NORWEGIAN ENVIRONMENT AGENCY

REPORT

125 - 2014

Informative Inventory Report (IIR) 2014. Norway.

Air Pollutant Emissions 1980-2012

COLOPHON

Executive institution

The Norwegian Environment Agency

Project manager for the contractor

[Project manager for the contractor]

Contact person in the Norwegian Environment Agency

Britta Maria Hoem

M-no

125 - 2014

Year

2014

Pages

244

Contract number

[Contract number]

Publisher

The Norwegian Environment Agency

The project is funded by

[The project is funded by]

Author(s)

[Authors]

Title - Norwegian and English

Informative Inventory Report (IIR) 2014. Norway. Air Pollutant Emissions 1980-2012
Submission under the UNECE Convention on Long-range Transboundary Air Pollution

Summary - sammendrag

This report documents the methodologies used in the Norwegian emission inventory of acidifying pollutants, particulate matters, heavy metals and persistent organic pollutants submitted under the UNECE Convention on Long-range Transboundary Air Pollution.

4 emneord

[4 emneord]

4 subject words

IIR, Air Pollutant Emissions

Front page photo

Photo: Kim Abel, Naturarkivet. Moutmarka naturreservat, Tjøme, Vestfold, Norway.

Content

Executive Summary

This report documents the methodologies used in the Norwegian emission inventory of acidifying pollutants, particulate matters, heavy metals and persistent organic pollutants.

The Norwegian emission inventory is a joint undertaking between the Norwegian Environment Agency[1] and Statistics Norway. This report has been prepared by the Norwegian Environment Agency but are mainly based on a report published by Statistics Norway's Division for Energy and Environmental Statistics each year (http://www.ssb.no/en/natur-og-miljo/artikler-og-publikasjoner/the-norwegian-emission-inventory-2013) which covers both greenhouse gases and long-range transboundary air pollutants, updated with recalculations performed for the 2013 submission to UNECE and a new key category analysis. The next complete documentation report for the Norwegian inventory with both greenhouse gases and long-range transboundary air pollutants will be published by Statistics Norway in summer 2014.

Contributors to the report are from Statistics Norway Ketil Flugsrud, Kristin Aasestad, Trond Sandmo, Marte Kittilsen and Henning Høie. Contributors from the Norwegian Environment Agency are Britta Maria Hoem, Nina Holmengen, Eilev Gjerald, Hans Kolshus, Simen Helgesen Ramberg and Ellen Bruzelius Backer.

The most important changes since the 2013 submission are:

- In the most recent emission inventory, emissions from NMVOC and particles from handling of coal at Spitsbergen are included for the first time. The emission of NMVOC has increased by 0.3- 0.6 per cent for period due to these inclusion, and the emission of TSP has increased by 0.1- 0.6 per cent for period.
- A new analysis of NOx emissions from diesel motors on offshore oil and gas installations has led to a significant reduction in estimated emissions for all years. The national total emission of NOx has decreased by 0.7- 1.5 per cent for period due to these recalculations.
- In 2010 measurements were done to measure unintentional formation of dioxins, at plants producing ferrosilicon and silicon products. The measurements showed that there was no formation of dioxins in these processes. All historical figures of dioxins from these plants have been removed for the period 1990 to 2011. The emission of dioxins has decreased by 0.5-3.9 per cent for period due to this recalculation.

Emissions of HCB have been included in the submission for all years since 1990.

Chapter 10.1 Recalculations gives a more thorough description of changes in the most recent emission calculations.

[1] Former names are "Climate and Pollution Agency" and "Norwegian Pollution Control Authority".

1 Introduction

1.1 National Inventory Background

The Norwegian national inventory for long-range transboundary air pollutants includes emission data for the years 1980, 1989-2012. The emissions covered in this report are those embraced by the convention on long-range transboundary air pollution, i.e. they are defined with a territorial delimitation. The calculation methods used and the documentation of these, are, as far as possible, in accordance with the strict demands formulated in the emission convention.

1.2 Institutional arrangements

The Norwegian emissions inventories have been produced for more than two decades as collaboration between Statistics Norway (SSB) and the Norwegian Environment Agency.

Statistics Norway is responsible for the official statistics on emissions to air. This includes:

- collection of activity data
- operation and further development of models for emission estimation
- emission calculations
- filling in most of the tables for international reporting to UNECE
- publishing national official statistics on emissions to air.

The Norwegian Environment Agency is responsible for:

- overall responsibility for international reporting UNECE
- emission factors for all sources
- measured emission data from large industrial plants based on individual reports submitted to the Norwegian Environment Agency on a regular basis
- considering the quality and assuring necessary updating, of emission models like, e.g. the road traffic model

Activity data[2] are collected either internally at Statistics Norway (e.g. data on energy use, industrial production, number of animals, etc.) or reported to Statistics Norway, and in some cases to the Norwegian Environment Agency, from external sources such as the Norwegian Petroleum Directorate (OD) and the Norwegian Public Roads Administration (VD). Emission figures are derived from models operated by Statistics Norway. In the modelling activities Statistics Norway makes use of the data collected by the Norwegian Environment Agency on emission factor and emissions from industrial plants.

The Norwegian Environment Agency is responsible for quality control of the data they deliver to the emission model operated by Statistics Norway, but Statistics Norway makes an additional consistency check (see chapter 1.6). Statistics Norway is responsible for quality control of the activity data and the emission figures from the model, but the Norwegian Environment Agency also participates in this quality control.

[2] Data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time.

1.3 Inventory preparation process

The Norwegian emission inventory is based on a general emission model and a series of more detailed satellite models, which cover specific emission sources and pollutants (e.g. road traffic, air traffic, solvents). These models are operated by Statistics Norway.

Data and information on point sources are recorded at the Norwegian Environment Agency in the database *Forurensning* and published in *Norske utslipp* (http://www.norskeutslipp.no). This is the Norwegian Pollutant Release and Transfer Register (PRTR). *Forurensning* is a further development of the old register Inkosys, which was introduced in 1978 as an internal tool for the authorities. The database was upgraded in 1992, and has later been under continuous development in order to harmonise with the PRTR adopted by the OECD in 1996. Each polluting industrial installation or plant is subjected to licensing and is obliged to produce an annual report to the pollution control authorities. The report should provide activity data, emission figures and information about the particular source, and it should address compliance with current environmental standards. The Norwegian Environment Agency supplies Statistics Norway with data from the Norwegian PRTR which are relevant for the preparation of the national emission inventory.

1.3.1 Pollutants included, data collection, processing and archiving

Statistics Norway collects the majority of data necessary to run the Norwegian emission model. These are as follows: activity levels, emission factors, aggregated results from the satellite models and emission figures for point sources. Table 1.1 gives an overview of pollutants included in the emission inventory which are restricted by CLRTAP.

Table 1.1. Definition of pollutants in the Norwegian emission inventory which are restricted by CLRTAP

Class	Pollutant	Symbol	Definition
Acidifying gases			
	Sulphur dioxide	SO_2	
	Nitrogen oxides	NO_x	NO + NO_2
	Ammonia	NH_3	
Heavy metals (HM)			
	Lead	Pb	
	Cadmium	Cd	
	Mercury	Hg	
	Arsenic	As	
	Chromium	Cr	
	Copper	Cu	
Persistent organic pollutants (POPs)			
	Polycyclic Aromatic Hydrocarbons	PAH	Emissions are calculated for PAH-total, PAH-6 and PAH-4. PAH-total includes 16 components according to Norwegian Standard (NS9815). PAH-6 is OSPARs Borneff-6 and include 6 components. PAH-4 is consisting of four components used as an indicator for PAH emissions required for reporting to CLRTAP.
	Dioxins	-	Dioxin emissions are given in the unit I-TEQ, which is required for reporting to CLRTAP. I-TEQ is based on the international model ("Nato-modell") and is the sum of PCDD/PCDF multiplied by the components toxicity equivalency factor (I-TEF). TEQ = sum ($PCDD_i$ * TEF_i) + sum ($PCDD_j$ * TEF_j).
Particulates			
	Total suspended particulates	TSP	
	-	PM_{10}	Particulate matter with diameter less than 10μm
	-	$PM_{2.5}$	Particulate matter with diameter less than 2.5μm
Other pollutants			
	Carbon monoxide	CO	
	Non-methane volatile organic compounds	NMVOC	

The collected data are subjected to the Quality Assurance and Quality Control (QA/QC) routines described in section 1.6 as well as source specific routines as described under each source chapter. They are subsequently processed by Statistics Norway into a format appropriate to enter the emission models. The models are designed in a manner that accommodates both the estimation methodologies reflecting Norwegian conditions and those recommended internationally.

Input data used and the model output are all stored at Statistics Norway. Relevant information including dates and procedures followed are also recorded.

1.3.2 Definitions and structure

The structure of this documentation follows the nomenclature used for reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) as Nomenclature For Reporting (NFR).

The main sectors here are:
1A. Energy combustion
1B. Energy production
2. Industrial processes
3. Solvent and other product use
4. Agriculture
5. Land use change and forestry
6. Waste

The description of the pollutants included is given in table 1.1.

Emissions of heavy metals, POPs and particulates are further described in the reports Finstad *et al*. (2001), Finstad *et al.* (2002b), Finstad and Rypdal (2003) and Finstad *et al*. (2003).

1.3.3 Archiving

The national emissions inventory is a part of Statistics Norway's data archiving system. All input data to, and results from, the general Norwegian emission model from every publication cycle are stored and documented in this system.

Several input data are used in preliminary calculations before entering into the general Norwegian emission model. This includes satellite models such as road traffic and air traffic, as well as a number of simpler calculations that do not fit into the framework of the general model. The preliminary calculations are not included in the central archiving system, which is not suited for such a diverse collection of data. For some satellite models there is an established archiving routine where all input data and results from every calculation cycle are stored.

1.4 Methods and data sources

This chapter describes the general structure of the Norwegian emission model. The model was developed by Statistics Norway (Daasvatn *et al.* 1992; Daasvatn *et al.* 1994). It was redesigned in 2003 in order to improve reporting to the UNFCCC and UNECE, and to

improve QA/QC procedures.

The Norwegian emission model is organised around a general emission model called "Kuben" ("the Cube"). Several emission sources, e.g. road traffic, air traffic and solvents are covered by more detailed satellite models. Aggregated results from the side models are used as input to the general model. The satellite models are presented in the appropriate sections of chapters 3-8. This chapter describes the general emission model.

1.4.1 Structure of the general emission model

The general emission model is based on equation (1.1).

(1.1) Emissions (E) = Activity level (A) · Emission Factor (EF)

For emissions from *combustion*, the activity data concern energy use. In the Norwegian energy accounts, the use of different forms of energy is allocated to industries (economic sectors). In order to calculate emissions to air, energy use must also be allocated to technical sources (e.g. equipment). After energy use has been allocated in this way, the energy accounts may be viewed as a cube in which the three axes are fuels, industries, and sources.

The energy use data are combined with a corresponding matrix of emission factors. In principle, there should be one emission factor for each combination of fuel, industry, source, and pollutant. Thus, the factors may be viewed as a four-dimensional cube with pollutants as the additional dimension. However, in a matrix with a cell for each combination, most of the cells would be empty (no consumption). In addition, the same emission factor would apply to many cells.

Emissions of some pollutants from major manufacturing plants (point sources) are available from measurements or other plant-specific calculations. When such measured data are available it is possible to replace the estimated values by the measured ones:

(1.2) $Emissions\ (E) = [\ (A - A_{PS}) \cdot EF] + E_{PS}$

where A_{PS} and E_{PS} are the activity and the measured emissions at the point sources, respectively. Emissions from activity for which no point source estimate is available (A-A_{PS}) are still estimated with the regular emission factor.

Non-combustion emissions are generally calculated in the same way, by combining appropriate activity data with emission factors. Some emissions may be obtained from current reports and investigations, and some are measured directly as described in chapters 3-8. The emissions are fitted into the general model using the parameters industry, source, and pollutant. The fuel parameter is not relevant here. The source sector categories are based on EMEP/NFR and UNFCCC/CRF categories, with further subdivisions where more detailed methods are available.

1.4.2 The four axes: Pollutants, industries, fuels, and sources

The *pollutants* currently included in the model are listed in table 1.1

The model uses approximately 130 *industries* (economic sectors). The classification is common with the basis data in the energy balance/accounts, and is almost identical to that used in the national accounts, which is aggregated from the European NACE (rev. 2) classification. The allocation of energy use and emissions to industries is the basis for

combining inventory results with economic data in economic/environmental accounts (Erlandsen 2002) and with economic models. The large number of sectors is an advantage in dealing with important emissions from manufacturing industries. The disadvantage is an unnecessary disaggregation of sectors with very small emissions. To make the standard sectors more appropriate for calculation of emissions, a few changes have been made, e.g. "Private households" is defined as a sector.

The *fuels* and technical *sources* used for combustion with energy use (NFR source sector 1A) are shown in tables 1.2-1.4.

Table 1.2 Energy commodities in the Norwegian emission inventory

Energy commodity	Aggregate fuel category in CRF and NFR
Coal	Solid Fuels
Coke	Solid Fuels
Petrol coke	Liquid Fuels
Wood	Biomass
Wood waste	Biomass
Black liquor	Biomass
Wood pellets	Biomass
Wood briquettes	Biomass
Charcoal	Biomass
Natural gas	Gaseous Fuels
Refinery gas	Liquid Fuels
Blast furnace gas	Solid Fuels
Landfill gas	Biomass
Biogas	Biomass
Fuel gas	Liquid Fuels
LPG	Liquid Fuels
Gasoline (road transport)	Liquid Fuels
Aviation gasoline	Liquid Fuels
Kerosene (heating)	Liquid Fuels
Jet kerosene	Liquid Fuels
Autodiesel	Liquid Fuels
Marine gas oil	Liquid Fuels
Light fuel oils	Liquid Fuels
Heavy distillate	Liquid Fuels
Heavy fuel oil	Liquid Fuels
Municipal waste	Other Fuels
Special waste*	Other Fuels

* Special waste was moved from *Liquid* to *Other* fuels in 2014.

Table 1.3. Sources for energy combustion in the Norwegian emission inventory

Source	CRF/NFR
Stationary combustion	
Direct fired furnaces	1A1, 1A2
Gas turbines	1A1c, 1A3e, 1A4a
Boilers	1A1, 1A2, 1A4, 1A5
Small stoves	1A2, 1A4, 1A5
Flaring	1B2C, 6C
*Mobile combustion**	
Passenger car	1A3b i, 1A5b
Light duty vehicles	1A3b ii, 1A5b
Heavy duty vehicles	1A3b iii, 1A5b
Motorcycle	1A3b iv
Moped	1A3b iv
Snowscooter	1A4b, c
Railway	1A3c
Aviation jet/turboprop (0-100 m)	1A3a ii (i), 1A5b
Aviation jet/turboprop (100-1000m)	1A3a ii (i), 1A5b
Aviation jet/turboprop (cruise)	1A3a ii (ii), 1A5b
Aviation helicopter (0-100 m)	1A3a ii (i)
Aviation helicopter (100-1000m)	1A3a ii (i)
Aviation helicopter (cruise)	1A3a ii (ii)
Aviation small craft (0-100 m)	1A3a ii (i)
Aviation small craft (100-1000m)	1A3a ii (i)
Aviation small craft (cruise)	1A3a ii (ii)
Ships	1A3d, 1A4c, 1A5b
Small boats 2 stroke	1A4b
Small boats 4 stroke	1A4b, c
Equipment 2 stroke	1A3e, 1A4c
Equipment 4 stroke, tractor	1A3e, 1A4b, c, 1A5b

* For road transport the source split is more detailed in the sub-model. See section 3.2.4.2.

Table 1.4. Combinations of fuels and sources in use

	Direct fired furnaces	Gas turbines	Boilers	Small stoves	Flaring	Passenger car	Light duty vehicles	Heavy duty vehicles	Motorcycle	Moped	Snowscooter	Railway	Aviation jet/turboprop	Aviation helicopter	Aviation small craft	Ships	Small boats 2 stroke	Small boats 4 stroke	Equipment 2 stroke	Equipment 4 stroke, tractor
Coal	x	..	X	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Coke	x	..	X	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Petrol coke	x	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Fuel wood	..	..	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Wood waste	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Black liquor	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Wood pellets	..	..	X	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Wood briquettes	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Charcoal	..	..	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Natural gas	x	x	X	..	x	x	..	x	..	..	..	..	..	..	..	x	..	..	..	..
Refinery gas	x	..	X	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Blast furnace gas	x	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Landfill gas	..	..	X	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Biogass	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Fuel gas	x	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
LPG	..	..	X	x	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Motor gasoline	..	..	..	..	..	x	x	x	x	x	x	..	..	..	..	..	x	x	x	x
Aviation gasoline	..	..	..	..	..	..	..	..	..	..	..	..	..	..	x	..	..	..	..	..
Kerosene (heating)	..	..	X	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Jet kerosene	..	..	..	..	..	..	..	..	..	..	..	..	x	x	..	..	..	..	..	..
Auto diesel	..	..	X	..	..	x	x	x	..	..	..	x	..	..	..	..	..	x	..	x
Marine gas oil/diesel	x	x	X	..	..	..	..	..	..	..	..	..	..	..	..	x	..	..	..	..
Light fuel oils	..	..	X	x	..	..	..	..	..	..	..	..	..	..	..	x	..	..	..	x
Heavy distillate	x	..	X	..	..	..	..	..	..	..	..	..	..	..	..	x	..	..	..	..
Heavy fuel oil	x	..	X	..	..	..	..	..	..	..	..	..	..	..	..	x	..	..	..	..
Municipal waste	..	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Special waste	x	..	X	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

The sources for non-combustion emissions and for combustion without energy use are based on EMEP/NFR and UNFCCC/CRF categories, with further subdivisions where more detailed methods are available.

1.4.3 Regions: a fifth axis

Information about the geographical distribution of emissions is useful for modelling and control purposes. The spatial distribution of emissions introduces another dimension (axis) to the general model.

1.4.3.1 Municipalities

The municipalities, of which there are 428 on the mainland (in 2013), have been chosen as the smallest unit for regionalisation. In addition we have included the regions Svalbard, sea areas north and south of 62 °N, and air space 100-1000 m and more than 1000 m above ground level.

Emissions are allocated to geographical units *after* the national totals have been calculated. Emissions are allocated in one of three ways:

- Emissions from *point sources* are allocated directly to municipalities.
- When figures for the activity used to calculate emissions are available *directly* at municipal level, these figures are used. Examples are fuel combustion in manufacturing industries and emissions from animals.
- When the activity at the municipal level is unknown, the national emissions are allocated *indirectly* using surrogate statistical data. For example, fuel combustion in service industries is allocated using employment figures. In a number of cases the activity is known directly at the intermediate level (county), but allocation within counties uses surrogate data.

Data from several important sources, e.g. industrial statistics, are not available at the municipal level until one and a half years after the year of emissions.

1.4.3.2 EMEP grid squares

Emissions by EMEP 50 km x 50 km grid square are reported to the UNECE and used in models of long-range air pollution. The emissions are allocated to grid squares as follows:

- Emissions from large point sources are allocated directly to the appropriate squares. From 2000, this also includes emissions from offshore petroleum activities.
- Emissions at sea from national sea traffic and offshore petroleum activities (before 2000) are allocated to squares on the basis of a detailed analysis of 1993 activity data (Flugsrud and Rypdal 1996). The 1993 emissions are projected using national emission trends for each of the categories fishing, other sea traffic, flaring, other combustion, and other emissions in the petroleum sector.
- The remaining emissions in each municipality are allocated to squares according to the proportion of the area of the municipality in each square.

The method assumes that emissions are evenly distributed within municipalities. In reality, emissions often occur only in small parts of a municipality. If a municipality is large relative to the grid squares, the emissions may be allocated wrongly. However, few municipalities measure more than 50 km across and the larger municipalities are usually sparsely populated,

with small emissions. It is therefore assumed that the level of error due to the method is acceptable. The direct allocation of large point sources also reduces the potential error.

1.5 Key Categories

Information about key categories is given in Appendix A.

1.6 QA/QC and Verification methods

This chapter describes general QA/QC procedures. For source specific QA/QC, see each source sector for detailed descriptions.

The QA/QC work has several dimensions. In addition to accuracy, also timeliness is essential. As these two aspects may be in conflict, the QA/QC improvements in recent years have been focused on how to implement an effective QA/QC procedure and how to obtain a more efficient dataflow in the inventory system.

During the past years several quality assurance and quality control procedures for the preparation of the national emission inventory have been established in Norway. Statistics Norway made its first emission inventory for some gases in 1983 for the calculation year 1973. The emission estimation methodologies and the QA/QC procedures have been developed continuously since then. Norway has implemented a formal quality assurance/quality control or verification plan. A detailed description of this is presented in Annex V in the National Inventory Report 2011.

The established QA/QC procedures include the following:

- The Norwegian Environment Agency is the national entity designated to be responsible for the reporting of the national inventory of greenhouse gases to the UNFCCC. This includes coordination of the QA/QC procedures;
- Statistics Norway is responsible for the quality control system with regard to technical activities of the inventory preparation;
- A Tier 1 general inventory level QC procedures, as listed in table 8.1 of the IPCC Good Practice Guidance is performed every year;
- Source category-specific QC procedures are performed for all key categories and some non-key categories; with regard to emission factors, activity data and uncertainty estimates (Tier 2).

1.6.1 QA Procedures

According to the IPCC Good practice guidance, good practice for QA procedures requires an objective review to assess the quality of the inventory and to identify areas where improvements could be made. Furthermore, it is good practice to use QA reviewers that have not been involved in preparing the inventory. In Norway, the Norwegian Environment Agency is responsible for reviewing the inventory with regard to quality and areas for improvement. For most sources it is a person within the Norwegian Environment Agency who has not been involved in the calculations and the quality controls who performs the QA for the particular source.

Norway has performed several studies comparing inventories from different countries (Haakonsen *et al.* 2000). Verification of emission data is another element to be assessed during the elaboration of a QA/QC and verification plan.

Both core institutions are responsible for archiving the data they collect and the estimates they calculate with associated methodology documentation and internal documentation on QA/QC. Due to the differences in the character of data collected, Norway has chosen to keep archiving systems in the core institutions, which means that not all information is archived at a single location. These archiving systems are, however, consistent, and operate under the same rules. Although the data are archived separately, all can be accessed efficiently during a review.

1.6.2 General QC procedures

The Norwegian emission inventory is produced in several steps. Preliminary estimates are first produced 4-5 months after the end of the inventory year. These data are based on preliminary statistics and indicators and data that have been subjected to a less thorough quality control. The "final" update takes place about one year after the inventory year. At this stage, final statistics are available for all sources. Recalculations of the inventory are performed annually, as methodological changes and refinements are implemented. In itself, this stepwise procedure is a part of the QA/QC-procedure since all differences in data are recorded and verified by the Norwegian Environment Agency before publication of the emission figures.

For each of the steps described above, general quality control procedures are performed, but with different levels of detail and thoroughness as mentioned. The national emission model was revised in 2002 in order to facilitate the QC of the input data rather than the emission data only. Input data include emissions reported from large plants, activity data, emission factors and other estimation parameters.

In the following, the procedures listed in table 8.1 of the Good Practice Guidance (IPCC 2000), the Tier 1 General Inventory Level QC Procedures, are gone through, and it is described how these checks are performed for the Norwegian greenhouse gas emission inventory.

Check that assumptions and criteria for the selection of activity data and emissions factors are documented
Thorough checks of emission factors and activity data and their documentation have been performed for existing emission sources. When new sources appear (for example a new industrial plant) or existing sources for the first time are recognised as a source, the Norwegian Environment Agency delivers all relevant information to Statistics Norway. This information is then thoroughly checked by the inventory team at Statistics Norway. All changes in methodologies or data are documented and kept up to date.

Check for transcription errors in data input and references
Activity data are often statistical data. Official statistical data undergo a systematic revision process, which may be manual or, increasingly frequently, computerised. The revision significantly reduces the number of errors in the statistics used as input to the inventory.

Check that emissions are calculated correctly
When possible, estimates based on different methodologies are compared. An important example is the metal production sector where CO_2 estimates reported by the plants are compared with estimates based on the Good Practice methodology corrected for national circumstances. In this case, both production based and reducing agent based calculations are performed to verify the reported value. The Norwegian Environment Agency and Statistics Norway control and verify emission data reported to the Norwegian Environment Agency by

industrial enterprises, registered in the database *Forurensning*. First, the Norwegian Environment Agency checks the data received from these plants, and if errors are discovered, they may then ask the plants' responsible to submit new data. Subsequently, Statistics Norway makes, where possible, occational comparable emission calculations based on activity data sampled in official statistics, and deviations are explained through contact with the plants.

Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used
All parameter values are compared with values used in previous years and with any preliminary figures available. Whenever large deviations are detected, the value of the parameter in question is first checked for typing errors or unit errors. Changes in emissions from large plants are compared with changes in activity level. If necessary, the primary data suppliers (e.g. The Norwegian Petroleum Directorate, Norwegian Public Roads Administration, various plants etc) are contacted for explanations and possible corrections.

Check the integrity of database files
Control checks of whether appropriate data processing steps and data relationships are correctly represented are made for each step of the process. Furthermore, it is verified that data fields are properly labelled and have correct design specifications and that adequate documentation of database and model structure and operation are archived.

Check for consistency in data between source categories
Emission data for the last year are compared with data for the previous year, in order to check the consistency and explain any changes in the data behaviour. For example, in 2010 Statistics Norway and the Norwegian Environment Agency calculated emission data for 2009 for the first time. These data were compared with the 2008 figures for detection of any considerable deviations. There may be large deviations that are correct, caused for instance by the shutdown of large industrial plants or the launch of new ones.

Check that the movement for inventory data among processing steps is correct
Statistics Norway has established automated procedures to check that inventory data fed into the model does not deviate too much from the figures for earlier years, and that the calculations within the model are correctly made. Checks are also made that emissions data are correctly transcribed between different intermediate products. The model is constructed so that it gives error messages if factors are lacking, which makes it quite robust to miscalculations.

Check that uncertainties in emissions and removals are estimated correctly
A new uncertainty analysis for greenhouse gases was undertaken in 2011. For long-range transbundary air pollutants the last uncertainty analysis was undertaken in 2001. See further information about the uncertainty analysis in section 1.7 and Appendix C.

