in Mg).

NFR Code	Long name	1990	2009	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	55.74	24.45	64.75%	64.75%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	5.02	6.05	16.02%	80.77%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
1A3bi	1A3bi Road transport: Passenger cars	224.99	0.04	66.93%	66.93%
2C1	2C1 Iron and steel production	55.74	24.45	16.58%	83.51%

Table 1.9.c Pb key source categories identified in the 1990–2009 trend assessment (Emission levels in Mg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
1A3bi	1A3bi Road transport: Passenger cars	224.99	0.04	7.51%	44.13%	44.13%
2C1	2C1 Iron and steel production	55.74	24.45	5.41%	31.81%	75.93%
1A3bvi	1A3bvi Road transport: Automobile tyre and brake wear	5.02	6.05	1.63%	9.59%	85.53%

Table 1.10.a Hg key source categories identified in the 2009 level assessment (Emission levels in Mg).

NFR Code	Long name	1990	2009	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	0.388	0.269	32.86%	32.86%
1A1a	1A1a Public electricity and heat production	0.012	0.124	15.12%	47.98%
2A1	2A1 Cement production	0.109	0.099	12.08%	60.06%
2A7d	2A7d Other Mineral products	0.000	0.099	12.04%	72.10%
6Cd	6Cd Cremation	0.057	0.076	9.27%	81.37%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
6Cc	6Cc Municipal waste incineration	1.675	0.061	47.70%	47.70%
2B5a	2B5a Other chemical industry	0.700	0.003	19.94%	67.64%
2C1	2C1 Iron and steel production	0.388	0.269	11.05%	78.69%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	0.272	0.037	7.74%	86.43%

Table 1.10.c Hg key source categories identified in the 1990–2009 trend assessment (Emission levels in Gg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
6Cc	6Cc Municipal waste incineration	1.675	0.061	9.39%	29.09%	29.09%
2C1	2C1 Iron and steel production	0.388	0.269	5.08%	15.75%	44.84%
2B5a	2B5a Other chemical industry	0.700	0.003	4.56%	14.13%	58.97%
1A1a	1A1a Public electricity and heat production	0.012	0.124	3.45%	10.67%	69.65%
2A7d	2A7d Other Mineral products	0.000	0.099	2.81%	8.70%	78.34%
2A1	2A1 Cement production	0.109	0.099	2.09%	6.49%	84.83%

Table 1.11.a Cd key source categories identified in the 2009 level assessment (Emission levels in Mg).

NFR Code	Long name	1990	2009	Contribution	Cumulative contribution
2C1	2C1 Iron and steel production	0.687	0.687	39.47%	39.47%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	0.022	0.659	37.88%	77.35%
6Cc	6Cc Municipal waste incineration	0.837	0.152	8.76%	86.11%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
6Cc	6 C c Municipal waste incineration	0.837	0.152	40.09%	40.09%
2C1	2 C 1 Iron and steel production	0.687	0.687	32.88%	72.96%
1A1a	1 A 1 a Public electricity and heat production	0.112	0.034	5.36%	78.33%
1A1b	1 A 1 b Petroleum refining	0.110	0.001	5.26%	83.59%

Table 1.11.c Cd key source categories identified in the 1990-2009 trend assessment (Emission levels in Mg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	0.022	0.659	30.66%	40.26%	40.26%
6Cc	6Cc Municipal waste incineration	0.837	0.152	26.10%	34.27%	74.54%
2C1	2C1 Iron and steel production	0.687	0.687	5.50%	7.22%	81.76%

Table 1.12.a Dioxine key source categories identified in the 2009 level assessment (Emission levels in g I-Teq).

NFR Code	Long name	1990	2009	Contribution	Cumulative contribution
3D3	3D3 Other product use	25.000	15.500	53.19%	53.19%
1A4bi	1A4bi Residential: Stationary plants	8.592	5.689	19.52%	72.71%
1A2a	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel	NO	NO	0.00%	72.71%
1A2b	1A2b Stationary Combustion in manufacturing industries and construction: Non-ferrous metals	NO	1.650	5.66%	78.38%
1A2c	1A2c Stationary combustion in manufacturing industries and construction: Chemicals	0.000	1.358	4.66%	83.04%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
6Cc	6Cc Municipal waste incineration	567.000	1.345	76.33%	76.33%
1A4ai	1A4ai Commercial / institutional: Stationary	100.018	0.010	13.46%	89.80%

Table 1.12.c Dioxine key source categories identified in the 1990-2009 trend assessment (Emission levels in g I-Teq).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
6Cc	6 C c Municipal waste incineration	567.00	1.35	2.81%	44.26%	44.26%
3D3	3 D 3 Other product use	25.00	15.50	1.95%	30.75%	75.01%
1A4bi	1 A 4 b i Residential: Stationary plants	8.59	5.69	0.72%	11.34%	86.35%

Table 1.13.a PAH key source categories identified in the 2009 level assessment (Emission in Mg).

NFR Code	Long name	1990	2009	Contribution	Cumulative contribution
1A4bi	1A4bi Residential: Stationary plants	3.535	2.899	69.89%	69.89%
2C3	2C3 Aluminum production	6.909	0.440	10.60%	80.48%

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

NFR Code	Long name	1990	2009	Contribution	Cumulative Contribution
2C3	2C3 Aluminum production	6.909	0.440	34.53%	34.53%
1A4bi	1A4bi Residential: Stationary plants	3.535	2.899	17.67%	52.20%
3A2	3A2 Industrial coating application	2.417	NA	12.08%	64.28%
2C1	2C1 Iron and steel production	1.642	0.061	8.21%	72.49%
2G	2G Other production, consumption, storage, transportation or handling of bulk products	1.370	NO	6.85%	79.34%
1 A 3 b i	1A3bi Road transport: Passenger cars	0.789	0.202	3.94%	83.28%

Table 1.13.c PAH key source categories identified by 1990-2009 trend assessment (Emission levels in Mg).

NFR Code	Long name	1990	2009	Trend	Trend contribution	Cumulative trend contribution
1A4bi	1A4bi Residential: Stationary plants	3.535	2.899	10.83%	73.37%	73.37%
2C1	2C1 Iron and steel production	1.642	0.061	1.40%	9.46%	82.84%

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Emissions of transboundary air pollutants in the Netherlands, 1990-2009. Explanation on the yearly set of emission data.
Between 1990 and 2009 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) 2011. 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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