Undertake review of internal documentation
For some sources expert judgements dating some years back are employed with regard to activity data/emission factors. In most of the cases these judgements have not been reviewed since then, and may not be properly documented, which may be a weakness of the inventory. The procedures have improved the last few years, and the requirements for internal documentation to support estimates are now quite strict; all expert judgements and assumptions made by the Statistics Norway staff should be documented. This should increase reproduceability of emissions and uncertainty estimates. The new model at Statistics Norway

has improved the process of archiving inventory data, supporting data and inventory records, which does facilitate review. The model runs are stored and may be reconstructed, and all input data from the Norwegian Environment Agency as well as notes with explanations on changes in emissions are stored. This is a continuous process of improvement at Statistics Norway.

Check of changes due to recalculations
Emission time series are recalculated every yearto ensure time series consistency. The recalculated emission data for a year is compared with the corresponding figures estimated the year before. The intention is to explain all major differences as far as possible. Changes may be due to revisions in energy data, new plants, correction of former errors and new emission methodologies.

Undertake completeness checks
Estimates are reported for all source categories and for all years as far as we know, apart from a few known data gaps, which are listed in section 1.8. There may, of course, exist sources of greenhouse gases which are not covered. However, we are quite certain that emissions from potentially additional sources are very small or negligible.

Compare estimates to previous estimates
Internal checks of time series for all emission sources are performed every year when an emission calculation for a new year is done. It is then examined whether any detected inconsistencies are due to data or/and methodology changes. For example, in 2010 Statistics Norway/the Norwegian Environment Agency calculated emission data for 2009 for the first time. These data were compared with the 2008 figures for detection of any considerable deviations. There may be large deviations that are correct, caused for instance by the shutdown of large industrial plants or the launch of new ones.

1.6.3 Source category-specific QC procedures

Statistics Norway and the Norwegian Environment Agency have carried out several studies on specific emission sources, e.g. emissions from road, sea, and air transport. These projects are repeated in regular intervals when new information is available. During the studies, emission factors have been assessed and amended in order to represent the best estimates for national circumstances, and a rational for the choice of emission factor is provided. The emission factors are often compared with factors from literature. Furthermore, activity data have been closely examined and quality controlled and so has the uncertainty estimates.

The QC procedures with regard to emission data, activity data and uncertainty estimates for the different emission sources are described in the QA/QC-chapters of the relevant source-categories. The source category-specific analyses have primarily been performed for key categories on a case-by-case basis, which is described as being good practice. The QA/QC process for many of the sources could be improved. The QC procedures are described in the report on the National System which was submitted by 1. January 2007.

The ERT requested in 2005 further information regarding the verification of quality of data reported by companies. The general checks performed are described earlier in this chapter. In the following is a more detailed description of QC of emission data reported from plants:

Plant emission data that are used in the emission trading system will undergo annual QC checks. The source-specific QC checks for other plants are performed less frequently (every 3

years) for emission estimates used in key categories, which account for 25-30 per cent of the total of that category. The frequency of checking of non-key plants which are not included in the emission trading scheme is every 5 years. Statistics Norway is responsible for reporting the results of the key category analysis to the Norwegian Environment Agency, while the Norwegian Environment Agency will perform the assessment of the "key plants" within a category.

The QC checks include:

- An assessment of the internal QA/QC of the plants reporting data to the Norwegian Environment Agency
  - Their QA/QC system including archiving
  - Any changes to the QA/QC system
- An assessment and documentation of measurements and sampling
  - Measurement frequency
  - Sampling
  - Use of standards (e.g. ISO)
  - Documentation for archiving
- An assessment and explanation of changes in emissions over time (e.g. changes in technology, production level or fuels) (annual check)
- An assessment of time-series consistency back to 1990 in cooperation with the Norwegian Environment Agency (if plant emission data are missing for some years and estimates are made using aggregate activity data and emission factors)
- A comparison of plant emissions to production ratios with those of other plants, including explanations of differences
- A comparison of the production level and/or fuel consumption with independent statistics
- An assessment of reported uncertainties (including statistical and non-statistical errors) to the extent this has been included in the reporting

The QC checks are made in close cooperation with the emission reporting plants.

For more details of QA/QC of specific source categories, see "source specific QA/QC" in relevant chapters.

1.6.4 Verification studies

In general, the final inventory data provided by Statistics Norway are checked and verified by the Norwegian Environment Agency.

In the following, some verification studies which have been performed are briefly described. Emission estimates for a source are often compared with estimates performed with a different methodology. In particular, Norway has conducted a study on verification of the Norwegian emission inventory (Haakonsen *et al.* 2000). The main goals of that work were to investigate the possibility of using statistical data as indicators for comparing emission figures between countries on a general basis, and to test the method on the Norwegian national emission estimates. In the report, Norwegian emission data were compared with national data for Canada, Sweden and New Zealand. It was concluded that no large errors in the Norwegian emission inventory were detected. The process of verification did, however, reveal several smaller reporting errors; emissions that had been reported in other categories than they should have been. These errors have been corrected in later reports to the UNFCCC. We do realise that this method of verification only considers consistency compared with what other

countries report. It is not a verification of the scientific value of the inventory data themselves.

In 2004, the Nordic Council of Ministers initiated a new project that was finalised in 2006. This project focused on NMVOC, heavy metals and POPs. An unpublished, final report has been worked out, containing the following elements:

- comparisons of the emission estimation methodologies and emission factors used in each country (review)
- identification of gaps in knowledge
- identification of possible "burden sharings" with respect to research areas (research taking place in one country, but used in all countries)
- discussions of the particular Nordic aspects influencing the emissions
- discussions of the possible contributions from research in the Nordic countries
- proposals for research areas

In 2006, the Nordic Council of Ministers initiated a new project that focuses on emission of particulate matter. A final report will be published with the following elements:

- comparisons of the emission estimation methodologies and emission factors used in each country (review)
- identification of gaps in knowledge
- discussions of the particular Nordic aspects influencing the emissions
- discussions of the possible contributions from research in the Nordic countries
- proposals for research areas
- recommendations for further work

1.7 General uncertainty evaluation

1.7.1 Acidifying substances and NMVOC

The emission estimates for long-range air pollutants in the Norwegian emission model may be ranked roughly in order of increasing uncertainty as follows:

$$SO_2 < NO_X < NH_3 \approx \text{NMVOC}$$

The sources of uncertainty in the emission estimates include sampling errors, poor relevance of emission factors or activity data, and gross errors.

Evaluation of the uncertainty in the long-range air pollutants is given in the report Rypdal and Zhang (2001). Summary tables with the results are given in Appendix C.

1.7.2 Heavy metals and POPs

The uncertainty is generally higher for HM and POPs than for other components in the Norwegian emission model except for N_2O. There are various reasons for this high uncertainty. The most important reason is that there is limited information about emission factors, and it is not clear how usable the emission factors found in international literature are for Norwegian conditions. Emission factors for some HM and POPs components are insufficient for some sources, so emission factors for similar sources have then been used. In addition it is not certain that all emission sources are known or sufficiently mapped. The industrial reporting to the Norwegian Environment Agency has improved in recent years. The reported figures can, however, vary a great deal from one year to another. For earlier years they can be insufficient, and since HM and POPs are to be calculated from 1990,

recalculations are necessary. These recalculations are based on a combination of assumptions and knowledge of the plants. Emission figures from the early 1990s are therefore more uncertain than figures produced today.

1.8 General Assessment of Completeness

Norway is requested to report emissions to UNECE for the pollutants restricted by CLRTAP (Convention on Long-Range Transboundary Air Pollution). Minimum reporting request each year includes the acidifying pollutants (NO_X, SO_2, NH_3) and NMVOC, the heavy metals Pb, Cd and Hg, particulate matter (TSP, PM_{10} and $PM_{2.5}$) and CO. Norway also reports, under the section "additional reporting", the heavy metals As, Cr and Cu, and the POPs dioxins and PAH. The reporting of emissions of individual PAH species and Ni, Se and Zn is voluntary and have been reported as NE.

In terms of spatial coverage, the calculated air emissions cover all activities within Norway's jurisdiction.

In the case of temporal coverage, emission figures for CO, SO_2, NO_X, NH_3 and NMVOC are produced and updated every year for the years 1980, 1987 and for all years from 1989. For HM, POPs and particles, emission figures are produced for all years from 1990.

With regard to sectoral coverage, the following sources with relevant emission amounts are not covered in the inventory even if emissions can be expected:

Energy sector:

- NH_3 emissions from Civil aviation, domestic cruise (1A3aii (ii))
- Emissions of particulate matters from clutch wear (1A3b)
- Emissions of particulate matters from use of unpaved roads (1A3b)
- Emissions of particulate matters from sand strewing (1A3b)
- Fugitive emissions of HM from solid fuel transformation (1B1b)
- Fugitive emissions of NO_X from natural gas (by land-based desulphurisation) (1B2b)

Industry sector:

- Emissions of NMVOC from asphalt roofing (2A5) and NMVOC and PAH from road paving with asphalt (2A6)
- Emissions of NO_X, NMVOC and NH_3 from ammonia production (2B1)
- Emissions of NMVOC from Nitric acid production (2B2)
- Emissions of NO_X from production of NPK-fertilisers (2B5) and emissions of Cd from production of Phosphate fertilisers (2B5)
- Emissions of NMVOC from the pulp and paper industry (2D1)
- Emissions of NH_3 from refrigeration and air conditioning equipments using other products than halocarbons (2G)

Agricultural sector:

- Emissions of NMVOC from manure management (4B)
- Emissions of NMVOC from agricultural soils (4D)
- Emissions of NMVOC from field burning of agricultural wastes (4F)

Waste sector:

- Emissions of NO_X, NMVOC, NH_3 and CO from solid waste disposal on land (6A)
- Emissions of NMVOC and NH_3 from waste-water handling (6B)

- Emissions of particulate matters and POPs from burning of bonfire, emissions of POPs from burning of garden waste, and emissions of particulate matters, POPs and HM from burning of animal carcasses and burning of waste in household stoves (6C)
- Emissions of HM and POPs in connection with fires and open burning at landfills (6C)
- Evaporation of Hg from landfills and emission of Pb by detonation of explosives (6C)
- Emissions of dioxins by smoking processes for preservation of meat and fish (6C)

The reasons for not including these emission sources are mainly lack of activity data, emission factors or known calculation methodology.

For some combinations of NFR category and pollutant, the 2009 Guidebook has indicated emission factors as Not Estimated. In such cases, if there is no reason to expect that emissions occur in Norway, emissions are reported as Not Applicable (NA). These cases are indicated in table 1.5.

Table 1.5. Combinations of NFR source categories and pollutants reported as NA due to lack of default emission factors in the 2009 EMEP/EEA Guidebook.

NFR source category	Pollutants reported as NA due to lack of default emission factors
1 B 1 a Fugitive emission from solid fuels: Coal mining and handling	SO_X, $PM_{2.5}$, TSP, Pb, Cd, Hg, As, Cr, Cu
1 B 1 b Fugitive emission from solid fuels: Solid fuel transformation	NO_X, SO_X, CO, Cr, Cu
1 B 1 c Other fugitive emissions from solid fuels	All pollutants
1 B 2 a v Distribution of oil products	SO_X
1 B 3 Other fugitive emissions from geothermal energy production , peat and other energy extraction not included in 1 B 2	NO_X, NMVOC, SO_X, $PM_{2.5}$, PM_{10}, TSP, CO, Pb, Cd, Cr, Cu
2 A 1 Cement production	NO_X, NMVOC, CO
2 A 2 Lime production	NO_X, NMVOC, SO_X, CO, Pb, Cd, Hg
2 A 4 Soda ash production and use	$PM_{2.5}$, PM_{10}
2 A 5 Asphalt roofing	NO_X, $PM_{2.5}$, PM_{10}, Pb, Cd, Hg
2 A 6 Road paving with asphalt	NO_X, SO_X, CO
2 B 1 Ammonia production	NMVOC; SO_X, $PM_{2.5}$
2 B 4 Carbide production	NO_X
2 B 5 b Storage, handling and transport of chemical products	All pollutants
2 C 1 Iron and steel production	NH_3, CO
2 C 2 Ferroalloys production	NH_3, CO

2 C 3 Aluminum production	NMVOC, NH_3
2 C 5 e Other metal production	NMVOC, CO
2 D 1 Pulp and paper	NH_3
2 D 2 Food and drink	$PM_{2.5}$, PM_{10}, TSP
2 D 3 Wood processing	NO_X, NMVOC; SO_X; NH_3, $PM_{2.5}$, PM_{10}, CO, As, Cu
2 E Production of POPs	All pollutants
4 B 1 a Cattle dairy	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 1 b Cattle non-dairy	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 2 Buffalo	NMVOC, SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 3 Sheep	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 4 Goats	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 6 Horses	NMVOC, SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 7 Mules and asses	NMVOC, SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 8 Swine	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 9 a Laying hens	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 9 b Broilers	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 9 c Turkeys	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 9 d Other poultry	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 B 13 Other	NMVOC, SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 D 1 a Synthetic N-fertilizers	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu
4 D 2 c N-excretion on pasture range and paddock unspecified	SO_X, CO, Pb, Cd, Hg, As, Cr, Cu

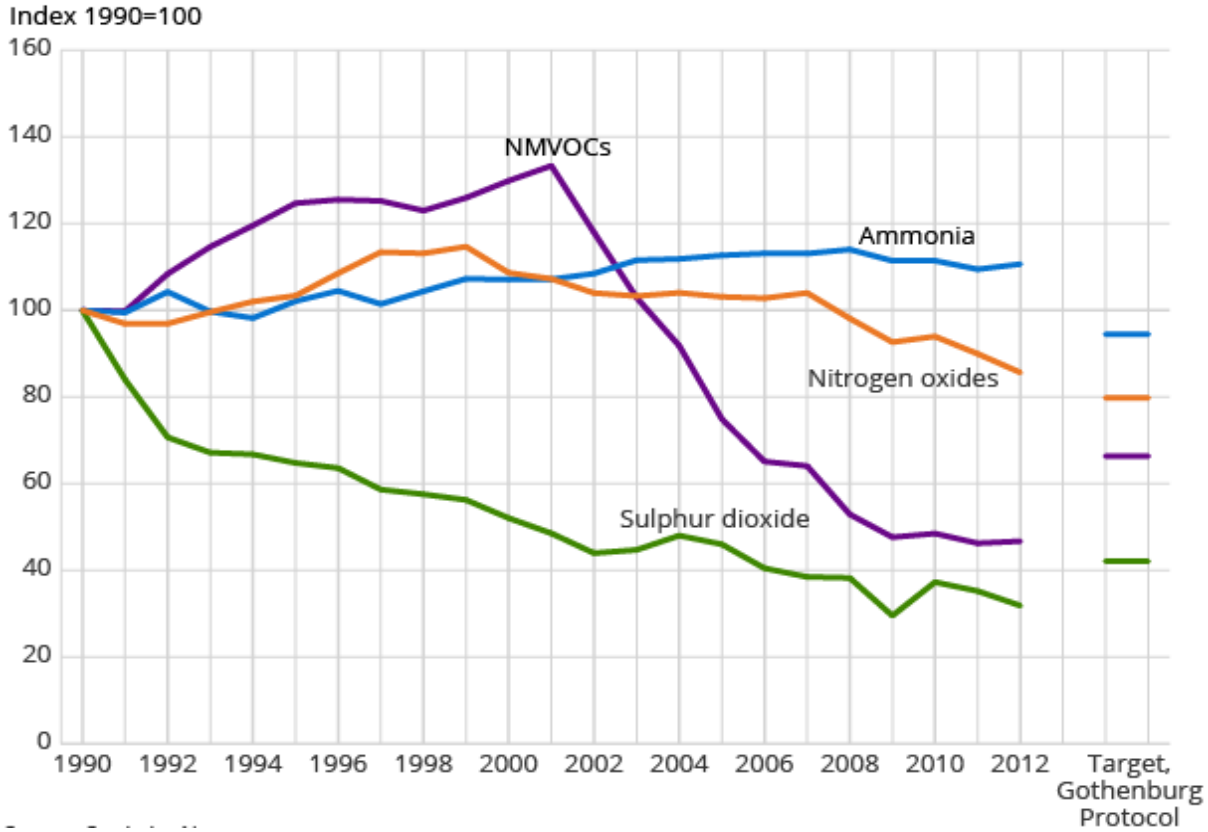
2 Explanation of key trends

2.1 Acidifying substances and NMVOC

2.1.1 Total acidifying emission

Emission of gases that transform into acid can be expressed in terms of acid equivalents. Total emissions of the three gases NO_X , SO_2 and NH_3 measured as acid equivalents have been reduced by 21 per cent since 1990, from 7 200 tonnes acid equivalents to 5 700 tonnes acid equivalents. SO_2 and NO_X emissions are down 68,1 and 13,3 per cent since 1990 respectively, while NH_3 emissions have increased by 10,7 per cent. In 2012, NO_X constituted 63,2 per cent of the acidifying emissions, while NH_3 and SO_2 were responsible for 27,7 and 9, 1 per cent of these emissions respectively. Norway has met the targets defined by the Gothenburg Protocol for SO_2 and NMVOC, but emissions of NH_3 and NO_X are currently above the Gothenburg targets.

Figure 2.1: Trends in emissions for NO_X, SO_2, NH_3 and NMVOC. 1990-2012.



Source: Emission inventory from Statistics Norway and the Norwegian Environment Agency.

2.1.2 NO_X

Norway's NO_X emissions totalled 166 000 tonnes in 2012. This is 10 000 tonnes higher than the emission ceiling at 156 000 tons set by the Gothenburg Protocol.

The total emission of NO_X has been reduced by 13 per cent since 1990. The biggest source of NOx emissions in 2012 was transport, with 35 per cent of the total emission. Emissions in the transport sector overall have been reduced by 40 per cent since 1990. This figure nonetheless hides some quite significant changes within the transport sector: emissions from civil and international aviation have increased by 95 per cent and 256 per cent respectively from 1990

to 2012, whereas emissions from passenger cars have been reduced by 62 per cent.

Emissions from aviation have increased primarily due to increased traffic. Within road transport, traffic has also increased significantly from 1990 to 2012. NO_X emissions have however been reduced due to policy measures. Stricter emission requirements for new passenger cars is the main cause of the reduction.

Emissions from national navigation are reduced by 38 per cent since 1990. The reduced emissions in navigation are partly due to measures implemented by the NO_X Fund, which is financed by industry and businesses. The measures are not directly linked to fuel efficiency, and energy consumption in national navigation has not had the same decrease as the emissions. In spite of these measures, national navigation was in 2012 still the largest emission source within the transport sector, with 32,5 per cent of NO_X emissions. Heavy duty vehicles and passenger cars followed at 30 and 23 per cent, respectively.

Figure 2.2: Trends in NO_X emissions, 1990-2012. 1000 tonnes

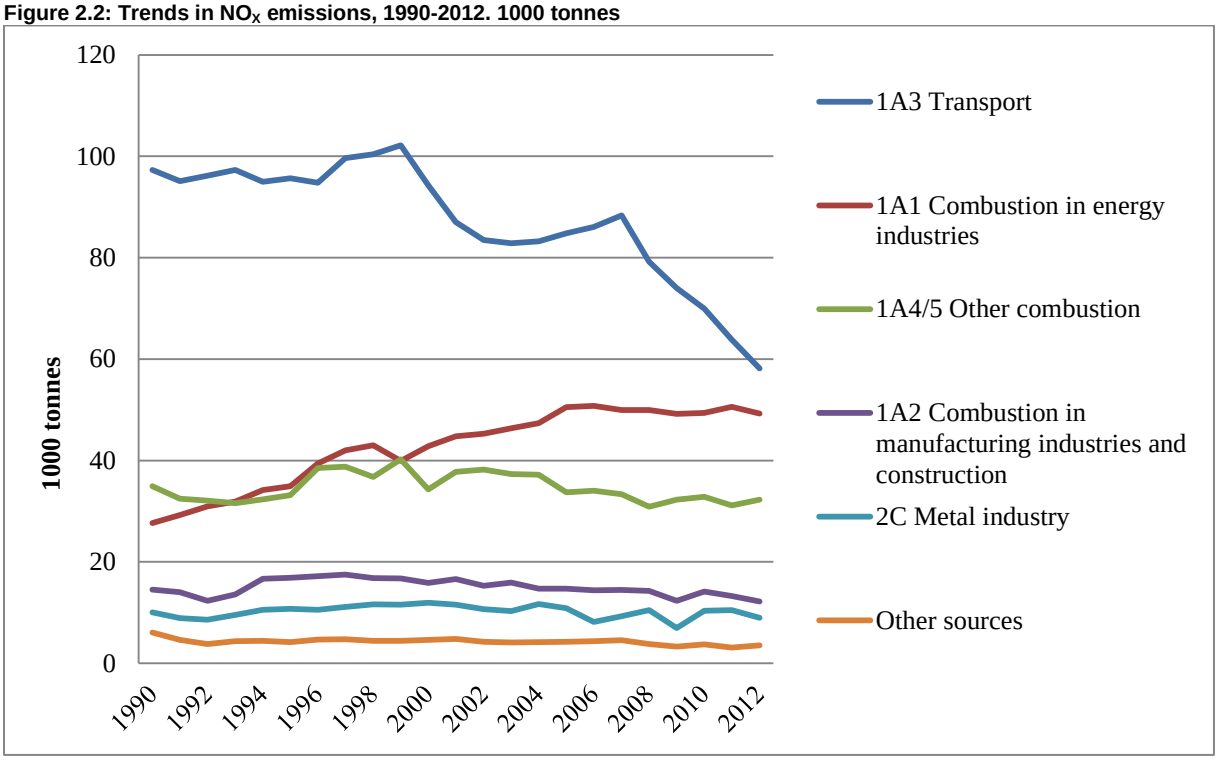
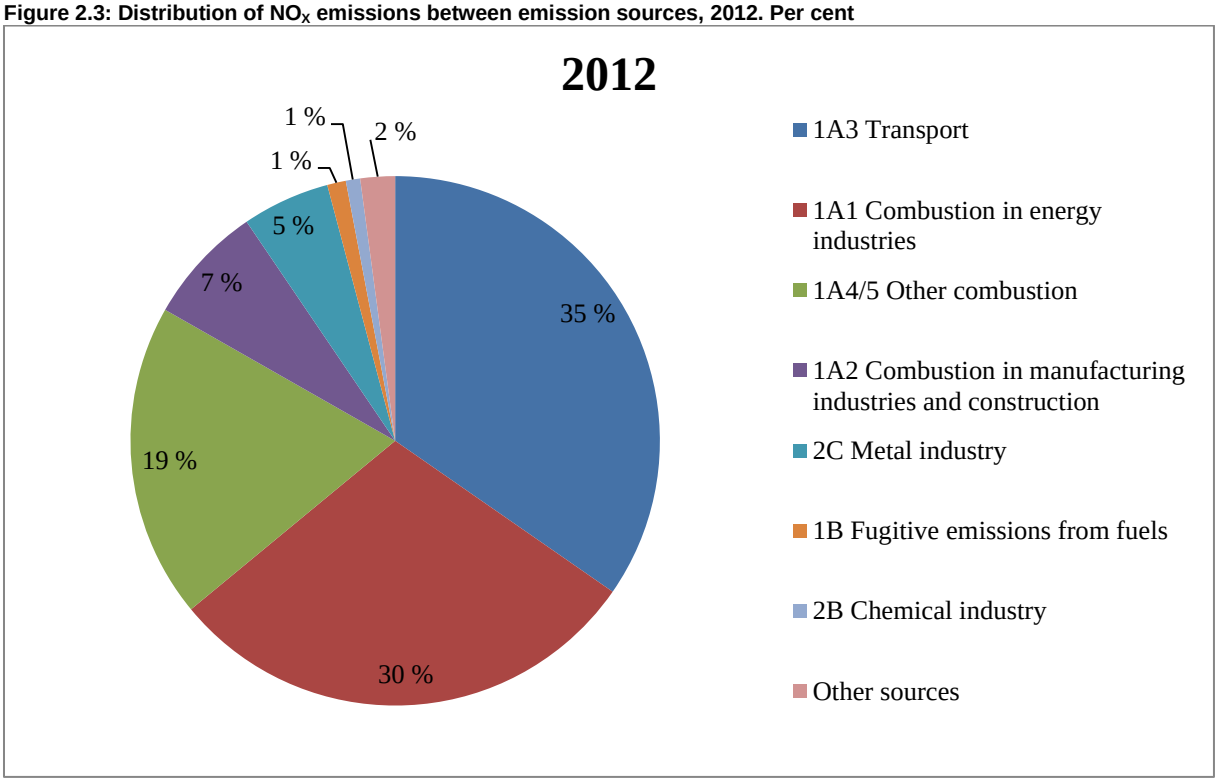


Figure 2.3: Distribution of NO_x emissions between emission sources, 2012. Per cent



The second and third largest sources of emissions of NOx in 2012 were combustion in energy industries such as public electricity and heat production and petroleum refining, 30 per cent, and other combustion, such as national fishing and off-road vehicles and other machinery in agriculture, forestry and fishing, 19 per cent. There has been a steady increase in emissions from the manufacture of solid fuels and other energy industries, with an incrase of 91 per cent from 1990 to 2012. National fishing is the largest source of emissions within Other combustion. Emissions from national fishing has deceased modestly since 1990, with 7 per cent.

2.1.3 SO_2

The SO_2 emissions in Norway in 2012 have been reduced by 68 per cent since 1990. This has been achieved by pollution control, the closure of pollution-generating businesses and a reduced consumption of petroleum products.

Emissions in the metal industry were the largest source of emissions in 2012 with 45 per cent of total emissions. Emissions from this sector have been reduced by 56 per cent since 1990, primarily due to reductions in the ferroalloys production. Nonetheless, the production of ferroalloys remains a significant source of emissions within this category, being responsible for 75 per cent of emissions from the metal industry.

Transport constituted 10 per cent of total emissions of SO_2 in 2012. The total reduction from transport is 78 per cent from 1990, which is mainly due to less sulphur in the fuels. Most of the reduction took place at the beginning of the period, and emissions from all subcategories have been reduced. Notably, there are currently only significant emissions from national navigation (shipping) in this category.

Figure 2.4: Trends in SO_2 emissions, 1990-2012. 1000 tonnes

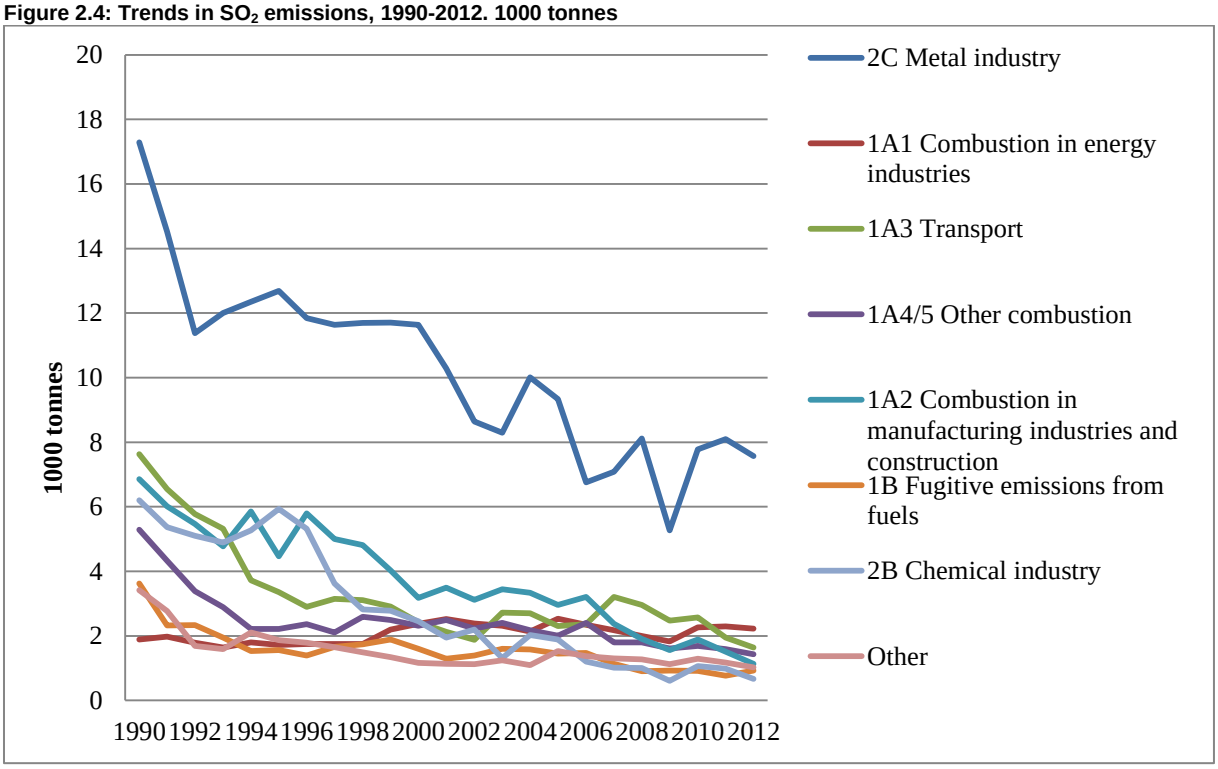
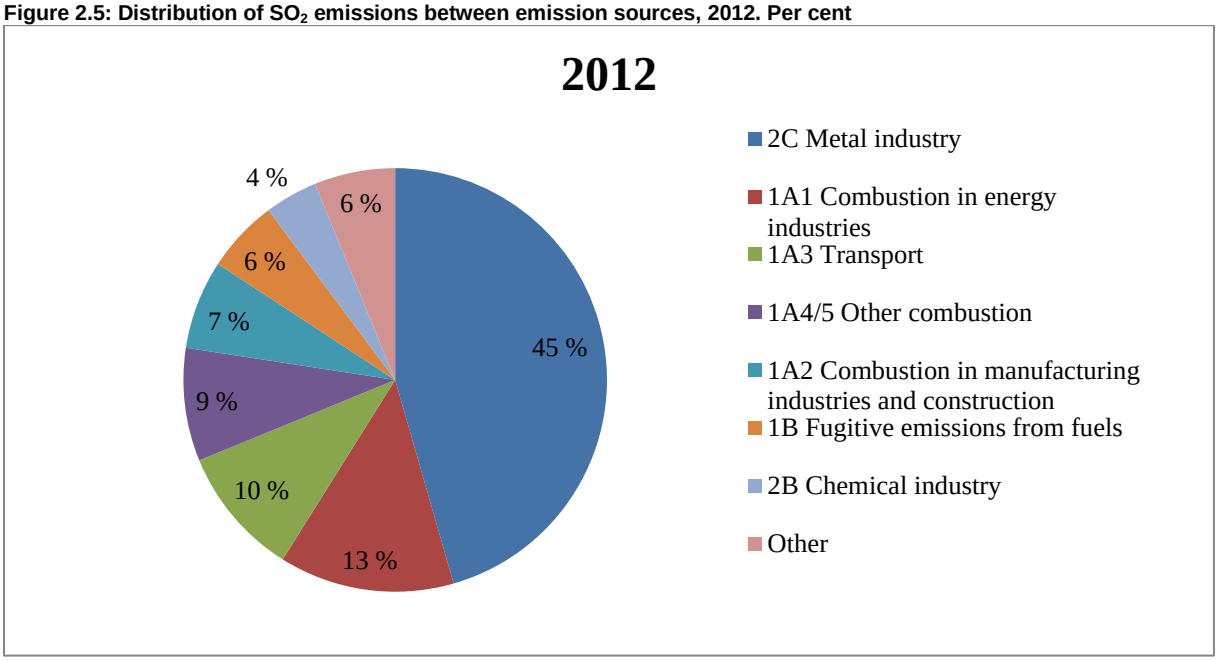


Figure 2.5: Distribution of SO_2 emissions between emission sources, 2012. Per cent



Emissions from combustions in manufacturing industries and construction has decreased by 84 per cent since 1990, whilst emissions from chemical industries, including carbide production, have decreased with 89 per cent. The reduction is a result of lower production and closures of two plants. In 2012, these two categories contributed with 7 and 4 per cent of SO_2 emissions, respectively.

2.1.4 NH_3

The Norwegian emissions of NH_3 increased with about 10,7 per cent from 1990 to 2012. The most important reasons were higher emissions from agriculture and higher emissions from private cars fitted with three-way catalytic convertors. One important reason to the increased

emissions from agriculture are higher protein content in cattle fodder, which gives higher nitrogen content in the cattle manure. From 2008 to 2011, the total NH_3 emissions have had a slight downward trend. From 2011 to 2012, the emissions increased with one per cent.

Figure 2.6: Trends in NH_3 emissions, 1990-2012. 1000 tonnes

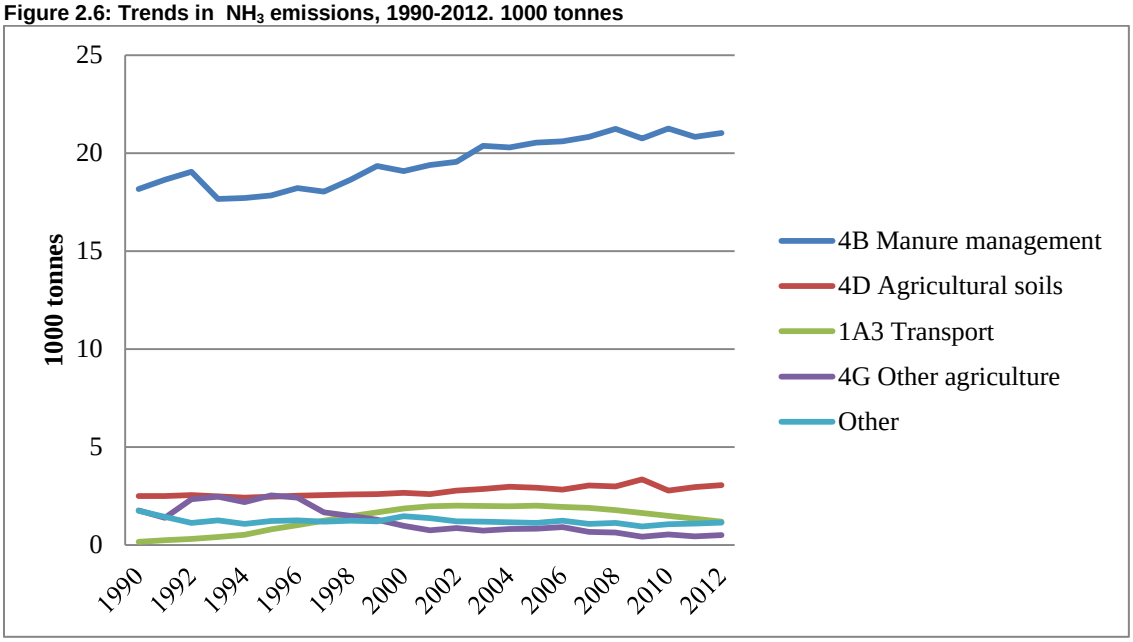
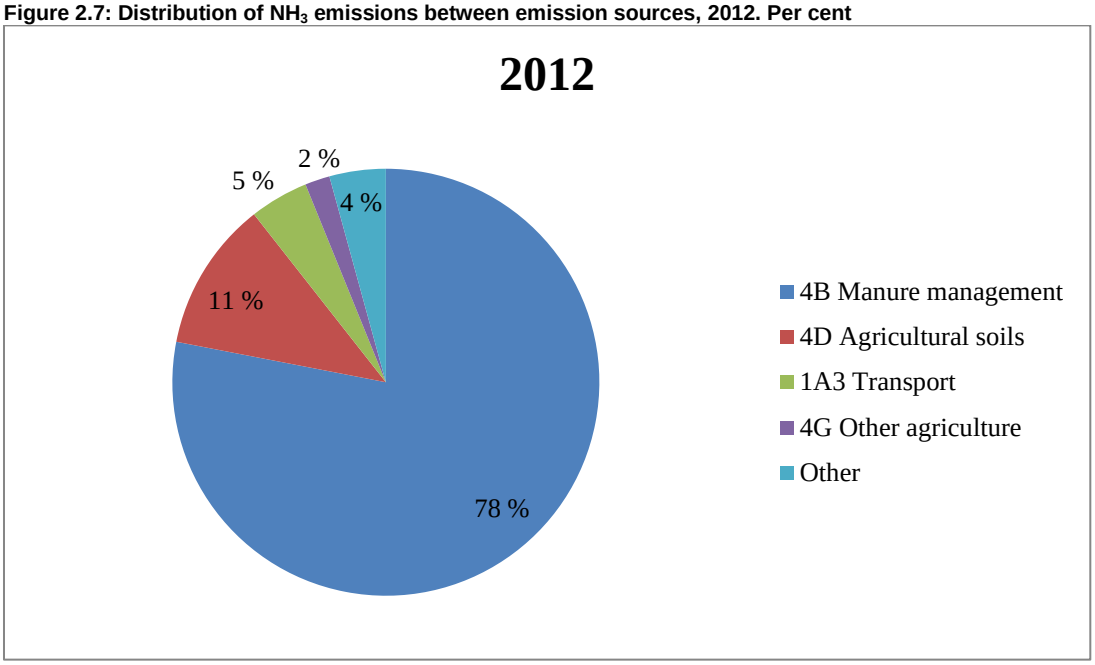


Figure 2.7: Distribution of NH_3 emissions between emission sources, 2012. Per cent



According to the Gothenburg Protocol, ammonia emissions are not to exceed 23 000 tonnes per year. In 2012, NH_3 emissions totalled 26 900 tonnes, which is 17 per cent above the ceiling level. Agriculture is the source of 91 per cent of the ammonia emissions in Norway; and 78 per cent of the total Norwegian emissions of NH_3 come from manure management. Within this category, cattle is the most important source of emissions, with dairy cattle and non-dairy cattle representing respectively 30 per cent and 25 per cent of emissions from this category. Emissions from dairy cattle have decreased with 10 per cent since 1990, mainly due to a reduction in the population. Emissions from non-dairy cattle have increased with 32 per cent since 1990, in spite of a population reduction. The main reasons for the increase in

emissions from non-dairy cattle are an increase in the ammonium nitrogen production due to increased nitrogen content in fodder, and that a bigger share of the manure are spread on meadows and spread in springtime, which both results in higher nitrogen losses as NH_3.

2.1.5 NMVOC

The emissions of NMVOC have been more than halved since 1990, and since the peak in 2001, emissions are down by two thirds. Loading of crude oil offshore was the main reason for the increase in emissions from 1990 to 2001. Measures to prevent these emissions have resulted in a decrease of 83 per cent from 2001 to 2012. Total emissions are now well below the target level in the Gothenburg Protocol. Fugitive emissions from fuels represent 34 per cent of total emissions of NMVOC in 2012.

One third of the emissions of NMVOC in 2012 was caused by product use, the most important subcategories being other product use, 44 per cent, and domestic solvent use including fungicides, 30 per cent of emissions withing this category. The category "Other combustion" is responsible for 17 per cent of total emissions of NMVOC in 2012. The two most significant sources of emissions are residential; household and gardening, and residential; stationary plants. These two subcategories are responsible for 87 per cent of emissions within this category. Emissions from household and gardening have remained stable since 1990 with a modest increase of 5 per cent, whilst there has been a more substantial increase in emissions from residential, stationary plants from 1990 to 2012 by 29 per cent.

NMVOC emissions from transport have decreased by per cent from 1990 to 2012, mainly due to reductions in emissions from passenger cars and gasoline evaporation. Stricter emission standards for petrol passenger cars were implemented in 1989, and these have led to reduced emissions. In addition, the increased share of diesel cars within the vehicle fleet has strengthened the downwards trend.

Figure 2.8: Trends in NMVOC emissions, 1990-2012. 1000 tonnes

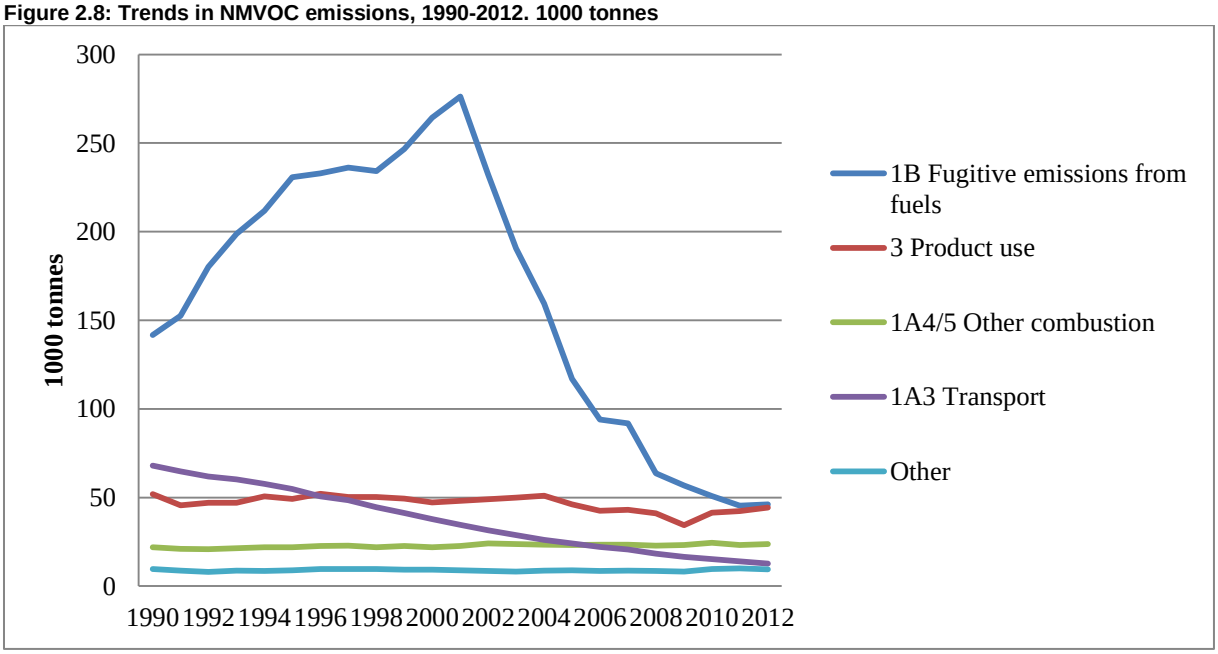
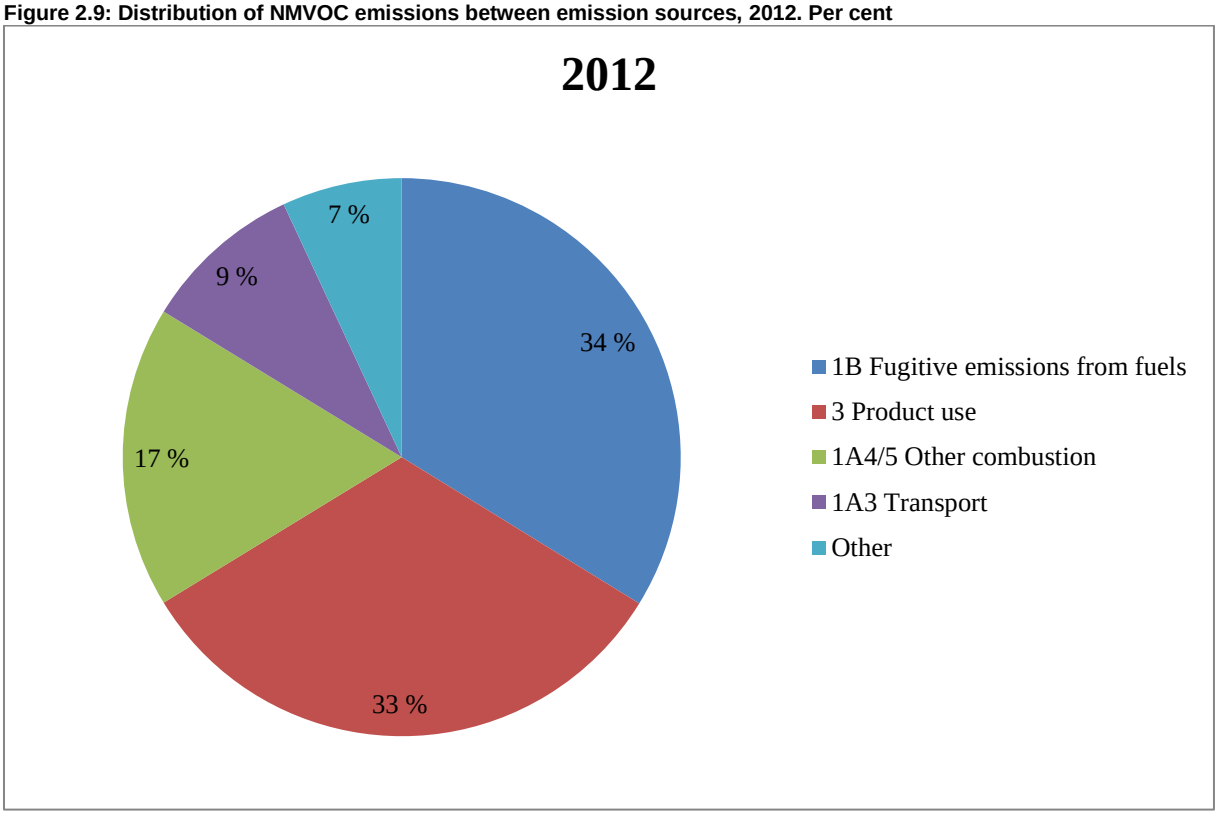


Figure 2.9: Distribution of NMVOC emissions between emission sources, 2012. Per cent



2.2 CO

Emissions from carbon monoxide, CO, have been reduced by 60 per cent since 1990. This is mainly due to reductions in emissions from transport, which have been reduced by 84 per cent since 1990. This is primarily due to reductions in emissions from passenger cars, which are reduced by 87 per cent since 1990 due to stricter emission standards. Emissions from light duty vehicles are also significantly reduced (89 per cent reduction from 1990 to 2012) albeit from a lower absolute level. Emissions from light duty vehicles were 11 per cent of emissions from passenger cars in 2012.

Emissions from the category Other combustion are primarily from the NFR category Residential stationary plants) (71 per cent) and residential; household and gardening (mobile) (22 per cent). Emissions from residential; stationary plants are mainly due to emissions from wood combustion for heating purposes. These emissions were at a peak in 2002 but have since then been reduced and were in 2012 13 per cent lower than in 1990. Emissions from residential; household and gardening (mobile) have remained stable since 1990.

Figure 2.10: Trends in CO emissions, 1990-2012. 1000 tonnes

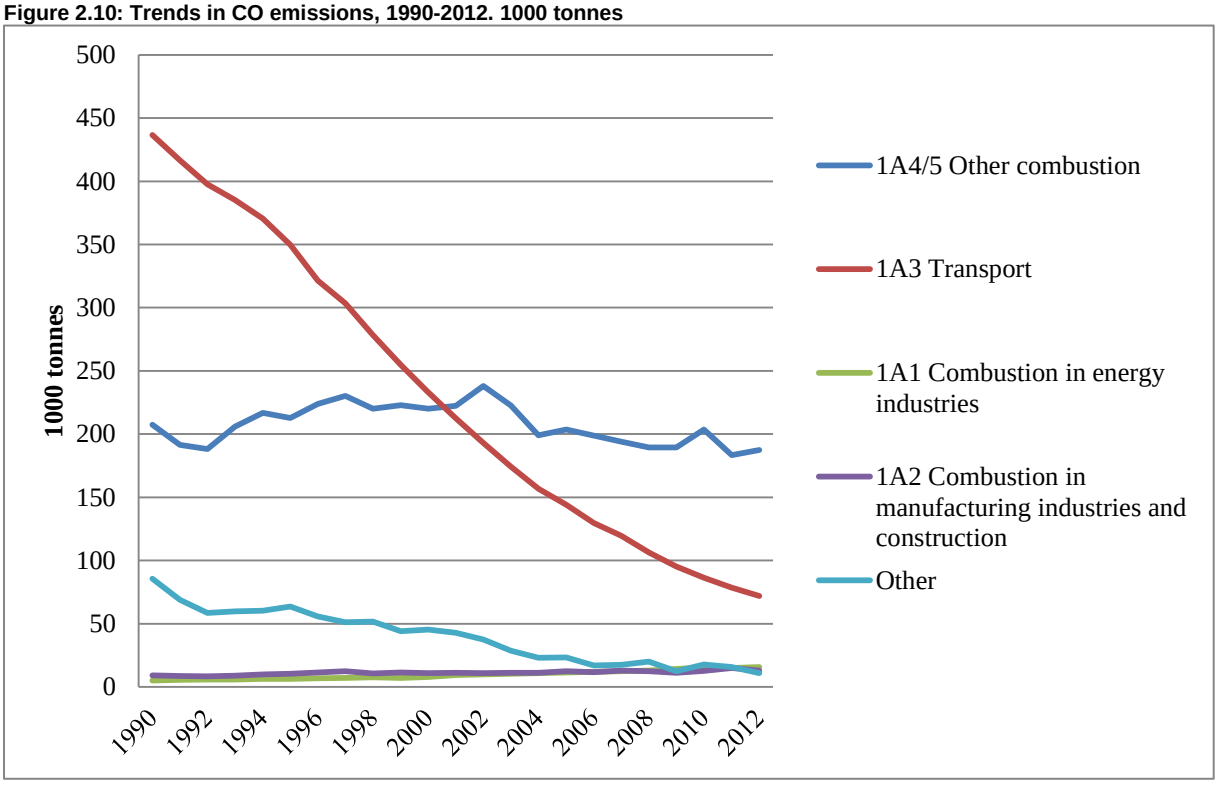
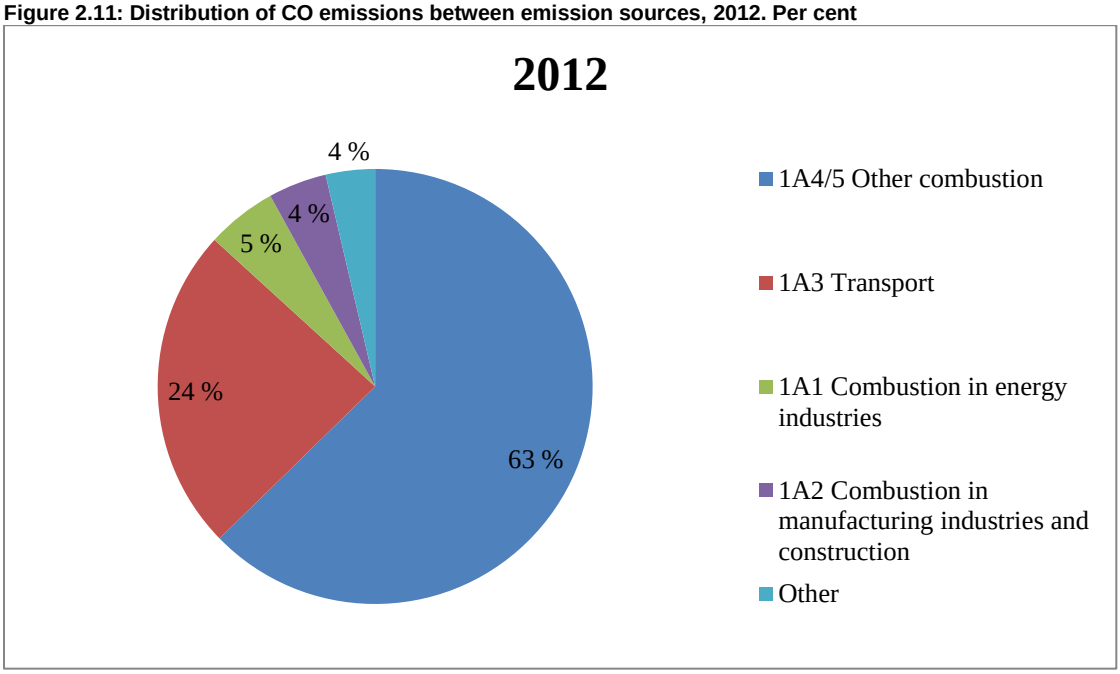


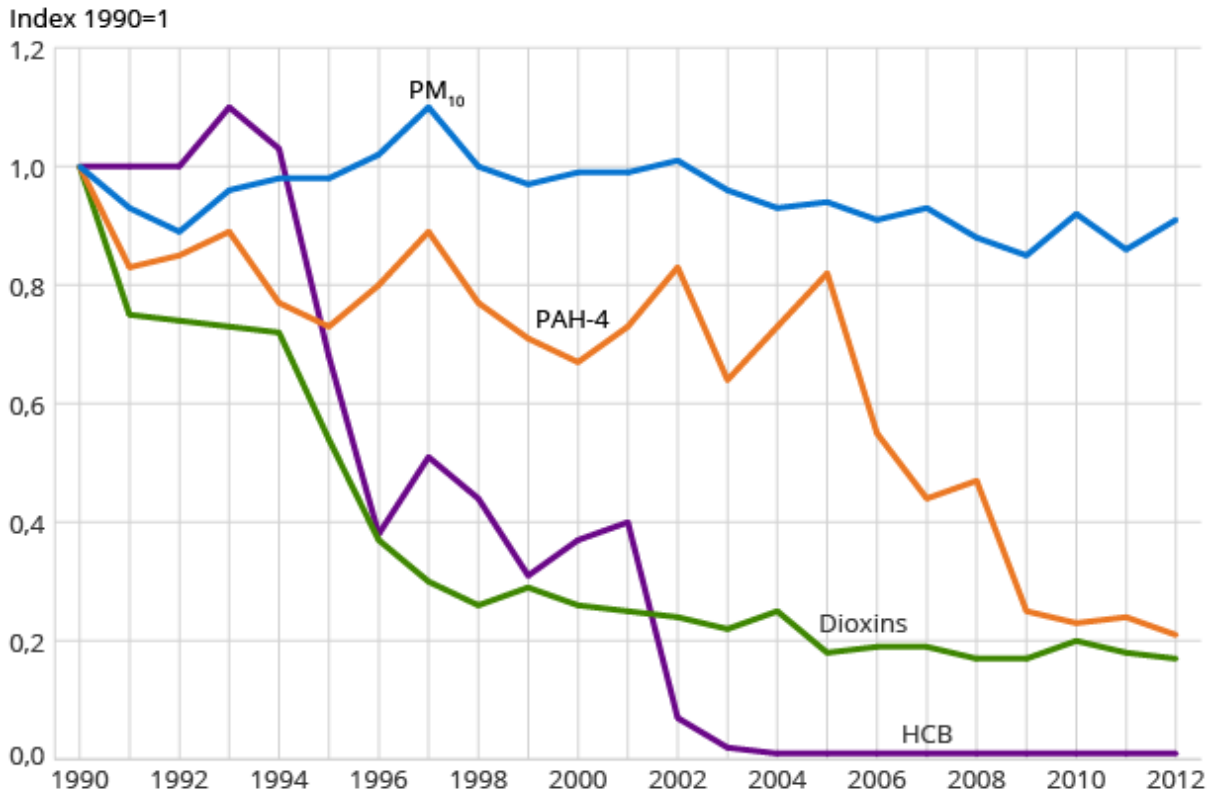
Figure 2.11: Distribution of CO emissions between emission sources, 2012. Per cent



2.3 PM, POPs and heavy metals

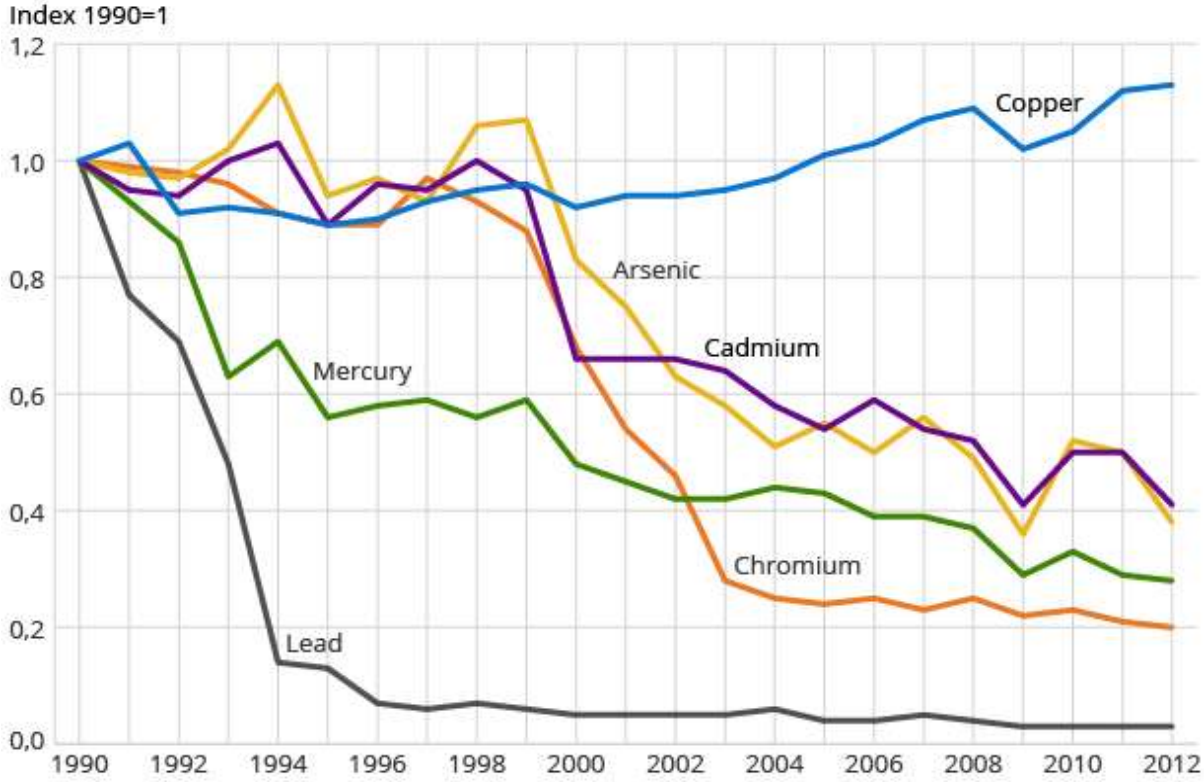
The emissions of most heavy metals, PAH and dioxins to air decreased from 2011 to 2012. The decrease was due to reduced activity in some areas of manufacturing, especially within the pulp and paper industry, metal industry and chemical industry. In addition, a fluctuating content of contaminants in raw materials and reducing agents used in metal production leads to interannual variations in emissions. The decrease is a contiunation of the trend seen in previous years.

Figure 2.12: Trends in emissions for PAH-4, PM10, dioxins and HCB. 1990-2012.



Source: Emission inventory from Statistics Norway and the Norwegian Environment Agency.

Figure 2.13: Trends in emissions for hazardous substances. 1990-2012.



Source: Emission inventory from Statistics Norway and the Norwegian Environment Agency.

The emissions to air of several hazardous substances including PAHs (polycyclic aromatic hydrocarbons) have been considerably reduced since 1990. The cause of the decrease since 1990 is primarily reduced emissions within manufacturing and mining. Cleaning measures, changes in production procedures and lower activity in some industries have all resulted in reduced emissions. Norway has a national target to reduce emissions compared with the emission levels in 1995. Internationally, we have an obligation to reduce emissions of selected hazardous substances compared to the level of emissions in 1990.

2.3.1 PM_{10}

Emissions of particulate matter (PM_{10}) were 45 900 tonnes in 2011, which is a 6 per cent increase from 2011. The most important source of emissions is residential plants, with 53 per cent of the emissions.The emissions from this source are mainly due to wood burning, which was responsible for approximately fifty per cent, or about 23 000 tonnes, of the emissions of particulate matter (PM_{10}) in 2012. The wood consumption increased by 5 per cent from 2011 to 2012. At the same time, the calculated emissions of particulate matter from this source increased by 4 per cent. This is due to a higher share of wood stoves with new technology.

Process emissions from manufacturing and mining amounted to 9 700 tonnes, or 13 per cent form the mineral industy and 7 per cent from the metal industry, of the emissions of particulate matter in 2011. Within the mineral industry, 78 per cent of emissions stem from sources labeled other mineral products. Emissions from these sources have increased by 60 per cent from 2011 to 2012, this is mainly from sandpit and rock-crushing plants. The second most important source of emissions within this category, construction and demolition, had a slight increase since 1992 and were in 2012 22 per cent higher than in 1990.

Motorized equipment and road dust/tyre wear were responsible for 7 and 4 per cent of the emissions of PM_{10} respectively.

Figure 2.14: Trends in PM_{10} emissions, 1990-2012. 1000 tonnes

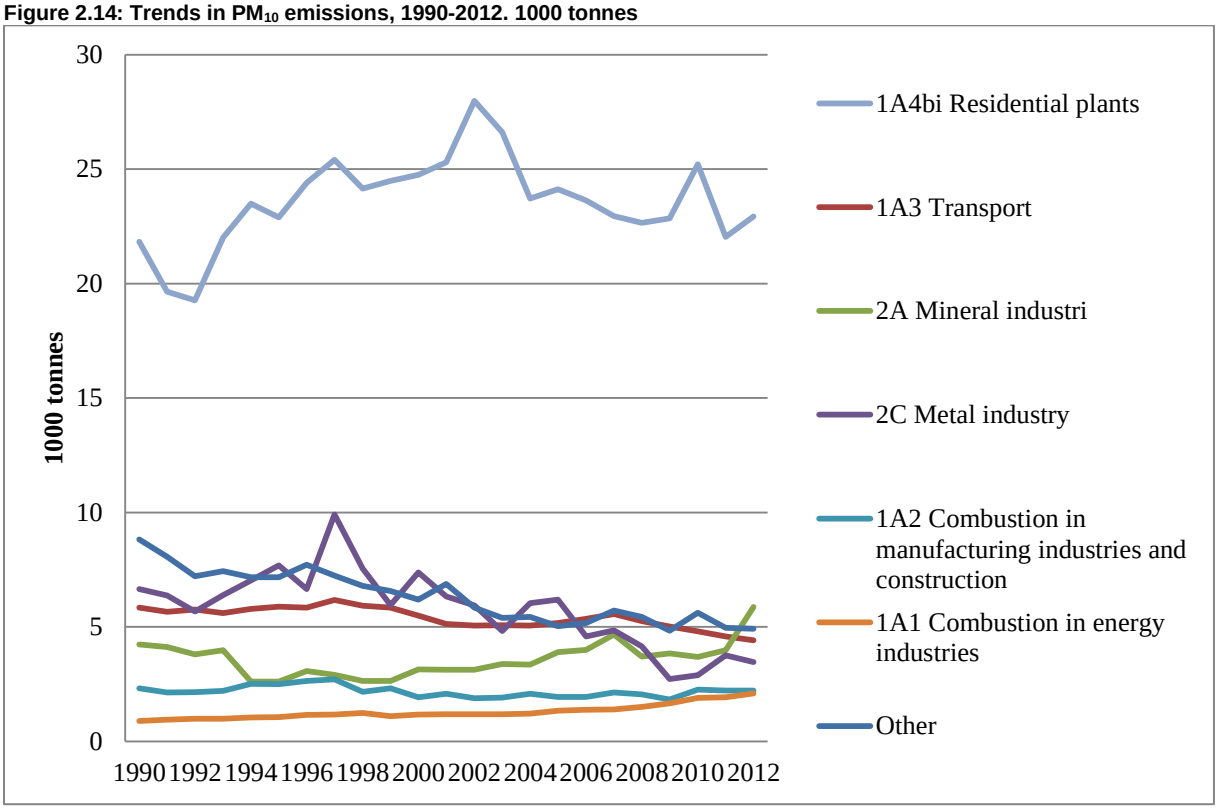
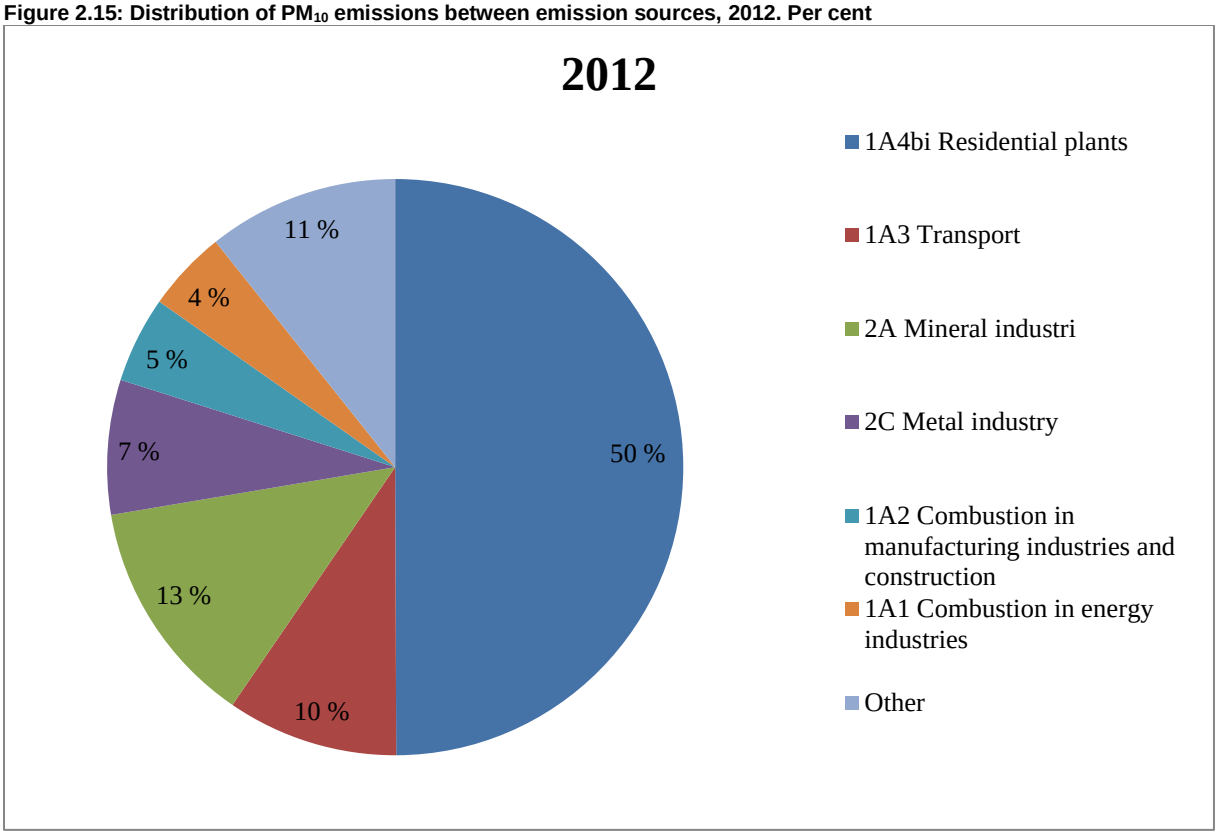


Figure 2.15: Distribution of PM_{10} emissions between emission sources, 2012. Per cent



2.3.2 Dioxins

In 2012, 22 grams of dioxins were emitted to air. Since 2011, emissions of dioxin have

decreased by 4 per cent. The emissions have been reduced by more than 80 per cent since 1990. A large proportion of this reduction is due to the closure of industrial plants and mines. In addition, emissions from energy supply were reduced by 94 per cent from 1990 to 2012 due to the introduction of cleaning measures at waste incineration plants. Since 2005, the emissions have been relatively stable. The most important emission source in 2012 was wood-burning in private households, which contributed with 36 per cent of the total dioxin emissions. Most emissions, 46 per cent, comes from the category other combustion which also incorporates wood-burning. The second largest source of dioxines within this category was National fishing with 19 per cent. Emissions from this source have remained more or less stable since 1990.

Emissions from combustion in energy industries are responsible for 12 per cent of total emissions of dioxins. There has been a significan decrease in emissions from public electricity and heat production, emissions in 2012 were 94 per cent lower than in 1990. Emissions from manufacture of solid fuels and other energy industries became the largest source of emissions within this category in 2004 and has remained so since, in 2012 this source was responsible for 69 per cent of dioxide emissions from combustion in energy industries. Emissions from manufacture of solid fuels and other energy industries have increased by 176 per cent since 1990.

Transport was responsible for 12 per cent of total emissions in 2012. National navigation (shipping) is by far the most significant source of emissions within this category, representing 86 per cent of the transport emissions. The emissions have been reduced after a peak in 1999 and are now 1 per cent above the level in 1990. Emissions from passenger cars, the other main source of emissions within this category in 1990, declined rapidly from 1990 to 1994 and further to 1996, and were in 2012 91 per cent below emissions in 1990, approximately the same absolute level of emissions since 1996.

Process emissions from metal production accounted 7 per cent of the total emissions of dioxins. Emissions from other waste has remained more or less stable since 1990, fluctuating somewhere between 2 and 2,6 g most years. Emissions had a peak in 2010 but have in the years since returned to the range previuosly experienced in the period.

Figure 2.16: Trends in dioxin emissions, 1990-2012. grams

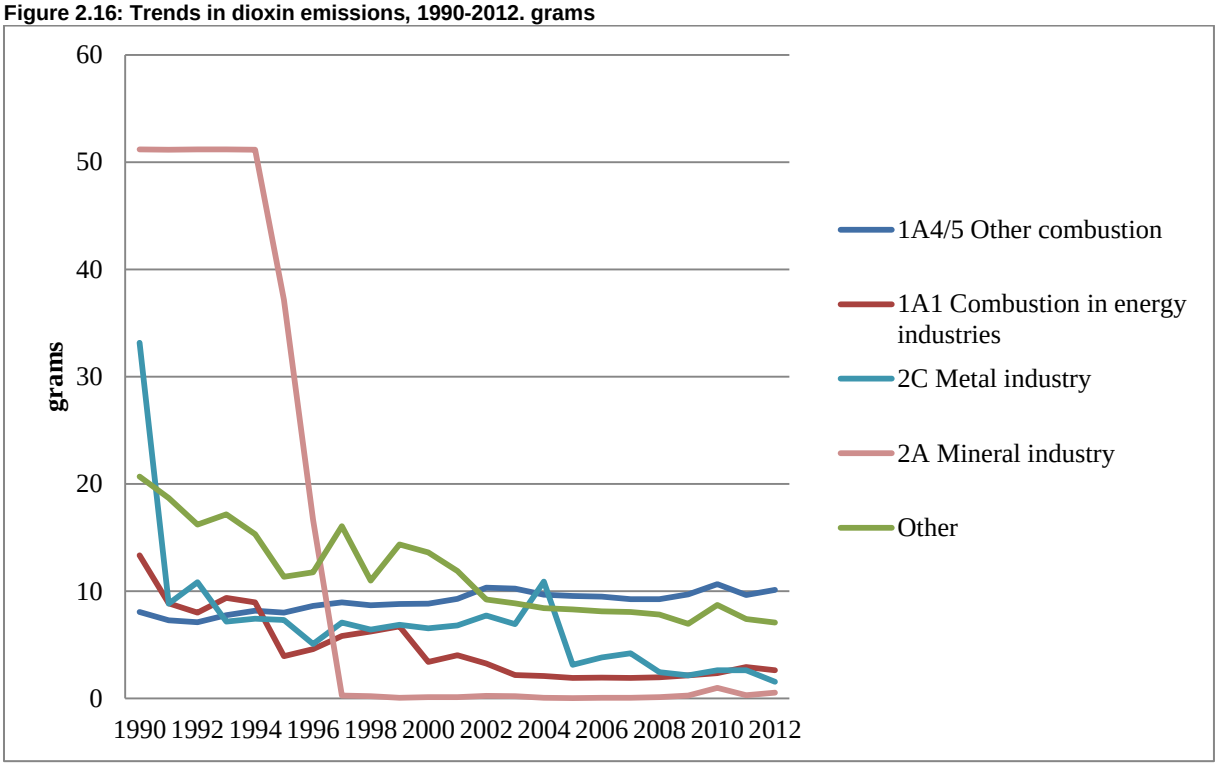
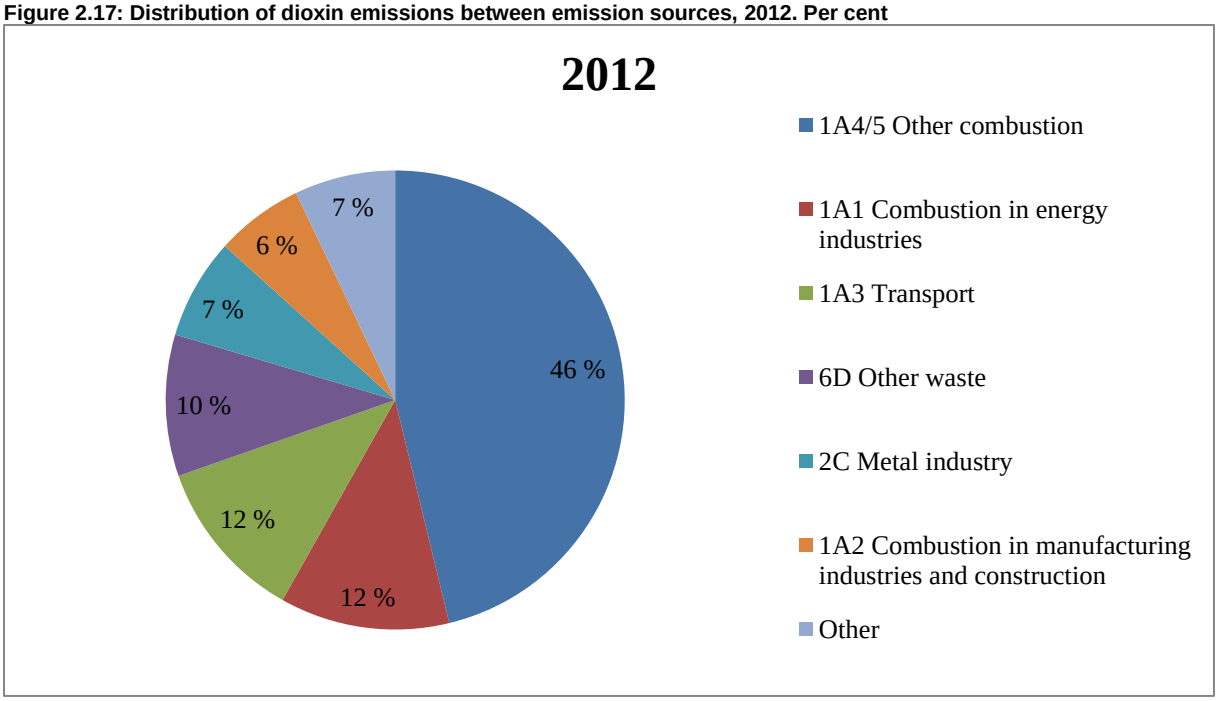


Figure 2.17: Distribution of dioxin emissions between emission sources, 2012. Per cent



2.3.3 PAH-4

Process emissions in aluminium production is the most dominant source for PAH-4 emissions, and contributed with 50 per cent of the total PAH-4 emissions to air in 2012. The figures for 1990 and 2011 were 84 and 58 per cent respectively. The PAH-4 emissions decreased primarily because of the discontinuation of Soederberg technology in the aluminium production. Emissions from aluminium production has been reduced by 87 per cent since 1990, yet aluminium production is still responsible for 94 per cent of emissions

from this category.

Wood-burning is the second most important source of emissions and contributed to 24 per cent of the emissions in 2012, compared with 7 and 21 per cent in 1990 and 2011 respectively. This is by far the most significant source of emissions within the category Other combustion. Emissions from residential; stationary plants have been reduced by 32 per cent since 1990, after a period with relatively higher emissions from 1996 to 2002.

Road traffic contributed to 15 per cent of the emissions in 2012. This includes both exhaust and tyre and brake wear. There is a general trend with increasing emissions from transport, emissions from passenger cars (without tyre and brake wear) have increased by 37 per cent since 1990, emissions from light duty vehicles have increased by 208 per cent whilst emissions from heavy duty vehicles have increased by 19 per cent.

Figure 2.18: Trends in PAH-4 emissions, 1990-2012. Tonnes

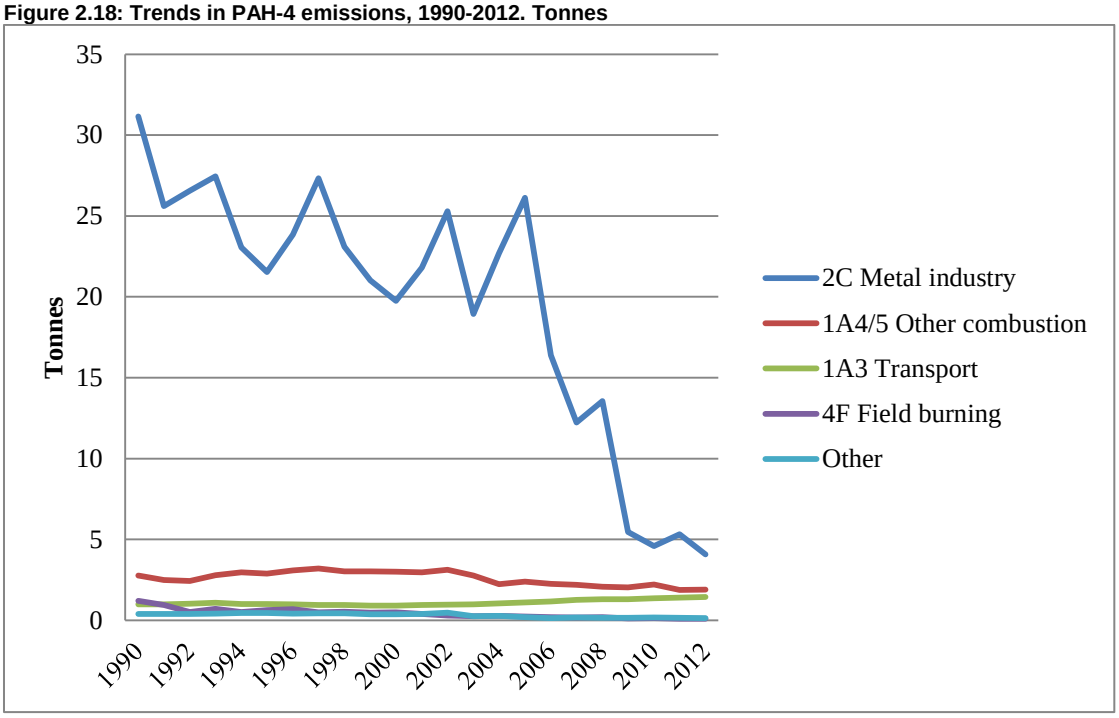
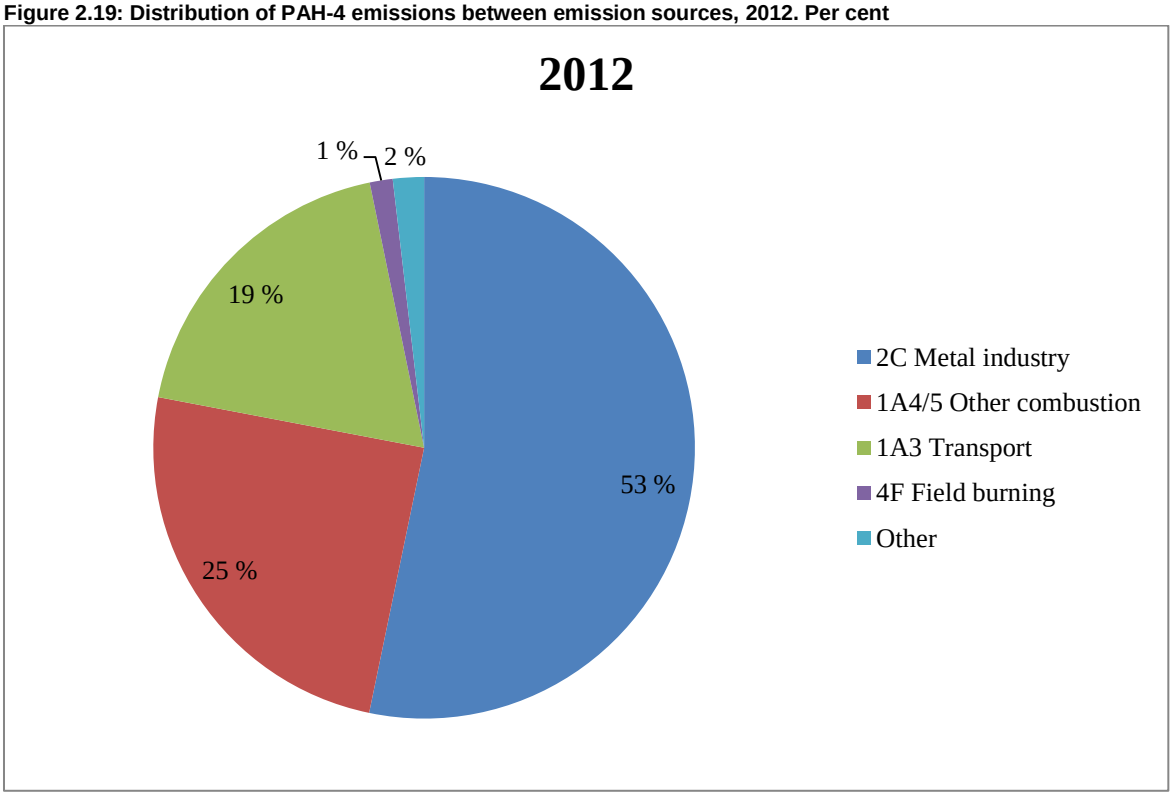


Figure 2.19: Distribution of PAH-4 emissions between emission sources, 2012. Per cent



2.3.4 HCB

HCB emissions were calculated for the first time for the 2014 submission. Estimated total emissions in Norway of HCB in 2012 were 1 300 grams. Emission of HCB has decreased by more than 99 per cent in the period 1990-2012 mainly due to the closure of magnesium production. In 1990, metal industry, where magnesium production is included, emitted 123 kg HCB, which constituted almost 99 per cent of the total.

The most important source for emissions of HCB in 2012 was road transport, which was responsible for 52 per cent of total emissions. Emissions from road transport have increased significantly from 1990-2012, mainly due to increased traffic activity. For instance, HCB emissions from passenger cars were more than twelve times higher in 2012 than in 1990.

Figure 2.20: Trends in total HCB emissions, 1990-2012. kilogram

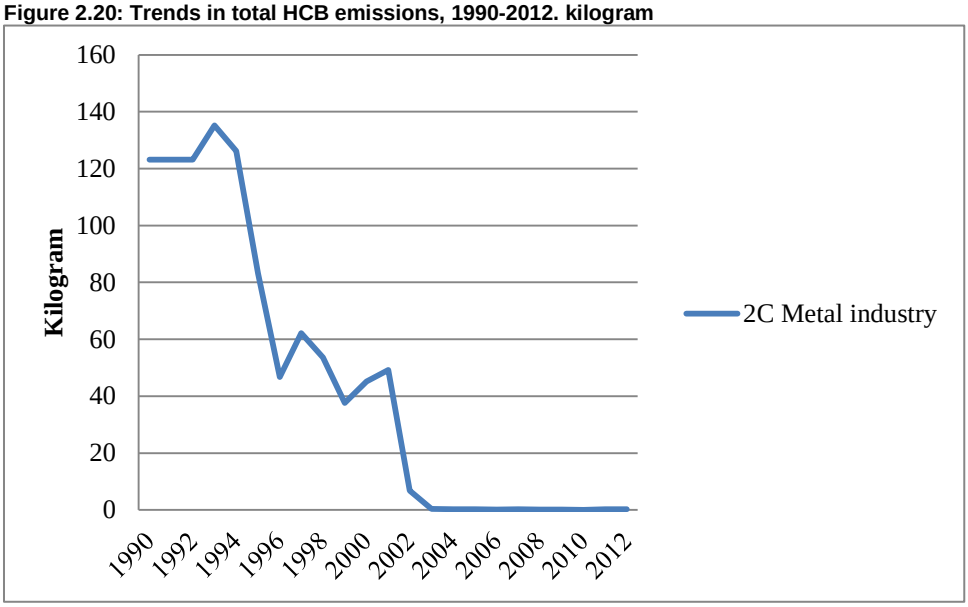
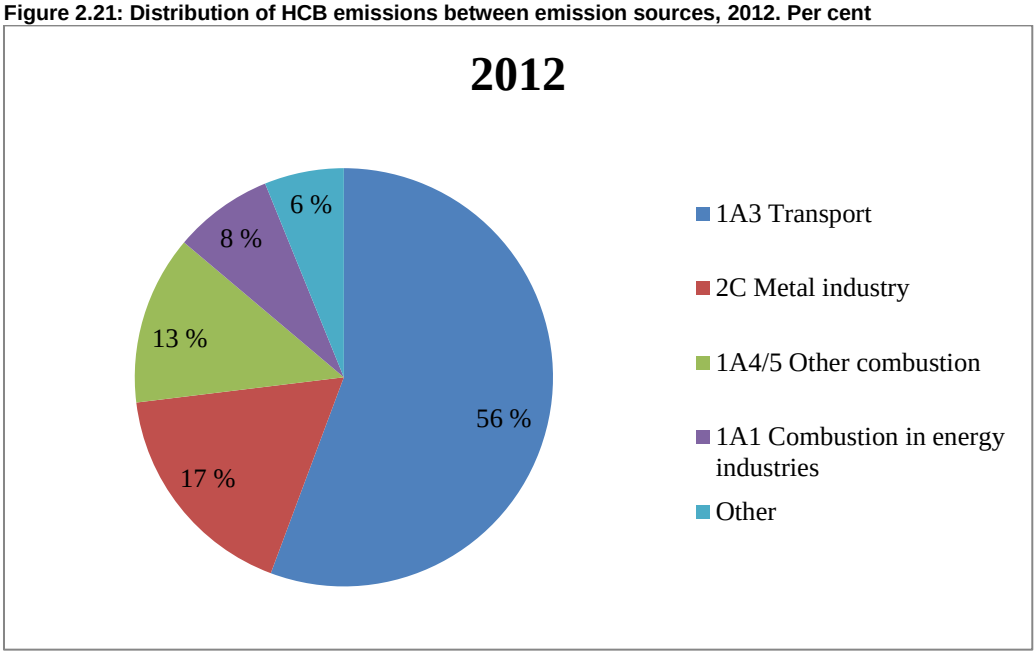


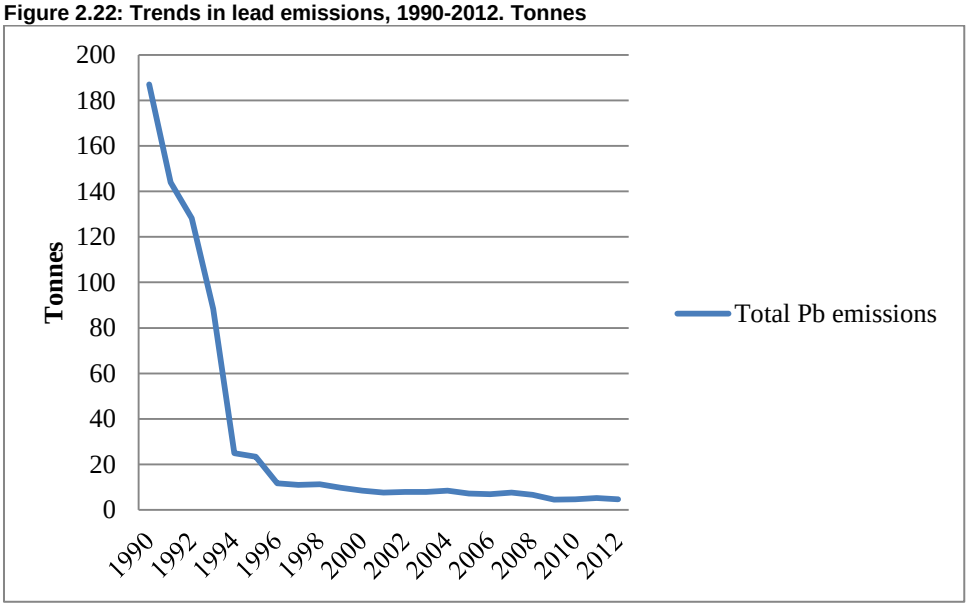
Figure 2.21: Distribution of HCB emissions between emission sources, 2012. Per cent



2.3.5 Lead

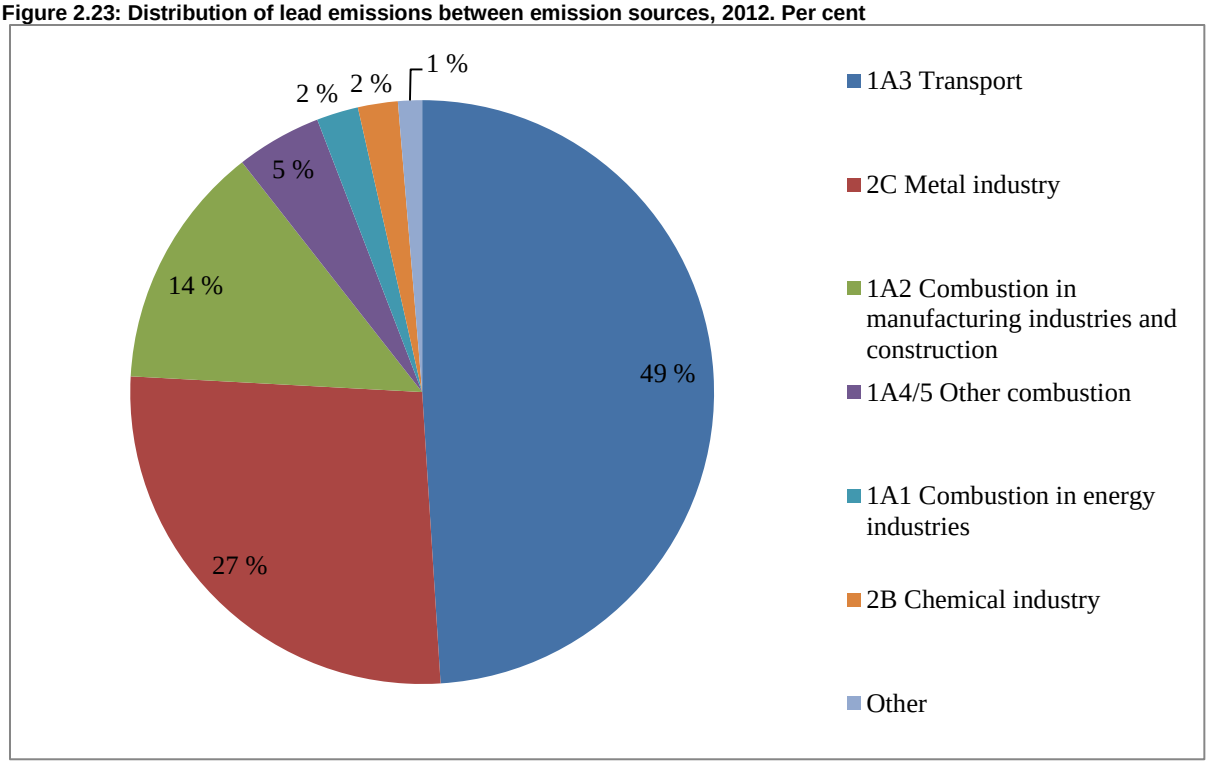
Emissions to air from lead totalled 4.7 tonnes in 2012. This is a reduction of 97 per cent from 1990. Regulations on lead content in fuels is the main reason for this reduction. Emissions from passenger cars constituted 82 per cent of the total in 1990, and only 3 per cent in 2012.

Figure 2.22: Trends in lead emissions, 1990-2012. Tonnes



Emissions of lead have been relatively constant in recent years. Transport is still a dominant source of lead emissions, but now brake wear is the most important source within the transport sector. Brake wear was responsible for 37 per cent of lead emissions to air in 2012. Process emissions from metal industry and combustion activities within manufacturing industries and construction emitted 27 and 14 per cent of the total in 2012, respectively.

Figure 2.23: Distribution of lead emissions between emission sources, 2012. Per cent



2.3.6 Cadmium

Emissions to air of cadmium totalled 0.5 tonnes in 2012. This is a reduction of 59 per cent from 1990. The main reason for this is reduced process emissions from production of iron, steel and ferroalloys due to emission reduction efforts and the closing down of production plants. These sources were responsible for 5 per cent of cadmium emissions in 2012,

compared to 26 per cent in 1990.

Wood-burning in private households and burning of refuse wood and waste liquor in the wood processing industry are currently the most important sources of emissions of cadmium to air. In 2012, these sources contributed with 29 and 18 per cent of the total emissions, respectively.

Figure 2.24: Trends in cadmium emissions, 1990-2012. Tonnes

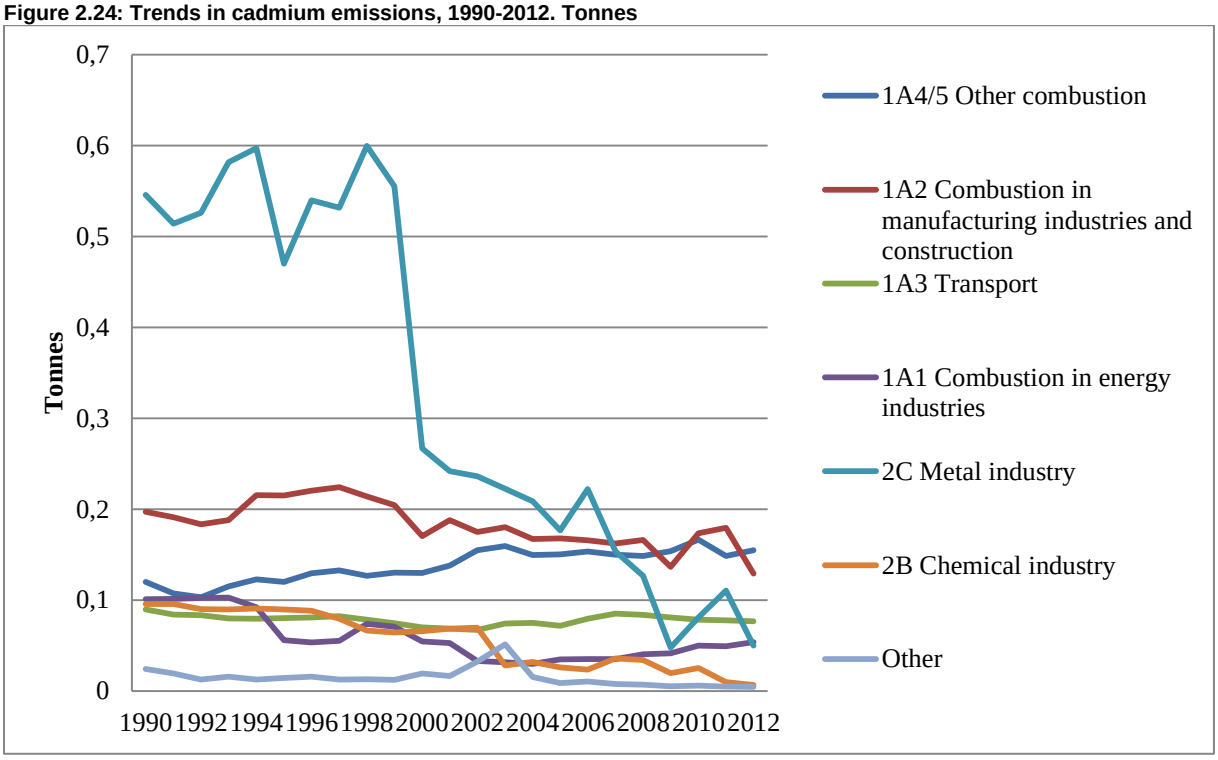
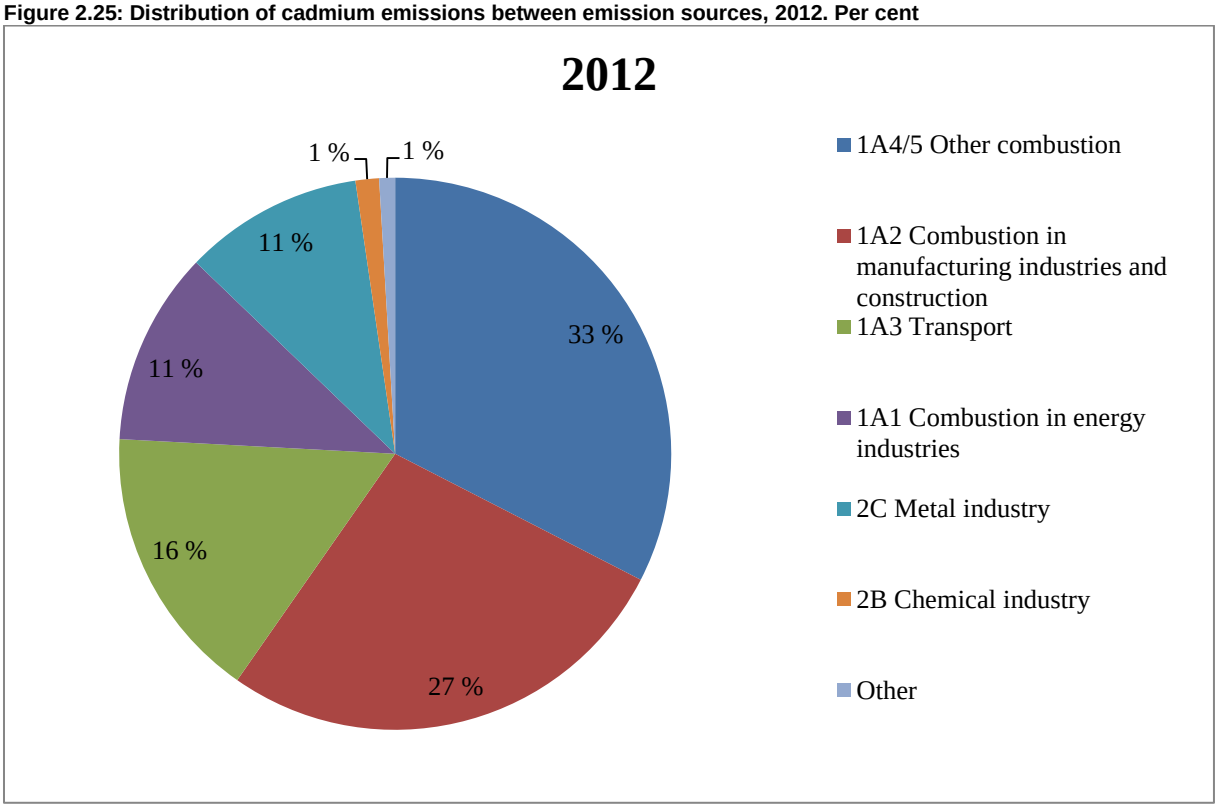


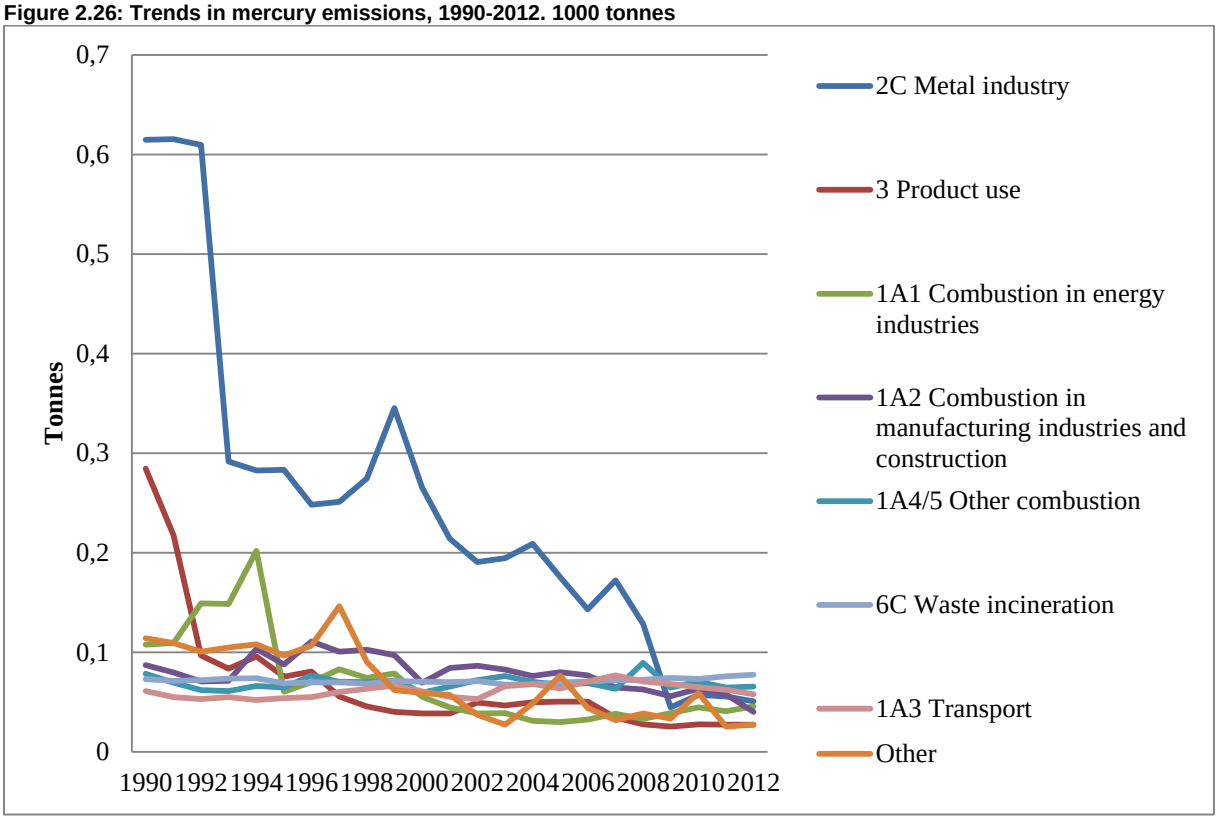
Figure 2.25: Distribution of cadmium emissions between emission sources, 2012. Per cent



2.3.7 Mercury

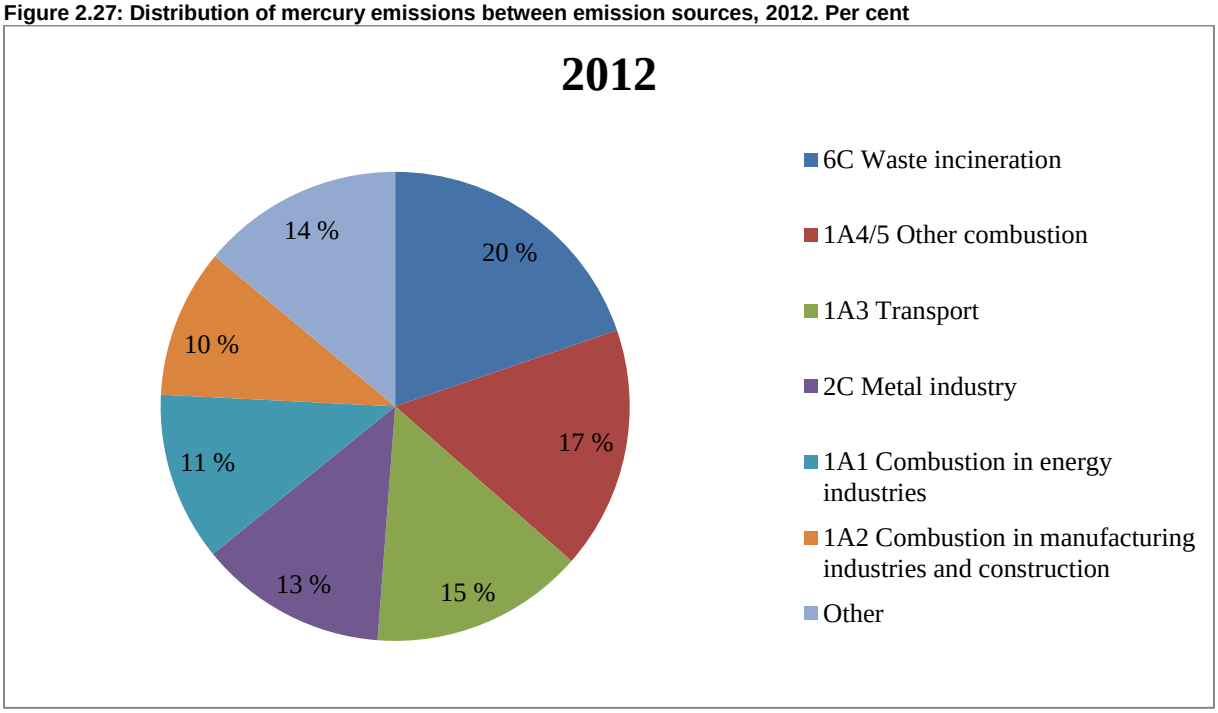
Emissions of mercury were 0.4 tonnes in 2012, which is a 72 per cent decrease since 1990. The decrease is most profound for process emissions within metal industry. This source contributed with 43 per cent of total mercury emissions in 1990, and has been reduced by 92 per cent since then.

Figure 2.26: Trends in mercury emissions, 1990-2012. 1000 tonnes



Mercury emissions comes from a wide range of sources. The most important source of mercury emissions in 2012 was waste incineration, in which cremations are included. The emissions from this source have been relatively stable in the time period 1990-2012.

Figure 2.27: Distribution of mercury emissions between emission sources, 2012. Per cent



2.3.8 Chromium, arsenic and copper

Emissions of chromium was 2.5 tonnes in 2012. The emissions have been relatively constant

in recent years. Combustion in the wood processing industry is the most dominant source of chromium emissions to air.

In 2012, 1.3 tonnes of arsenic were emitted to air, which is a reduction of 24 per cent from 2011. For the past few years, the variation in arsenic emissions has been due to varying arsenic content in raw materials and reducing agents used in metal production. The total arsenic emissions have been reduced by 62 per cent since 1990.

Emissions of copper were 29 tonnes in 2012. Copper emissions have increased by 13 per cent since 1990. Emissions from brake wear are the dominant source for emissions to air of copper.

3 ENERGY (NFR sector 1)

3.1 Overview

This chapter provides descriptions of methodologies employed to calculate emissions from the energy sector. The disposition of the chapter is following the NFR classifications of the emission sources. In section 3.2 emission estimations from energy combustion are described. This includes combustion emissions from energy industries, manufacturing industries and construction, transport and other combustion sources. Section 3.2 also includes memo items about international bunker fuels.

In section 3.3 a description is given for fugitive emissions from fuels. This includes fugitive emissions from coal mining and handling, and from oil and natural gas.

3.2 Energy combustion

NFR 1A
Last update: 10.02.2014

3.2.1 Overview

Combustion of fossil fuels and biomass leads to emissions of SO_2, NO_x, NMVOC, CO, particulate matter, heavy metals, PAH and dioxins. Small amounts of NH_3 can also be emitted.

Table 3.1 Energy combustion emissions as per cent of total emissions, 2012

Pollutant	Percent of emissions
SO_2	40
NO_X	93
NMVOC	32
CO	97
NH_3	5
PM_{10}	73

The emissions of SO_2, NMVOC and CO have been significantly reduced since 1990. The reduction of SO_2 emissions has taken place in al sectors due to reduced sulphur content in fuels. NMVOC and CO emissions are lower mainly due to reductions in emissions from petrol passenger cars. NH_3 emissions are caused by catalysts in petrol passenger cars. The emissions of NO_X and particles have not shown an dramatic development in the time period from 1990.

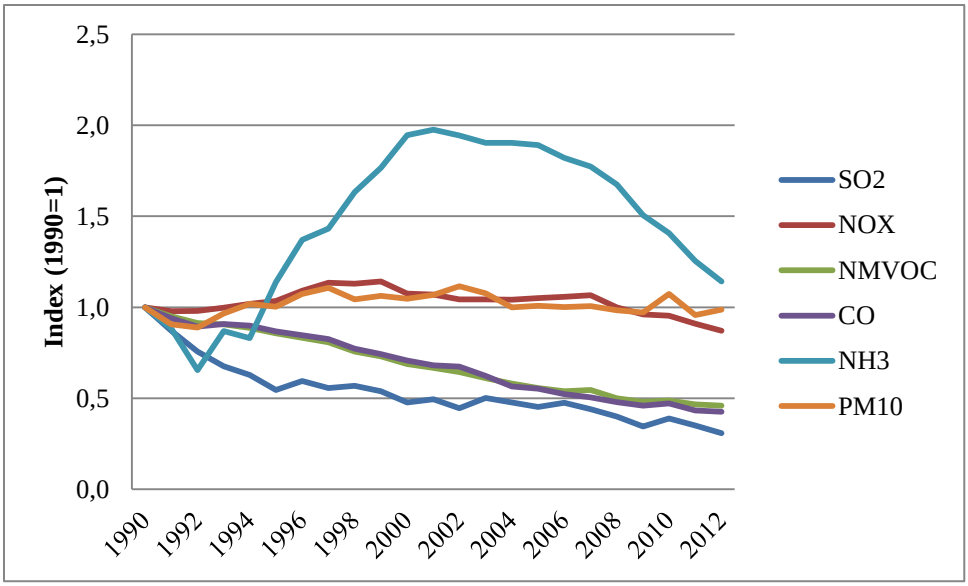


Figure 3.1. Trends for the emissions for most of the long-range transboundary air pollutants from energy combustion (1990 = 1).

Emissions from energy combustion include contributions from all sources addressed in the UNECE Guideline. Emissions from waste incineration at district heating plants are accounted for under the energy sector, as the energy is utilised. Emissions from flaring in the energy sectors are described in section 3.3 *Energy production*. Coal and coke used as reducing agents and gas used for production of ammonia (non-energy part) are accounted for under industrial processes. Flaring of natural gas and fuel gas in chemical industry is recorded in section 4.3.3. Other flaring outside the energy sectors is described in chapter 7 *Waste*. The same applies to emissions from accidental fires etc. Emissions from burning of crop residues and agricultural waste are accounted for in chapter 6 *Agriculture*. Emissions from tobacco are described in chapter 5 *Solvents and other product use*.

The main source for calculation of emissions from energy combustion is the energy balance, which annually is prepared by Statistics Norway. The data used in the emission calculations are at a much more disaggregated level than the published energy balance. Many different sources are utilised in the preparation of the energy balance. E.g., energy use in extraction of oil and gas, which constitutes an important part of Norwegian energy use, is reported from the Norwegian Petroleum Directorate. Other energy producers, such as oil refineries and district heating plants, also report their own energy use to Statistics Norway.

For different oil products, the total frame for annual use is given by Statistics Norway's statistics on deliveries of petroleum products. These statistics are also used in the estimation of use in different economic sectors, together with other available information. The distribution between sectors is of varying quality – e.g., in some cases projections of previous surveys are used in this process. For manufacturing industries, however, Statistics Norway's annual survey on all types of energy use, based on reports from plants responsible for approximately 96 per cent of the energy use in these sectors, combined with estimations for the remaining plants, provides figures of high quality.

3.2.1.1 Method

Emissions from energy combustion are estimated at the sectoral level in accordance with the IPCC sectoral approach Tier 2/Tier 3. Often total fuel consumption is better known than the

sectoral consumption.

The general method to estimate emissions from fuel combustion is multiplication of fuel consumption by source and sector by an appropriate emission factor. Exceptions are road and air transport where more detailed estimation models are used, involving additional activity data (see section 3.2.4.2 and 3.2.4.1 respectively). Fuel consumption figures are taken from the Norwegian energy balance. The mean theoretical energy content of fuels and their density are listed in table 3.2.

Table 3.2. Average energy content and density of fuels

Energy commodity	Theoretical energy content[1]	Density
Coal	28.1 GJ/tonne	..
Coal coke	28.5 GJ/tonne	..
Petrol coke	35.0 GJ/tonne	..
Crude oil	42.3 GJ/tonne = 36.0 GJ/m^3	0.85 tonne/m^3
Refinery gas	48.6 GJ/tonne	..
Natural gas (dry gas)[2]	35.5 GJ/1000 Sm^3	0.74 kg/Sm^3 (domestic use)
Natural gas (rich gas)[2]	40.3 GJ/1000 Sm^3	0.85 kg/Sm^3 (continental shelf)
Liquefied propane and butane (LPG)	46.1 GJ/tonne = 24.4 GJ/m^3	0.53 tonne/m^3
Fuel gas	50.0 GJ/tonne	..
Petrol	43.9 GJ/tonne = 32.5 GJ/m^3	0.74 tonne/m^3
Kerosene	43.1 GJ/tonne = 34.9 GJ/m^3	0.81 tonne/m^3
Diesel oil, gas oil and light fuel oil	43.1 GJ/tonne = 36.2 GJ/m^3	0.84 tonne/m^3
Heavy distillate	43.1 GJ/tonne = 37.9 GJ/m^3	0.88 tonne/m^3
Heavy fuel oil	40.6 GJ/tonne = 39.8 GJ/m^3	0.98 tonne/m^3
Methane	50.2 GJ/tonne	..
Wood	16.8 GJ/tonne = 8.4 GJ/solid m^3	0.5 tonne/solid m^3
Wood waste (dry wt)	16.25-18 GJ/tonne	..
Black liquor (dry wt)	7.2-9.2 GJ/tonne	..
Waste	10.5 GJ/tonne	..

[1] The theoretical energy content of a particular energy commodity may vary; Figures indicate mean values.

[2] Sm^3 = standard cubic metre (at 15 °C and 1 atmospheric pressure).

Source: Energy statistics, Statistics Norway.

However, for some major manufacturing plants (in particular offshore activities, refineries, gas terminals, cement industry, production of plastics, ammonia production), emissions of one or more compounds, reported to the Norwegian Environment Agency from the plants, are used instead of figures calculated as described above. In these cases, the energy consumption at the plants in question is subtracted from the total energy use before the general method is used to calculate the remaining emissions of the compound in question, in order to prevent double counting.

Reported figures are used for a relatively small number of plants, but as these contribute to a large share of the total energy use, a major part of the total emissions are based on such reported figures. For the source categories petroleum refining, manufacture of solid fuels and other energy industries and iron and steel, more than 90 per cent of the sector emissions are based on reported data from plants. The reports are from the mandatory reporting obligation that is a part of the plants' permits given by the authorities.

Figures on energy use are based on data reported from the plants to Statistics Norway. Some of the energy figures used to calculate reported emissions may deviate from the figures in Statistics Norway's energy balance. This is a general challenge when several data sources are available. However, as a part of the QC procedures for the energy statistics and the emission inventory there is a continuous evaluation of the cases where the deviations are significant,

and these cases only contribute very little to the overall uncertainty of the emission inventory.
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Four documentation reports have been published describing the methodologies used for road traffic (Bang *et al.* 1999), aviation (Finstad *et al.* 2002a) and navigation (Tornsjø 2001) and (Flugsrud *et al.* 2010).

3.2.1.2 Activity data

The annual energy balance, compiled by Statistics Norway, forms the framework for the calculation of emissions from energy use. However, a large part of the total emissions are based on reports from plants which use much energy, i.e. offshore activities and energy-intensive industries on shore. Such energy use is included in the energy balance, but is subtracted before the remaining emissions are calculated by the standard method of multiplying energy use by emission factors. Energy figures reported from the plants to Statistics Norway, which are used in the energy balance, sometimes deviate from the energy figures used to estimate reported emission figures, and this may cause inaccuracies in implied emission factors.

The energy balance surveys the flow of the different energy carriers within Norwegian territory. It includes energy carriers used as raw materials and reducing agents, but these are presented in a separate item and are not included in the data used to estimate emissions from combustion. Some emissions vary with the combustion technology; a distribution between different sources is thus required. Total use of the different oil products is based on the Norwegian sales statistics for petroleum products. For other energy carriers, the total use of each energy carrier is determined by summing up reported/estimated consumption in the different sectors. A short summary of the determination of amounts used of the main groups of energy carriers and the distribution between emission sources is given below.

Natural gas
Most of the combustion of natural gas is related to extraction of oil and gas on the Norwegian continental shelf. The amounts of gas combusted, distributed between gas turbines and flaring, are reported annually to Statistics Norway by the Norwegian Petroleum Directorate (NPD). These figures include natural gas combusted in gas turbines on the various oil and gas fields as well as on Norway’s four gas terminals on shore. Statistics Norway's annual survey on energy use in manufacturing industries and sales figures from distributors give the remainder. Some manufacturing industries use natural gas in direct-fired furnaces; the rest is burned in boilers and, in some cases, flared.

LPG and other gases
Consumption of LPG in manufacturing industries is reported by the plants to Statistics Norway in the annual survey on energy use. Figures on use of LPG in households are based on sales figures, collected annually from the oil companies. Use in agriculture and construction is based on non-annual surveys; the figure for agriculture is interpolated for years not included in surveys, whereas the figure for construction is adjusted annually, based on employment figures. Use of refinery gas is reported to Statistics Norway from the refineries. The distribution between the sources direct-fired furnaces, flaring and boilers is based on information collected from the refineries in the early 1990's. However, the total emissions from the refineries included in the inventory are equal to emissions reported from the plants and are regarded being of high quality.

At some industrial plants, excess gas from chemical and metallurgical industrial processes is burned, partly in direct-fired furnaces and partly in boilers. These amounts of gases are reported to Statistics Norway. Two ferroalloy plants sell excess gas (CO gas) to some other plants (one producer of ammonia, a district heating plant, iron and steel producers and mineral industry), where it is combusted for energy purposes. Amounts sold are annually reported to Statistics Norway. One sewage treatment plant utilizes biogas extracted at the plant, and reports quantities combusted (in turbines). By definition, no CO_2 emissions arise from bio gas, but other emissions are estimated by Statistics Norway, using the same emission factors as for combustion of natural gas in turbines.

Oil products

Total use of the different oil products is based on Statistics Norway's annual sales statistics for petroleum products. The data are generally considered reliable (with some reservations which are accounted for further down in this chapter), since all major oil companies selling oil products have interest in and report to these statistics[3]. The use of sales statistics provides a given total for the use of oil products, which the use in the different sectors must sum up to. This is not the case for the other energy carriers. The method used for oil products defines use as identical to sales; in practice, there will be annual changes in consumer stocks, which are not accounted for.

However, since the late 1990s the distribution in the sales statistics between different middle distillates has not been in accordance with the bottom-up estimated consumption of the products. In particular, the registered sales of light fuel oil have generally been too low, and it is known that some auto diesel also is used for heating. In order to balance the accounts for the different products, it has since 1998 been necessary to transfer some amounts between products instead of using the sales figures directly. The most important transfer is from auto diesel to light fuel oil, but in addition some auto diesel has also been transferred to heavy distillate.

Due to inaccuracies in the reporting of sales of marine gas oil from approximately 2005, there is also some uncertainty connected to the distribution between domestic and international sea transport for the latest years.

Stationary use takes place in boilers and, in some manufacturing industries, in direct-fired furnaces. There is also some combustion in small ovens, mainly in private households. Mobile combustion is distributed between a number of different sources, described in more detail in chapter 3.2.4 Transport. In addition to oil products included in the sales statistics, figures on use of waste oil are given in Statistics Norway's statistics on energy use in the manufacturing industries. Statistics Norway also collects additional information directly from a few companies about the use of waste oil as a fuel source.

Generally, in Norway there is a continual shift between use of oil and hydroelectricity, corresponding to changes in prices. Between years, this may cause changes in use of oil products and corresponding emissions which can be considerable.

Coal

Use of coal, coke and petrol coke in manufacturing industries is annually reported from the

[3] The statistics are corrected for direct import by other importers or companies.

plants to Statistics Norway. The statistics cover all main consumers and are of high quality. Combustion takes place partly in direct-fired furnaces, partly in boilers. Figures on some minor quantities burned in small ovens in private households are based on sales figures. In addition, the figure on an insignificant use of coal in the agricultural sector was formerly collected from one farmer. Since 2002, there has been no use of coal in Norwegian agriculture.

Biofuels
Use of wood waste and black liquor in manufacturing industries is taken from Statistics Norway's annual survey on energy use in these sectors. Use of wood in households is based on figures on the amount of wood burned from the annual survey on consumer expenditure for the years before 2005. The statistics cover purchase in physical units and estimates for self-harvest. The survey figures refer to quantities *acquired*, which not necessarily correspond to *use*. The survey gathers monthly data that cover the preceding twelve months; the figure used in the emission calculations (taken from the energy balance), is the average of the survey figures from the year in question and the following year. For the years after 2005 the figures are based on responses to questions relating to wood-burning in Statistics Norway's Travel and Holiday Survey. The figures in the new survey refer to quantities of wood *used*. The survey quarterly gathers data that cover the preceding twelve months. The figure used in the emission calculations is the average of 5 quarterly surveys. Figures on some minor use in agriculture and in construction are derived from earlier surveys for these sectors. Combustion takes place in boilers and in small ovens in private households. Consumption figures for wood pellets and wood briquettes are estimates, based on annual information from producers and distributors. Data on use of peat for energy purposes is not available, but according to the Energy Farm, the centre for Bioenergy in Norway, such use is very limited (Hohle 2005).

Waste
District heating plants and incineration plants annually report combusted amounts of waste (boilers) to Statistics Norway and the Norwegian Environment Agency. There is also some combustion in manufacturing industries, reported to Statistics Norway.

According to the Norwegian Pollution Act, each incineration plant has to report emission data for SO_2, NO_X, CO, NH_3, particles, heavy metals and dioxins, and the amount of waste incinerated to the county governor. The county governor then reports this information to the Norwegian Environment Agency. If emissions are not reported, the general method to estimate emissions from waste incineration is to multiply the amount of waste used by an appropriate emission factor. Normally a plant specific emission factor is made for the component in question. This factor is based on the ratio between previous emission figures and quantities of waste burned. This factor is then multiplied with the amount of waste incinerated that specific year.

Energy balance sheets vs. energy accounts
There are two different ways of presenting energy balances: Energy balance sheets (EBS) and energy accounts. The energy figures used in the emission calculations are mainly based on the energy balance sheets.

The energy accounts follow the energy consumption in Norwegian economic activity in the same way as the national accounts. All energy used by Norwegian enterprises and households is to be included. Energy used by Norwegian transport trades and tourists abroad is also included, while the energy used by foreign transport industries and tourists in Norway is

excluded.

The energy balance sheet follows the flow of energy within Norway. This means that the figures only include energy sold in Norway, regardless of the users' nationality. This leads to deviations between the energy balance sheet and the energy accounts, especially for international shipping and aviation.

The energy balance sheet has a separate item for energy sources consumed for transportation purposes. The energy accounts place the consumption of all energy under the relevant consumer sector, regardless of whether the consumption refers to transportation, heating or processing.

Figures from the energy sources balance sheet are reported to international organisations such as the OECD and the UN. The energy balance sheet should therefore usually be comparable with international energy statistics.

Important differences between figures presented in the energy balance sheet (EBS) and figures used in the emission calculations (EC) are:

- *Air transport*: EC use only Norwegian domestic air traffic (excluding military), while EBS includes all energy sold in Norway for air transport, including military and energy used for international air transport.
- *Coal/coke for non-energy purposes*: This consumption is included in net domestic consumption in EBS, whereas EC include only energy used for combustion in the calculation of emissions from energy.

3.2.1.3 Emission factors

Emission factors used for the energy sector are given in Appendix B. Emission factors for SO_2 are independent of combustion technology. In cases where technology for cleansing of SO_2 has been installed, this will be reflected in the emission figures reported from the respective plants. For the other emission components further descriptions are also given for each source sector.

The emission factors of NO_X, CO, NMVOC and NH_3 for stationary combustion have been evaluated by Norsk Energi for the Norwegian Environment Agency. The evaluation is described in the report ”Vurdering av utslippsfaktorer for beregning av NO_X-utslipp med mer fra stasjonær forbrenning i Norge” (Evaluation of NO_X emissions factors etcetera from stationary combustion in Norway) (Norsk Energi 2003). The report focused mainly on NO_X, but also emission factors for CO, NMVOC and NH_3 were considered.

The conclusion in Norsk Energi (2003) was that there are significant discrepancies between the emission factors from literature and the factors used in the inventory. Some of the emission factors used in the national inventory are higher and some lower than the emission factors found in literature. To some extent the discrepancy is due to the fact that the emission factors from literature are not reflecting technology used in Norway and therefore not are valid for Norwegian conditions. In addition it is considered that some of the Norwegian emission factors are based on more reliable data than the factors from literature. However,(Norsk Energi 2003) proposed to change some of the emissions factors, due to the fact that the factors from literature were considered to be of better quality than those used in the Norwegian emission inventory. One of the factors was the NO_X emission factor for heavy fuel oil, see below. In general, for all other compounds the emissions factors proposed in

Norsk Energi (2003) were lower than the emission factors that are used in the Norwegian emission inventory. We consider that the effect on national totals of not replacing the emission factors with the proposed factors in Norsk Energi (2003) has led to overestimated emissions. However, Norway is continuously considering all aspects of the Norwegian emission inventory, including the emission factors, and with the updated EMEP 2009 Guidelines (EMEP 2009) we now consider to evaluate the emission factors in our inventory.

NO_X
The NO_X emission factors used in the Norwegian emission inventory have, as mentioned above, been evaluated by Norsk Energi in Norsk Energi (2003) and also in "NO_X-utslipp i forbindelse med eventuell NO_X-avgift" (Evaluation of NO_X emissions in connection with implementing NO_X tax) (Norsk Energi 2006). The conclusion in both reports is that the NO_X emission factors used in the inventory are within the intervals Norsk Energi found in their own measured data and from literature.

Norsk Energi (2003) concluded that the general emission factor for heavy fuel oil should be considered to be changed from 4.2 to 5 kg NO_X per tonne fuel and for chemical and metal industry from 5 to 6 kg NO_X per tonne heavy fuel oil. The consumption of heavy fuel oil in stationary combustion in Norway is very small and NO_X emissions in the Norwegian inventory from the largest consumers of heavy fuel oil in industry are based on plant specific data. Due to this, the proposed emission factors from Norsk Energi (2003, 2006) are not included in the Norwegian emission inventory. Norway intends to compare the NO_X emission factors in our inventory with EMEP 2009 Guidelines.

SO_2
The emission factors for SO_2 from oil products change yearly, in accordance with variations in the sulphur content in the products. The presented factors refer to uncleansed emissions; in cases where the emissions are reduced through installed cleansing measures, this will be reflected in emission figures reported from the respective plants.

3.2.1.4 Uncertainties
Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C, as well as under the individual underlying source categories.

Generally, the total energy use is less uncertain than the energy use in each sector. For some sectors (e.g. the energy and manufacturing industries) the energy use is well known, while it is more uncertain in households and the service sectors. The energy use in the most uncertain sectors has been adjusted in the official energy statistics, so that the sum of the energy use in all sectors equals the total sales.

3.2.1.5 Completeness
All known combustion with energy utilization in different industries and private households is included.

3.2.1.6 QA/QC
The emission sources in the energy sector are subjected to the QA/QC procedures described in section 1.6. Four documentation reports have been published describing the methodologies used for road traffic (Bang *et al.* 1999), aviation (Finstad *et al.* 2002a) and navigation (Tornsjø 2001) and (Flugsrud *et al.* 2010).

3.2.2 Energy industries

NFR 1A1
Last update: 19.12.2013

3.2.2.1 Description

Energy industries include emissions from electricity and heat generation and distribution, extraction of oil and natural gas, coal production, gas terminals and oil refineries. Norway produces electricity mainly from hydropower, so emissions from electricity production are small compared to most other countries. Due to the large production of oil and gas, the emissions from combustion in energy production are high.

Emissions from drilling at moveable offshore installations are included here. Emissions from these installations while not in operation (during transport, etc.) are included with 1A3D Navigation.

3.2.2.2 Method

A general description of the method used for estimation of emissions from fuel combustion is given in section 3.2.1.1. For waste incineration also a more detailed description of the methodology for some components is given in this section.

Waste incineration

N_2O and NO_x
Emissions of NO_X are reported from each plant to the Norwegian Environment Agency. An estimated amount of 2.5 per cent of this NO_X is subtracted and reported to UNFCCC as N_2O (Sandgren *et al.* 1996). Accordingly, the net NO_X emissions constitute 97.5 per cent of the emissions reported by the plants. For some years, emissions of NO_x have not been reported for a number of plants. In these cases, specific emission factors for the plants have been made, based upon earlier emissions and amounts of waste incinerated. These new factors have been used to estimate the missing figures.

Particles
Emissions of particles from district heating plants are reported to the Norwegian Environment Agency. The different plants started to report particulate emissions at various points in time. Most of them started reporting from 1994. Emissions of particles in the years before reporting have been assumed to be the same as in the first year the plant reported. New control device systems (mainly wet scrubbers) were installed at the end of the 1980s at the largest plants. Around 1995 more control device systems were installed as a result of stricter emission requirements. Most plants today have fabric filter or electrofilter together with wet scrubbers. Only two plants do not have wet scrubbers.

The emission permits do not state which particle fraction that is going to be measured. It is common to measure total amount of particles. It is however presumed that the particles emitted are less than $PM_{2.5}$. TSP and PM_{10} are therefore the same as $PM_{2.5.}$

Dioxins
Emissions of dioxins from waste burning at district heating plants are reported to the Norwegian Environment Agency. We have reported data for each plant from the period 1994/1995. Before 1994 we have only national totals. For estimating the emissions of dioxins for each plant before 1994 we derived an emission factor from total amount of waste burned

together with the total dioxin estimate. The emissions of dioxins were estimated by multiplying the given emission factor of 20 µg/tonne waste by the amount of waste burned at each plant. This calculation was done for each of the missing years for plants that did not report emissions.

Heavy metals
The estimate of heavy metals from waste combustion at district heating plants is reported to the Norwegian Environment Agency. Before 1999 many emissions of heavy metals were reported together as one group. This made it difficult to use the data to estimate the emission of each component. From 1999 there are separate data for each component, but for As, Cr and Cu there are a few plants that have insufficient reporting. To calculate the emissions of heavy metals before 1999 we have estimated an emission factor for each plant with the aid of reported emission data and amount of waste burned at each plant. The emission factor derived has been used to calculate emissions for previous years by multiplying each specific emission factor with the amount burned for the corresponding year for each plant.

Every district heating plant had stricter emission requirements for particles from 1995. It is expected that the emissions of heavy metals, except for mercury, were reduced analogously. At the same time the emission of mercury was regulated from 0.1 mg/Nm^3 to 0.05 mg/Nm^3. These regulations are considered while calculating emissions for previous years.

3.2.2.3 Activity data

Electricity and heat generation and distribution
The energy producers annually report their use of different energy carriers to Statistics Norway. There is only some minor use of oil products at plants producing electricity from hydropower. Combustion of coal at Norway's only dual purpose power plant at Svalbard/Spitsbergen is of a somewhat larger size. The amount of waste combusted at district heating plants is reported annually both to Statistics Norway and the Norwegian Environment Agency. The data are considered to be of high quality.

Extraction of oil and natural gas
Production of oil and natural gas is the dominating sector for emissions from combustion in the energy industries in Norway. The Norwegian Petroleum Directorate annually reports the amounts of gas combusted in turbines and diesel burned in turbines and direct-fired furnaces on the oil and gas fields. The data are of high quality, due to the CO_2 tax on fuel combustion. These activity data are used for 1990-2002. From 2003 onwards, reported emission figures from the field operators are used.

Coal production
Norway's coal production takes place on Svalbard. The only coal producing company annually reports its coal consumption and some minor use of oil products. In addition to emissions related to Norway's own coal production, also emissions from Russian activities are included in the Norwegian emission inventory. Russian activity data are scarce, and emissions from an estimated quantity of coal combusted in Russian power plants are calculated. Since 1999 there has been only one such plant, in earlier years there were two of those.

Gas terminals
Natural gas from the Norwegian continental shelf is landed, treated and distributed at gas terminals on shore. There are four gas terminals in Norway. The eldest started up before 1990, one in 1996 and two in 2007. Annual figures on natural gas combusted in turbines and flared

are reported to the Norwegian Petroleum Directorate (figures on flaring at one plant is reported to the Norwegian Environment Agency).

Gas power plants
Norway had in 2011 two major gas power plants and several minor ones. The first of the large plants was opened in 2007 and runs intermittently, depending on electricity and gas pricesThe second large plant was opened in 2010. Several of the smaller plants are back-up plants that are run only in emergency situations. Thus, there will be large annual fluctuations in emissions.

Oil refineries
The oil refineries annually report their use of different energy carriers to Statistics Norway. Refinery gas is most important, but there is also some use of LPG and oil products. Burning of coke while regenerating the catalyst in cracker units is reported under 1B2A4 – Fugitive emissions – Refining/Storage.

3.2.2.4 Emission factors

Emission factors used for the energy sector are given in Appendix B. For some industries and components more information about the derivation of the emission factors are given in this section.

3.2.2.4.1 SO_2

Russian electricity and heat production
Emissions from combustion of coal for electricity production in the Russian settlements on Svalbard are included in the Norwegian emission inventory. Up to 1998 there were two Russian settlements with electricity and heat production: Barentsburg and Pyramiden. Since the coal production at Pyramiden was closed down in 1998, the settlement was abandoned, and all activity now takes place in Barentsburg. For SO_2, emission factors are based on information from Trust Arktikugol in Moscow. From 1999 the factor 70 kg/tonne is used, and for earlier years 16 kg/tonne. The factor estimated figures are reduced by 60 per cent, due to the assumption that such an amount of the sulphur is bound in the ash.

3.2.2.4.2 NO_X

Offshore installations
NO_x emissions from diesel engines at offshore installations were revised in 2014 based on Karlsson and Finborud (2012). The recommended factors are shown in table 3.3.

Table 3.3. Recommended emission factors for NOx for different engine types

	Engine building year		Previous
	Before 2000	After 2000	default
	kg NO_x/tonne fuel	kg NO_x/tonne fuel	factor
200-1000 rpm: Medium speed	54	53	70
1000-1500 rpm: High speed, lower range	50	50	60
> 1500 rpm: High speed, higher range	45	44	55

Source: Karlsson and Finborud (2012).

From 2003, emissions at fixed installations and at moveable installations during drilling operations are taken from reports from operators. Some operators use default emissions factors, whereas an increasing fraction use plant-specific factors.

In the implementation of the factors from Karlson and Finborud (2012), the following principles were used:

- Reported emissions with implied emission factors less than 1% from the old default values (70/60/55 kg/t) were assumed to having used the default factors. These emissions were reduced to the new default values for engines from before 2000 (54/50/45 kg/t).
- Other reported emissions were assumed to having used plant-specific factors and were left unchanged.
- Emissions from other consumption in engines were calculated with a general factor of 54 kg NO_x/tonne. This applies to all emissions before 2003, and the remaining fraction of sales to the oil and gas industry from 2003 onwards.
- Emissions from use of marine gas oil for turbines has not been part of this revision.

3.2.2.4.3 TSP, PM_{10} and $PM_{2.5}$

Electricity and heat generation

Emission factors for TSP, PM_{10} and $PM_{2.5}$ are based on emission data given in EPA (2002). EPA (2002) gives emission data based on measurements made from various boilers using different control device systems. The Norwegian power plant at Svalbard is equipped with a multicyclone, and emission factors derived from measurements from boilers controlled with multicyclone device systems are used.

3.2.2.4.4 Dioxins and PAH

Electricity and heat generation

Dioxin emissions from coal combustion at the power plants at Svalbard are derived from emission factors found in literature. The emission factor used is the emission factor recommended in Bremmer *et al*. (1994). The same emission factor is also used in Parma *et al.* (1995) and Hansen (2000). Burning of coal at power plants is also expected to give particle-bound dioxin emissions, but because of the effective control device using multicyclone collector, the emissions are expected to be low.

Emission factors for PAH-4, PAH-6 and PAH-total are derived from an emission profile developed from emission measurements from boilers using different control device systems (EPA 1998).

PAH emissions from waste incineration are calculated by emission factors and amount of waste burned. The emission factor used for calculating emissions of PAH before 1995 is 2.5 g PAH/tonne waste burned. It is assumed that the emissions have been reduced by 70 per cent since then because of stricter emission requirements from 1995. The new emission factors have been identified using information from Sweden. We have no plant or country specific emission profile of PAH from waste incineration at district heating plants in Norway. Instead an emission profile from a district heating plant in Sweden, burning wood powder, is used (Karlsson *et al.* 1992; Norwegian institute for air research and Norwegian institute for water research 1995).

3.2.2.4.5 Heavy metals

Electricity and heat generation

The emission factors for heavy metals used for calculating emissions from coal fired power plants are from EEA (2001). The factors are, however, not specific for coal fired power plants but standard factors recommended for calculating emissions from coal combustion in energy and transformation industries.

3.2.2.5 Uncertainties

Uncertainty estimates for long-range air pollutants are given in Appendix C. Since the energy use is well known for the energy industries, the uncertainty in the activity data is considered to be minor.

The uncertainty in the activity data is ± 3 per cent of the mean for oil, ± 4 per cent for gas and ± 5 per cent of the mean for coal/coke and waste.

3.2.2.6 Completeness

Major missing emission sources are not likely.

3.2.2.7 Source specific QA/QC

The energy industries are subjected to the general QA/QC procedures described in section 1.6. Some source specific QA/QC activities were conducted in the following industries:

Heat generation in district heating plants
Emissions of heavy metals and POPs from waste incineration have been subject to detailed control. The estimates are based on measurements, but the values are uncertain due to high variability. Reported emission values can vary by orders of magnitude from year to year. Each historical value has been checked in the QA/QC process, and some data have been rejected and replaced by calculated values.

Extraction of oil and natural gas
For emissions of NO_X from turbines offshore, time series over the emissions calculated with field specific emission factors have been compared with the emissions given, using the earlier used average emission factor.

From 2003 onwards field specific emission figures reported from the companies are used directly in the emission model. These figures are compared with emissions calculated on the basis of field specific activity data and emission factors.

3.2.3 Manufacturing industries and construction

NFR 1A2
Last update: 20.05.09

3.2.3.1 Description

Emissions from the sector of manufacturing industries and construction include industrial emissions to a large extent originating from the production of raw materials and semi-manufactured goods (e.g. metals, petrochemicals, pulp and paper and mineral products). These emissions are related to fuel combustion only, that is, emissions from use of oil or gas for heating purposes. Consumption of coal as feedstock and reduction medium is not included in this sector, but it is accounted for under the industrial processes sector (chapter 4).

The interannual variation in implied emission factors for heavy metals and dioxins in 1A2 is in some cases considerable. Examples are emissions of Pb, Hg and dioxin in 1A2d. These emission estimates are based on a combination of reported figures from the plants to the Norwegian Environment Agency and emissions based on activity data multiplied with emission factors given in Appendix B. Energy use from the same plants is reported to

Statistics Norway. Whenever emissions are reported these figures are used in the inventory.

Emissions of Pb in 1A2d have increased since 2000 due to increased combustion of special waste at the plants. The EF used for burning of special waste is 14 g Pb/tonne while for instance the EF for burning of heavy fuel oil is 1 g Pb/tonne. Emissions have increased, while the total consumption energy (activity data) has been more or less at the same level since 1994, with a minor decrease the latest years. This has led to increased IEFs.

For Hg the emissions in 1A2d follow the same trend as the amount of liquid fuels used. The IEFs increases the years the consumption of liquid fuels increases and decreases the years the consumption of liquid fuels decreases.

For dioxins, IEFs vary due to variations in reported figures for one plant. The plant burnt various waste fractions in addition to regular fuel. The plant was closed down during 2001.

3.2.3.2 Activity data

Most of the emission figures are calculated on the basis of activity data and emission factors. For some large plants varying emission figures are based on reported figures from the plants.

Statistics Norway carries out annual surveys on energy use in manufacturing industries, which supply most of the data material for the calculation of combustion emissions in these sectors in cases when reported emission figures not are used. The energy use survey is assumed to cover approximately 96 per cent of the energy use in this sector. For the remaining companies, figures are estimated based on data from the sample, together with data on economic turnover, taking into account use of different energy carriers in the same industries and size groups. A change in methodology from 1998 has had minor consequences for the time series, since the energy use is mainly concentrated to a few major plants within the industry, from which data were collected both in the present and the earlier method. The data on energy use in manufacturing industries are considered to be of high quality. Information on use of waste oil and other hazardous waste is also collected through the energy use statistics.

For the construction industry, the figures on use of the different energy carriers are partly taken from the annual sales statistics for petroleum products and partly projected from earlier surveys; the energy data are considered rather uncertain. In some sectors autodiesel is mainly used in machinery and off-road vehicles, particularly in mining and construction. This amount of fuel is based on reported consumption of duty-free autodiesel in the manufacturing industries and on reported sales of duty-free autodiesel to construction. The methods for calculating emissions from motorized equipment are discussed in section 3.2.4.7. Emissions from off-road machinery in manufacturing industries and construction are reported in NFR category 1A2f ii.

3.2.3.3 Emission factors

Emission factors used for the energy sector are given in Appendix B.

3.2.3.4 Uncertainties

Uncertainty estimates for long-range air pollutants are given in Appendix C. The energy use is considered well known for the manufacturing industries.

3.2.3.5 Completeness

Major missing emission sources are not likely.

3.2.3.6 Source specific QA/QC

There is no specific QA/QC procedure for this source. See section 1.6 for the description of the general QA/QC procedure.

3.2.4 Transport

NFR 1A3

3.2.4.1 Aviation

NFR 1A3a
Last update: 13.06.06

3.2.4.1.1 Method

The calculation methodology applied is described in Finstad *et al*. (2002a). According to the IPCC Good Practice Guidance the methodology used is Tier 2 based on the detailed methodology in EEA (2001). This methodology allows estimation of emissions and fuel consumption for different types of aircraft according to the average flying distance and numbers of landings and take-offs (LTO). All movements below 1000 m are included in the "Landing Take Off" (LTO) cycle. Movements over 1000 m are included in the cruise phase. All emissions from international aviation are excluded from national totals, and are reported separately (see section 3.2.6.3).

3.2.4.1.2 Activity data

Statistics Norway annually collects data on use of fuel from the air traffic companies. These data include specifications on domestic use and amounts bought in Norway and abroad. The types of fuel used in aircraft are both jet fuel (kerosene) and aviation petrol. The latter is used in small aircraft only. Emissions from the consumption of jet kerosene in domestic air traffic are based directly on these reported figures. Domestic consumption of jet kerosene has been reported to Statistics Norway by the airlines since 1993. The survey is annual, but data from the surveys for 1993 and 1994 have not been used here, as one of the largest airlines in Norway was not included. Domestic consumption prior to 1995 is estimated by extrapolation on the basis of domestic kilometres flown and is more uncertain (Finstad *et al.* 2002a). Sales figures are used for the minor use of aviation petrol. The time series for liquid fuels used in avation is given in table 3.4.

Table 3.4. Liquid fuels in aviation, 1990-2012. TJ.

	1 A 3 a ii (i) Civil aviation (Domestic, LTO)	1 A 3 a i (i) International aviation (LTO)
1990	3234	1379
1991	3321	1340
1992	3427	1462
1993	3432	1571
1994	3838	1430
1995	4127	1511
1996	4570	1639

1997	4724	1814
1998	4806	1956
1999	5507	2331
2000	5008	2222
2001	4924	2062
2002	4190	1813
2003	4392	1850
2004	4365	2223
2005	4407	2318
2006	4586	2926
2007	4696	3005
2008	5054	2982
2009	5019	3043
2010	5306	3970
2011	5606	3956
2012	5739	4308

3.2.4.1.3 Emission factors

Emission factors used are given in Appendix B, table B1 and B3, and tables B6-B8.

The Norwegian Petroleum Industry Association provides emission factors for SO_2 for the combustion of jet fuel and gasoline (Finstad *et al.* 2002a). The emission factor for SO_2 varies annually depending on the sulphur content of the fuel used. Emission factors for particles are from Brock *et al*. (1999) and Döpelheuer and Lecht (1998), and all particles are found to be less than $PM_{2.5}$ (Finstad *et al.* 2002a).

The NO_X, CO and VOC emission factors are aircraft specific as given in EEA (2001).

Only aggregated emission factors (kg/tonnes fuel used) are used in the Norwegian inventory. The emission factors are calculated based on total emission divided by activity data for LTO and in the cruise phase, respectively. Recalculations have been done based on the new methodology (EEA 2001; Finstad *et al.* 2002a) and this led to a change in emission factors for previous years. New emission factors back to 1980 have therefore been used in the inventory. Emission factors were calculated with activity data for 1989, 1995, and 2000. Factors for the years 1990-1994 and 1996-1999 were interpolated. Factors before 1989 and after 2000 were kept constant. Emission factors for small aircraft are the same for the whole period.

3.2.4.1.4 Uncertainties

Activity data

The uncertainty in the activity data for civil aviation is estimated to be ±20 per cent of the mean, primarily due to the difficulty in separating domestic emissions from emissions from fuel used in international transport (Rypdal and Zhang 2000). In a study on emissions from aircraft (Finstad *et al.* 2002a), fuel consumption was also estimated bottom-up and compared to the reported figures (see also section 3.2.4.1.6.*)*. The estimated and reported data differed by about 10 per cent. However, the reported data are considered most accurate and were used in the calculation. As described above, data before 1995 are more uncertain than for later years.

3.2.4.1.5 Completeness
Major missing emission sources are not likely.

3.2.4.1.6 Source specific QA/QC
In 2002 a methodology improvement was made in the emission calculations for civil aviation (Finstad *et al.* 2002a). According to the IPCC Good Practice Guidance the methodology used is Tier 2 based on the detailed methodology in EEA (2001) . This methodology allows estimation of emissions and fuel consumption for different types of aircraft according to the average flying distance and numbers of landings and take-offs (LTO).

3.2.4.2 Road transport
NFR 1A3b i-v
Last update: 18.01.2013

3.2.4.2.1 Description
Emissions from this source includes combustion emissions from vehicles driven on roads, i.e. the categories passenger cars, light duty vehicles, heavy duty vehicles (including buses and coaches) and mopeds and motorcycles, as well as NMVOC emissions from gasoline evaporation. The methodology used for calculating emissions corresponds to a Tier 3 methodology from the EMEP/EEA 2013 Guidebook, using detailed information on vehicle fleet composition and driving patterns.

For passenger cars and light duty vehicles there has been a marked shift from petrol to diesel vehicles. In the 1990's petrol consumption within road transport far exceeded auto diesel. Distance driven by petrol passenger cars equally exceeded distances for auto diesel passenger cars. From 1.1.2007 there was a change in the registration tax for new passenger cars, and CO2 became one parameter in calculating the level in addition to curb weight and engine power. This led to an increase in the sale of new diesel passenger cars. In 2006 the share of diesel vehicles within new passenger cars was 48 per cent. In 2007 the same share had increased to 74 per cent and was steady on that level until 2011. From 2012 a NO_X – component was added to the passenger cars taxation. After that the share of diesel cars sold was reduced to 53 per cent in 2013.

3.2.4.2.2 Method
The consumption of gasoline for road traffic is estimated as total sales minus consumption for other uses, i.e a top-down approach. Other uses for gasoline are e.g. small boats, snow scooters and motorized equipment. For auto diesel, the total consumption in road traffic is all auto diesel charged with auto diesel tax, with two per cent addition for assumed tax free auto diesel used in road traffic. For the years prior to 1997, the auto diesel taxation was incomplete, and the consumption of auto diesel in road traffic was calculated as for gasoline, by subtracting the consumption for other uses. Other uses of auto diesel are e.g. motorized equipment in agriculture and construction. CNG and LPG are estimated by bottom-up approaches. The total consumption of each fuel is attributed to different vehicle classes based on results from the emission model of the Handbook of Emission Factors (HBEFA; (INFRAS 2009)).

Pollutants other than CO_2 are estimated by the emission model of the Handbook of Emission Factors (HBEFA; (INFRAS 2009)). The model uses a mileage approach: Emissions = mileage * emission per km. The model results are used directly without any adjustment for discrepancies between estimated and registered fuel consumption.

The HBEFA model provides emission factors and possibilities for calculating emissions for segments and sub-segments for the six vehicle classes; passenger cars, light commercial vehicles, heavy commercial vehicles, urban buses, coaches and motorcycles (including mopeds). The segments are based on engine volume for passenger cars and motorcycles, total weight for heavy commercial vehicles, urban buses and coaches, and tare weight for light commercial vehicles. The segments are further disaggregated to subsegments based on fuel type and technology type (e.g. Euro-1 – Euro-5). The segments used for Norway in the HBEFA model are given in table 3.5.

Table 3.5. Segments used for Norway in the HBEFA

Vehicle class	Segment	Fuel type	Segment split based on	Engine volume/ weight class
Passenger car	PC petrol <1,4L	Petrol	Engine volume	< 1.4 litres
	PC petrol 1,4-<2L	Petrol	Engine volume	1.4- 2.0 litres
	PC petrol >=2L	Petrol	Engine volume	>= 2.0 litres
	PC diesel <1,4L	Diesel	Engine volume	< 1.4 litres
	PC diesel 1,4-<2L	Diesel	Engine volume	1.4- 2.0 litres
	PC diesel >=2L	Diesel	Engine volume	>= 2.0 litres
	PC LPG	LPG	-	All engine volumes
Light commercial vehicles	LCV petrol M+N1-I	Petrol	Tare weight	< 1305 kilos
	LCV petrol N1-II	Petrol	Tare weight	>= 1305-1760 kilos
	LCV petrol N1-III	Petrol	Tare weight	>= 1760-3859 kilos
	LCV diesel M+N1-I	Diesel	Tare weight	< 1305 kilos
	LCV diesel N1-II	Diesel	Tare weight	>= 1305-1760 kilos
	LCV diesel N1-III	Diesel	Tare weight	>= 1760-3859 kilos
Heavy goods vehicles	RT petrol	Petrol	-	Alle gross weights
	RigidTruck <7,5t	Diesel	Gross weight	<= 7.5 tonnes
	RigidTruck 7,5-12t	Diesel	Gross weight	> 7.5 - 12 tonnes
	RigidTruck >12-14t	Diesel	Gross weight	> 12 - 14 tonnes
	RigidTruck >14-20t	Diesel	Gross weight	> 14 - 20 tonnes
	RigidTruck >20-26t	Diesel	Gross weight	> 20 - 26 tonnes
	RigidTruck >26-28t	Diesel	Gross weight	> 26 - 28 tonnes
	RigidTruck >28-32t	Diesel	Gross weight	> 28 - 32 tonnes
	RigidTruck >32t	Diesel	Gross weight	> 32 tonnes
	Tractor for AT <=7,5t	Diesel	Gross weight	<= 7.5 tonnes
	Tractor for AT>7,5-14t	Diesel	Gross weight	> 7,5 - 14 tonnes
	Tractor for AT>14-20t	Diesel	Gross weight	> 14 - 20 tonnes
	Tractor for AT>20-28t	Diesel	Gross weight	> 20 - 28 tonnes
	Tractor for AT >34-40t	Diesel	Gross weight	> 34 - 40 tonnes
	Tractor for AT >40-50t	Diesel	Gross weight	> 40 - 50 tonnes
	Tractor for AT >50-60t	Diesel	Gross weight	> 50 - 60 tonnes
Coach	Coach Std <=18t	Diesel	Gross weight	<= 18 tonnes
	Coach 3-Axes >18t	Diesel	Gross weight	> 18 tonnes
Urban bus	Ubus Midi <=15t	Diesel	Gross weight	<= 15 tonnes
	Ubus Std >15-18t	Diesel	Gross weight	>15 - 18 tonnes
	Ubus Artic >18t	Diesel	Gross weight	> 18 tonnes
	Ubus Std >15-18t CNG	CNG	Gross weight	>15 - 18 tonnes
	Ubus Artic >18t CNG	CNG	Gross weight	> 18 tonnes
Motorcycles and mopeds	Moped <=50cc (v<50kmh)	Petrol	Engine volume	<= 50 cc
	MC 2S <=150cc	Petrol	Engine volume	<= 150 cc
	MC 2S >150cc	Petrol	Engine volume	>150 cc
	MC 4S <=150cc	Petrol	Engine volume	<= 150 cc

MC 4S 151-250cc	Petrol	Engine volume	151-250 cc
MC 4S 251-750cc	Petrol	Engine volume	251-750 cc
MC 4S >750cc	Petrol	Engine volume	> 750 cc

The model combines the number of vehicles within each segment with driving lengths for the same segments to produce annual national mileage per subsegment. For heavy goods vehicles, the vehicle number is corrected for vehicles driving with trailers, and the driving is split into three load classes (empty, half loaded and fully loaded).

The annual national mileage is split between shares driven in different traffic situations. The traffic situations are a combination of area (urban/rural), road type (e.g. trunk road and access road), speed limit and level of service (freeflow, heavy, saturated, and stop and go). The traffic situations are further disaggregated by gradients, where the amount of driving on roads with slopes ranging from -6 per cent to 6 per cent is specified for each traffic situation.

Hot emission factors are provided on the disaggregated level of subsegments and traffic situations with different gradients, and the emissions are estimated after these steps of disaggregation.

The HBEFA model provides emission factors for cold emissions and evaporative emissions (soak, running losses and diurnal), in addition to hot emission factors. In order to calculate cold and evaporative emissions, information on diurnal variation in curves of traffic, trip length distributions, parking time distributions and driving behaviour distributions must be provided, in addition to variations in mean air temperature and humidity.

3.2.4.2.3 Activity data

All activity data are, as far as possible, updated for every year of the inventory. Data are taken primarily from official registers, public statistics and surveys. However, some of the data are based on assumptions. Many of the data sources are less comprehensive for the earliest years in the inventory. The sources of activity data are listed below:

- *Total fuel consumption*: the total amounts of fuels consumed are corrected for off-road use (in boats, snow scooters, motorized equipment, etc.). These corrections are estimated either from assumptions about the number of units, annual operation time and specific fuel consumption, or from assumptions about and investigations of the fraction of consumption used off-road in each sector. Statistics Norway's sales statistics for petroleum products supply the data for total fuel consumption (Statistics Norway Annually-b). Fuel consumption in road transport is given in table 3.6.
- *Number of vehicles*: the number of vehicles in the various categories and age groups is taken from the statistics on registered vehicles, which receives data from the official register of the Norwegian Directorate of Public Roads. The model input is number of vehicles per vehicle class for each inventory year, and the share of vehicles for any given combination of segment and fuel type. These data are combined with information on the introduction of technology classes to provide number of vehicles within each subsegment. The information on introduction of technology classes are for recent years based on information from the official register of the Norwegian Directorate of Public Roads, and on legislation for the years in which the information in the register is insufficient.
  - The HBEFA model distinguishes between two types of buses: urban buses, mainly used for urban driving, and coaches, mainly used for rural and motorway driving. Due to lack of specific information to make this split in the national vehicle register, the distinction between urban buses and coaches are based on a methodology used in Sweden (Swedish

environmental protection agency 2011), where the split is made based on the ratio *p/w*. Here, *p* is equal to the maximum allowed number of passengers (number of seats plus number of allowed standing passengers), and *w* is equal to the gross vehicle weight. These data are available from the national vehicle register. Buses with a *p/w*-value above 3.75 are classified as urban buses, whereas buses with a *p/w*-value below 3.75 are classified as coaches.

- *Average annual mileage*: Mileages for passenger cars, light commercial vehicles, heavy goods vehicles, coaches and urban buses are from 2005 onwards based on odometer readings taken during annual or biannual roadworthiness tests. The readings are collected by the Directorate of Public Roads and further processed by Statistics Norway (Statistics Norway 2010a). For earlier years, most figures are determined from surveys by Statistics Norway or the Institute of Transport Economics. In some instances assumptions are needed.
  - The statistics on number of vehicles depict the vehicle fleet per December 31st of the inventory year, while the statistics on mileages represents annual driving for the entire year, including vehicles that have been scrapped or in other ways been in the vehicle fleet for only parts of the inventory year. To adjust for this discrepancy for the years 2005-2011, mean annual driving lengths for each vehicle category have been adjusted upwards in such a way that the totals correspond to the total annual traffic activity from the statistics on annual driving lengths.

  - The average annual mileages vary as a function of age, with older vehicles generally driving shorter annual distances than newer vehicles. The correction of driving as a function of vehicle age is based on odometer readings taken during the roadworthiness test. The functions are calculated as the mean of the years 2005-2011, and the same correction curve is used for all years.
  - Motorcycles and mopeds are not subject to roadworthiness tests in Norway. Average annual mileages are taken from a report on transport volumes in Norway (Vågane and Rideng 2010). Due to lack of data, corrections of annual mileage as a function of age for motor cycles and mopeds are taken from a Swedish survey (Bjørketun and Nilsson 2007) under the assumption that annual mileages as a function of age are comparable in Norway and Sweden.
- *Load data* are taken from the Road goods transport survey (Statistics Norway 2010b).
- *Transformation patterns* are calculated using information from Statistics Norway' Road goods transport survey on use of trailers and trailer size (Statistics Norway 2010b).
- *Traffic situations*: The Directorate of Public Roads has data on the annual number of vehicle-kilometres driven on national and county roads. The data are allocated by speed limits, road type, area type (urban/rural), and vehicle size (small/ large). Traffic on municipal roads (approx. 15 per cent) is estimated by Statistics Norway based on road lengths, detailed population data, traffic on adjoining roads, etc. The HBEFA model has emission factors for different situations of traffic flow (freeflow, heavy traffic, saturated traffic, and stop and go). Assumptions have been made as to this distribution for the different combinations of area type, road type and speed limits for Norway. Effects of road gradients are included, based primarily on Swiss data supplied to the HBEFA.
- *Ambient conditions* (air temperature and humidity) are included in the model to calculate cold and evaporative emissions. An average of five larger Norwegian cities has been used for spring, summer, autumn and winter separately. The data are based on measurements from the Norwegian Meteorological Institute.

- *Trip length and parking time distributions* are calculated from the Norwegian travel survey (Institute of transport economics 1993). The distributions are given on an hourly basis.

Table 3.6. Fuel consumption in road transport[1], 1990-2012. TJ.

Year	Petrol	Diesel	LPG	Gaseous fuels
1990	75597	30587		
1991	73424	31647		
1992	71663	35639		
1993	71525	41762		
1994	71325	38921		
1995	70362	41850		
1996	71443	44174		
1997	70236	45396		
1998	71043	47855		
1999	70518	47752		
2000	68290	47468		
2001	70946	51812		
2002	70394	53434		
2003	69593	56181		
2004	69172	60839		
2005	66613	65577		
2006	63990	72270		
2007	60523	79801	161	108
2008	56550	84129	161	136
2009	52883	86152	161	144
2010	49895	93135	161	185
2011	45560	96778	161	212
2012	42383	100961	161	485

[1]Petrol and diesel includes energy consumption in mobile military sources.

3.2.4.2.4 Emission factors

Emission factors are taken from the Handbook of Emission Factors (HBEFA). Factors are given as emission per vehicle kilometers for detailed combinations of subsegments and traffic situations.

Biofuels for transport are not handled as separate fuels. The consumption is included with gasoline and autodiesel.

Average factors are listed in Appendix B.

3.2.4.2.5 Uncertainties

The uncertainty estimates are given in Appendix C.

The comparison of bottom up estimates of fuel consumption from HBEFA with total sales (source specific QA/QC) reveals a discrepancy of 5-15 per cent. This is deemed to be a reasonable difference. This discrepancy is handled differently for different emission components. The total consumption of each type of fuel is the most important parameter in relation to the reporting requirements of the UNFCCC, as this forms the basis for the

calculation of CO_2 from road traffic (Eggleston et al 2006). One kilogram of gasoline or autodiesel yields a fixed amount of CO_2 irrespective of vehicle type.

Guidelines for greenhouse gas reporting, the IPCC guidelines (Eggleston et al 2006), states that CO_2 emissions should be calculated using fuel consumption, and that sold amount of fuel should form the basis. Calculations of emissions of CH_4, N_2O and many of the components of emissions reported to CLRTAP (e.g. NO_X and particulates), however, depends on more detailed information about vehicle types and driving patterns, and here a more detailed model (for example HBEFA) should be applied. The relationship between emissions and fuel consumption must be considered differently for the emission components that are directly dependent on the composition and quantity of fuel (CO_2, SO_x and heavy metals) and those who to a larger extent depend on the type of vehicle and driving mode (eg. NO_x, CH_4, N_2O, NH_3, CO, particles).

Fuel consumption is not an input to HBEFA, where emissions are calculated based on mileage and number of vehicles in each subsegment of vehicle classes , as well as other data sets, such as cold start and age distribution of mileage. Fuel consumption is however calculated in the model similarly to emission calculations. The estimated fuel consumption for the country as a whole can be compared with sold fuel sales statistics for petroleum products and energy balance. The comparison shows that the fuel consumption calculated in HBEFA are systematically lower than the fuel in the energy balance, and that the difference is greater for auto diesel than for petrol. The difference has been between approximately 1 and 10 percent for gasoline, and 4 and 15 percent for diesel in the period 1990-2011. Exceptions are 1990 and 1991 for auto diesel when the difference was very small, and 1993, when the difference was almost 30 percent. There is no increasing or decreasing trend in the deviations, but there seems to be a correlation between the deviation of petrol and diesel.

It is not known why there is a discrepancy between the consumption of energy balance and bottom-up calculation in HBEFA, but there are several possible explanations as to why fuel sold does not match the fuel consumption calculated from road transport emission model:

1. *Fuel purchased by foreign vehicles.* Foreign vehicles si not included in the vehicle register statistics, even though they drive on Norwegian roads. Similarly, no fuel bought by Norwegian vehicles abroad is sampled. It is likely that there is no systematic "fuel tourism" across the Norwegian border, as there are no significant price differences between fuel prices in Norway and Sweden. The current calculations are based on the assumption that driving in Norway by foreign vehicles equals the driving of Norwegian vehicles abroad.
2. *Vehicles drives longer in reality than what the model calculates.* Seeing as the Technical Inspection of vehicles is a new data source for mileage, it is hard to imagine that mileages in the model are systematically underestimated. Motorcycles does not have such a Technical Inspection. They can however not explain the discrepancy between the calculated and the amount of fuel sold. For example, they mostly run on gasoline, while the largest deviation is within auto diesel.
3. *Driving patterns.* There may be elements in the driving patterns that causes fuel consumption per kilometer per vehicle to be higher than what the model calculates. One possible reason here is that the fuel consumptions stated in the vehicle type approvals are used as part of the input to the model, and there is an ongoing discussion about whether these systematically underestimates consumption. These data are however available only for the latter part of the series, and can not explain the discrepancies in the 1990s.

Whether the emission calculations should be corrected for differences in fuel consumption depends on the pollutants in questions. For those components that are directly dependent on the amount of fuel (CO_2 , SO_2 , heavy metals) it will always be appropriate to use the fuel consumption from the energy balance as a basis for calculation. For the other emission components the decision on wether to correct for total fuel consumption or not will depend on what is causing the discrepancy between fuel consumption calculated in the model and fuel consumption in the energy balance. If the reason is that the total mileage is underestimated in the model , and that the energy balance represents a "truer" picture of the consumption of fuels , emissions should be corrected. If the discrepancy, however, is due to an underestimation of the fuel consumption per kilometer, the emission estimates should not be corrected unless one finds a clear correlation between changes in consumption per kilometer and emissions per kilometer for the relevant emission components. As long as we do not know the reason for the discrepancy, an assessment of data quality in the various input data is crucial to determining whether emissions should be reconciled against fuel sales or not.

While the previous model (Norwegian Pollution Control Authority in 1993 , Bang et al 1999), the emissions of all substances were corrected to account for the discrepancy between the energy balance and the model calculations, because the energy balance was considered the most secure data source. When HBEFA was introduced as the computational model, a new data source was also introduced, namely the mileage statistics at Statistics Norway. These statistics are based on data from periodical technical inspections, and goes back to 2005. This important new data source is considered to be of good quality, and it has changed the assessment of whether the emissions shall be corrected for the consumption of energy balance or not. There is no reason to believe that the total run lengths are underestimated, and we consider it likely that the reason for the discrepancy lies in the estimates of fuel consumption per kilometer. The energy balance is based on the assessment that Norwegian purchases abroad corresponds to foregin purchases in Norway, and the same assessment is applied to the emissions calculations. We have not found any reason to believe that the reasons for the discrepancies in fuel consumption are directly correlated with driving behavior. It has therefore been assessed that HBEFA estimated emissions of pollutants that are not directly related to fuel consumption should not be reconciled with fuel consumption.

There are currently no comprehensive statistics on foreign vehicles driving in Norway. One possible explanation for the discrepancy between the calculated fuel consumption in HBEFA and sold quantity of fuel is that foreign driving in Norway exceeds Norwegian of vehicles driving abroad. There has been an issue that the proportion of heavy vehicles with foreign vehicles increases. However, we see no clear increasing trend in the difference between the model results and sales. Better data related to foreign driving in Norway and the Norwegian driving vehicles abroad would strengthen or refute the current assumption that these two balance each other out.

3.2.4.2.6 Completeness

Major missing emission sources are not likely.

3.2.4.2.7 Source specific QA/QC

Top-down and bottom-up data on fuel consumption are compared for gasoline and diesel vehicles on an annual basis. The consumption of gasoline and auto diesel for road traffic is estimated as total sales minus consumption for other uses, i.e. a top-down approach. The HBEFA emission model also makes bottom-up estimates of consumption, which can be compared with the top-down data. The estimated fuel consumption from HBEFA deviates from the top-down

estimate by approximately 5-15 per cent per year, with the higher value for auto diesel. The causes are on one hand uncertainties in the amount of non-road use and on the other hand uncertainties in mileage and specific consumption in road transport.

However, the total consumption of auto diesel is well known. The uncertainty only concerns the allocation between road and non-road use, connected to illegal use of diesel without road tax in road traffic. The total emissions may be sensitive to this allocation, due to different emission calculation methodologies. When inspected, taxed and tax free diesel can be identified by color. The fine for illegal use of tax free diesel is currently from NOK 20 000,- and upwards. There is no reason to believe that this is a major problem.

3.2.4.3 Railways

NFR 1A3c
Last update: 10.02.2014

3.2.4.3.1 Description

Railway traffic in Norway uses mainly electricity. Auto diesel is used at a small number of lines, for shunting etc. There is also a minor consumption of coal in museum railways.

3.2.4.3.2 Method

General estimation methodology for calculating combustion emissions from consumption figures and emission factors is used.

3.2.4.3.3 Activity data

Consumption figures for auto diesel used in locomotives are collected annually from the Norwegian State Railways. Consumption of coal is estimated based on information from different museum railways; the same figure is used for all years from 1990. There has been a continuous electrification of the railroads in Norway, and the diesel consumption is more than halved from the level in the early 1990's.

Table 3.7. Fuel consumption in railways, 1990-2012. TJ.

	Liquid fuels	Solid fuels
1990	1306	3.9
1991	1254	3.9
1992	1330	3.9
1993	1394	3.9
1994	1431	3.9
1995	1405	3.9
1996	955	3.9
1997	1009	3.9
1998	784	3.9
1999	738	3.9
2000	663	3.9
2001	641	3.9
2002	590	3.9
2003	552	3.9
2004	601	3.9

2005	581	3.9
2006	564	3.9
2007	593	3.9
2008	617	3.9
2009	612	3.9
2010	535	3.9
2011	514	3.9
2012	573	3.9

3.2.4.3.4 Emission factors

Emission factors for NO_x, HC, CO, and PM_{10} were estimated by Bang (1993) based on a literature survey and data on Norwegian usage profiles. The HC factor of 4 g/kg was used directly for NMVOC.

The other emission factors are the same as for diesel machinery in mining and quarrying (see section 3.2.4.7.4), with the following exception:

- NH_3: 0.007 g/kg vs 0.005 g/kg for machinery (EMEP/EEA Guidebook)

General emission factors for coal are used in the calculations.

3.2.4.3.5 Uncertainties

The consumption data are of high quality. Their uncertainty is estimated to be ±5 per cent of the mean.

3.2.4.3.6 Completeness

Major missing emission compounds are not likely.

3.2.4.3.7 Source specific QA/QC

Consumption data from the Norwegian State Railways have previously been compared with sales to railways according to the Petroleum statistics. However, the latter includes some consumption by buses operated by the Norwegian State Railways. From 1998, the reported sales of "tax-free" auto diesel to railways have been higher than the consumption data from the Norwegian State Railways, although there was only a minor difference in 2009. The reason for this discrepancy has not been checked. "Tax-free" auto diesel is only for non-road use, so consumption by buses should not be the cause.

3.2.4.4 Electric railway conductions

NFR 1A3c
Last update: 01.09.05

3.2.4.4.1 Method

Electric railway conductions contain copper that is emitted in contact with trains. In the inventory copper emissions are calculated by emission factors and activity data.

3.2.4.4.2 Activity data

The activity data used for calculating emissions of copper from electric wires are annual train kilometers given by the Norwegian State Railways (NSB).

3.2.4.4.3 Emission factors

According to Norwegian State Railways (Rypdal and Mykkelbost 1997) the weight of a contact wire is 0.91 kg/meters. The weight is reduced by 20 per cent after 3 million train passes. This gives an emission factor of 0.06 g/train kilometers. It is, however, uncertain how much of this is emitted to air. In the inventory it is assumed that 50 per cent is emitted to air. This gives an emission factor of 0.03 g/ train kilometer.

Table 3.8. Emission factor for electric railway conductions. g/km

	Emission factor (g/train kilometers)
Cu	0.03

3.2.4.4.4 Uncertainties

The emission factor used is uncertain. First, there is an uncertainty connected to the reduction of 20 per cent after 3 millions train passes. Secondly, there is uncertainty regarding the assumption that 50 per cent are emissions to air (Finstad and Rypdal 2003).

3.2.4.4.5 Completeness

No major components are assumed missing.

3.2.4.4.6 Source specific QA/QC

There is no specific QA/QC procedure for this source. See section 1.6 for the description of the general QA/QC procedure.

3.2.4.5 Navigation

NFR 1A3d
Last update: 17.03.11

3.2.4.5.1 Description

According to CLRTAP Norwegian national sea traffic is defined as ships moving between two Norwegian ports. In this connection, installations at the Norwegian part of the continental shelf are defined as ports.

Fishing is described in section 3.2.5

3.2.4.5.2 Method

Emissions from navigation are estimated according to the Tier 2 IPCC methodology. Emissions from moveable installations used in oil and gas exploration and extraction are split between 1A1 – energy industries (section 3.2.2) and navigation: Emissions from drilling are reported under 1A1, while emissions from transport and other activities are reported under navigation. Emissions from international marine bunkers are excluded from the national totals and are reported separately (section 3.2.6.2), in accordance with the IPCC Good Practice Guidance.

Annual emissions are estimated from sales of fuel to domestic shipping, using average emission factors in the calculations.

For 1993, 1998, 2004 and 2007 emissions have also been estimated based on a bottom-up approach. Fuel consumption data were collected for all categories of ships (based on the full population of Norwegian ships in domestic transport); freight vessels (bulk and tank), oil loading vessels, supply/standby ships, tug boats, passenger vessels, fishing vessels, military

ships and other ships. Emissions were estimated from ship specific emission factors and fuel use. From this information, average emission factors were estimated for application in the annual update based on fuel sales. This approach is unfortunately too resource demanding to perform annually.

3.2.4.5.3 Activity data

The annual sales statistics for petroleum products gives figures on the use of marine gas oil, heavy distillates and heavy fuel oil in domestic navigation. Information on fuel used in the ship categories in the bottom-up analysis is mainly given by data from the Business Sector's NO_x fund for 2007 and by earlier SSB analyses for 1993 and 1998 (Tornsjø 2001), and 2004. Data on fuel consumed by public road ferries are available from the Directorate of Public Roads.

Information on fuel use at mobile drilling rigs is taken from the sales statistics, but information on use (whether it is used for drilling, stationary combustion etc,) is taken from Environmental Web (reported from oil companies to the Norwegian Environment Agency and the Norwegian Petroleum Directorate). Consumption during drilling activities are reported under "Energy industries" (CRF 1A1c). Only the remaining part of sales, assumed to be for drilling rigs during transit etc., is included with Navigation.

For marine gas oil, the amount used for navigation is equal to total sales figures except bunkers, after the deduction of estimated stationary use, mainly in oil and gas extraction, but also some minor use in manufacturing industries and construction. Due to inaccuracies in the reporting of distribution of marine gas oil between domestic and international shipping from approximately 2005, there is some uncertainty connected to the figures for the latest years.

Use of natural gas in navigation, which was introduced in 2000 and has increased considerably from 2007, is based on sales figures reported to Statistics Norway from the distributors. Fuel consumption in national navigation is given in table 3.9.

Table 3.9. Fuel consumption in national navigation, 1990-2012. TJ.

	Liquid fuels	Gaseous fuels
1990	22817	0
1991	22417	0
1992	23600	0
1993	26352	0
1994	24533	0
1995	25606	0
1996	26230	0
1997	29300	0
1998	31790	0
1999	34831	0
2000	30117	46
2001	26131	48
2002	25255	54
2003	25719	174
2004	26377	277
2005	26459	332
2006	27641	329

2007	29143	1577
2008	24653	1856
2009	25410	1980
2010	26718	2157
2011	25304	2465
2012	23168	3173

3.2.4.5.4 Emission factors

Emission factors used for navigation are given in Appendix B, table B1, table B4 and tables B12-B16.

SO_2

The emission factors are determined from the sulphur content of the fuel.

NO_x

NO_x factors for different engine types (slow, medium and high speed) have been estimated by Marintek based on data from a comprehensive measure programme for NO_x emissions from ships, which has been implemented under the leadership of the Business Sector's NO_x fund. The new basis factors from Marintek apply to emissions from different engine types built before and after emission restrictions were implemented in 2000 (Bremnes Nielsen and Stenersen 2009).

Table 3.10. Recommended emission factors for NOx for different engine types

	Engine building year	
	Before 2000 kg NO_x/tonne fuel	After 2000 kg NO_x/tonne fuel
Slow speed NO_X factor	82	78
Medium speed NO_X factor	54	53
High speed NO_X factor	47	41

Source: Bremnes Nielsen and Stenersen (2009).

The factors were weighted in two steps: First, by engine type distribution within ship categories (passenger, general cargo, offshore, fishing, etc). Secondly, by estimated fuel consumption among categories. The fuel consumption weights were calculated based on data for 1993, 1998, 2004 and 2007, which are years with good availability of activity data. Average factors for other years were interpolated. In the interpolation of the average factors over the time series, a peak in the use of shuttle tankers has been taken into consideration. The fact that we have reported data for public road ferries for some years, and a gradual change to new engines with lower emissions starting in 2000 due to new restrictions, has also been taken into consideration. The NO_x factors used in the inventory are documented in (Flugsrud *et al.* 2010).

For gas engines the NO_X factor 5.6 kg NO_X/ tonne LNG is established based on the mass of LNG consumed (Bremnes Nielsen and Stenersen 2010).

For offshore drilling rigs, the factor 54 kg NO_x/tonne is used (Karlsson and Finborud 2012).

See further discussion on NO_x from offshore installations in the section on stationary combustion.

Average NO_X factors for fishing and for general shipping are given in Appendix B, table B14.

NH_3
Emissions of NH_3 from navigation are reported as "Not Estimated". The EMEP/EEA Guidbook (EEA 2013) has no emission factors, and in table 2-2 over "Contributions to total emissions" NH_3 is stated as "No emissions reported".

Particles
Factors for particulate matter are based on measurements performed by MARINTEK and literature sources. The factors are presented in table 3.10.

Table 3.10. Particulate matter emission factors for oil and gas operated vessels.

Fuel	Emission factor	
	$PM_{2.5}$	PM_{10}, TSP
Marine gas oil, light fuel oils (kg/tonne)	**1.5**	**1.6**
Heavy fuel oil, heavy distillate (kg/tonne)	**5.1**	**5.4**
LNG (kg/1000 Sm^3)	**0.032**	**0.032**

Source: Bremnes Nielsen and Stenersen (2010).and Bremnes Nielsen (*pers.comm.*[4])

For oil based fuels it is assumed that all particles are included in PM_{10} and 95 per cent of the particles are included in $PM_{2.5}$ (Finstad *et al.* 2003).

Emission factors for particle emissions from gas operated vessels are based on measurements made by MARINTEK (Bremnes Nielsen, *pers.comm*), which show 95-99 per cent emission reduction compared to marine gas oil.

3.2.4.5.5 Uncertainties
The estimation of fuel used by fishing vessels is assumed to be rather uncertain. There is also uncertainty connected to the fuel use for other domestic sea traffic due to uncertainty in the sales statistics for petroleum products. Particularly, the delimitation between sales of marine gas oil for national use and bunkers has become more uncertain from approximately 2005, due to new and less accurate reporting routines in some oil companies.

Some uncertainty is also connected to the emission factors.

The uncertainty in the activity data for navigation is assessed to be ±20 per cent. The uncertainty in the NO_x factors depends both on the uncertainty in the basis factors from Marintek (Bremnes Nielsen and Stenersen 2009) and on the uncertainty in the allocations that are made of the factors between ship types and years. Marintek has estimated the uncertainty in their basis NO_x factors for different engine types to ±5 per cent. Uncertainties in emission factors are shown in table 3.11.

[4] Bremnes Nielsen, J. (2010): Personal information, email from Jørgen Bremnes Nielsen, 11 Nov. 2010, Marintek.

Table 3.11. Uncertainties in emission factors for ships and fishing vessels. Per cent

	Standard deviation (2σ)
SO_2	±25
NO_x[1]	±15
NMVOC	±50

[1] It is assumed that the uncertainty might be lower now than in this estimate from Rypdal and Zhang (2001) since more measures have been performed in connection with the Business Sector's NO_x fund.
Source: Rypdal and Zhang (2000; 2001).

3.2.4.5.6 Completeness

Major missing emission sources are not likely.

3.2.4.5.7 Source specific QA/QC

As mentioned, emission estimates for ships have been made bottom-up for 1993 and 1998 (Tornsjø 2001) and for 2004 and 2007. These results have been compared with top-down data (from sales) on fuel consumption used in the annual estimates.

The outcome showed that data from sales were only 1 per cent higher than data from reported consumption in 2007. For 2004 the sales data were 27 per cent higher than the consumption data in the bottom-up analysis. This can be explained by the fact that the bottom-up method does not cover all ships, but it may also be that the domestic/international distinction is not specified precisely enough in the sales statistics. Another element, which not has been taken into account, is possible changes in stock. For the years 1993 and 1998 a deviation of -12 and -15 per cent, respectively, has been found. In the calculations, sales figures are used, as they are assumed to be more complete and are annually available.

3.2.4.6 Pipeline

NFR 1A3e i
Last update: 22.03.10

Figures on natural gas used in turbines for pipeline transport at two separate facilities are reported annually from the Norwegian Petroleum Directorate to Statistics Norway. However, energy generation for pipeline transport also takes place at the production facilities. Specific data on consumption for transport are not available. Thus, the consumption at the two pipeline facilites does not give a correct picture of the activity in this sector. As a consequence, all emissions from pipelines are reported under NFR 1A1.

3.2.4.7 Motorized equipment

NFR 1A2f ii etc.
Last update: 10.02.2014

3.2.4.7.1 Description

The category "motorized equipment" comprises all mobile combustion sources except road, sea, air, and railway transport. Farm and construction equipment are the most important categories. Other categories include mines and quarries, forestry, snow scooters, small boats and miscellaneous household equipment.

Emissions from motorized equipment are reported under several categories. Motorized equipment are allocated differently in the CRF reporting and in the NFR tables:

	IPCC	NFR
Manufacturing and construction		1A2f-ii
Commercial and institutional	1A3e	1A4a-ii
Households		1A4b-ii
Agriculture/Forestry/Fishing	1A4c	1A4c-ii
Military	1A5b	1A5b

Primarily consumption of gasoline and auto diesel is considered. A small amount of fuel oil used for equipment in construction is also accounted for.

3.2.4.7.2 Method

Emissions are estimated through the general methodology described earlier, involving consumption figures and appropriate emission factors.

3.2.4.7.3 Activity data

Gasoline and auto diesel are handled differently. Consumption of *gasoline* is estimated bottom-up for each type of machinery based on data on the number of each type of equipment, usage and specific consumption.

Snow scooters: Number of equipment is obtained annually from the Norwegian Public Roads Administration. We assume a mileage of 850 km/year and a specific consumption of 0.15 l/km (National institute of technology 1991). A portion of 16 per cent of petrol consumption in agriculture is assigned to snow scooters. The remaining snow scooter fuel consumption is assigned to households.

Chainsaws and other two-stroke equipment: Only consumption in forestry is considered, based on felling data. Felling statistics are gathered by Statistics Norway. 50 per cent is supposed to be felled with use of chain saws, with a consumption of 0.33 l/m^3. Note: Consumption has been kept fixed since 1994 based on a calculation by the Institute of Technology (Bang 1996).

Lawn mowers and other four-stroke equipment: Only consumption in households is considered.

Consumption of *auto diesel* is based on data from the energy balance. Auto diesel used in off-road vehicles has no road tax from 1993. Total use of auto diesel in motorized equipment is given as the difference between total sales of tax free diesel and estimated use for railway transportation. It is important to bear in mind that the total consumption of auto diesel in motorized equipment from 1993 is considered being of good quality since there from 1993 is no road tax on this part of the auto diesel. There is CO_2 tax on the auto diesel used for motorized equipment as well as for road traffic..

Distribution of auto diesel between industries: From 2001, a certain fraction of the consumption in a number of industries is allocated to motorized equipment, based on the distribution of taxed and tax-free diesel – the latter is meant for use outside road transport. The distribution formulas are based on figures from the statistics on energy use in manufacturing industries or from the sales statistics. The statistics on energy use in manufacturing industries did not have such a split before 2001, and therefore distribution formulas for 2001 are used for 2000 and earlier years.

3.2.4.7.4 Emission factors

Emission factors used are given in Appendix B.

For diesel machinery, emission factors for HC, CO, and PM_{10} were estimated by Bang (1993), based on a literature survey and data on Norwegian usage profiles. Source for emission factor for NO_X from diesel machinery is from Bang (1993) for motor gasoline and light fuel oils. For autodiesel emission factors from a Danish report (Winther and Nielsen 2006) is used. NMVOC factors were calculated by subtracting an assumed CH_4 fraction of 0.3 g/kg diesel.

3.2.4.7.5 Uncertainties

The estimates of consumption are considered quite uncertain, particularly for gasoline. However, the total consumption of gasoline is well known. For auto diesel, some uncertainty in the delimitation of different middle distillates may cause variations in figures on total use in motorized equipment between years.

3.2.4.7.6 Completeness

Major missing emission sources are not likely.

3.2.4.7.7 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

3.2.4.8 Automobile tyre and brake wear

NFR 1A3b vi
Last update: 11.01.13

3.2.4.8.1 Tyre wear

3.2.4.8.1.1 Description

Tyre wear is a source for emission of particles, heavy metals and persistent organic pollutants. The tyres are worn down by 10 to 20 per cent of its total weight during its lifetime. Most of the rubber is lost during acceleration and braking. All rubber lost is assumed to be particles containing heavy metals and PAH.

3.2.4.8.1.2 Method

Particles
All rubber lost is assumed to be small particles. The emissions of particles are calculated based on emission factors and annual mileage.

Heavy metals
Rubber particles contain heavy metals. Emissions of the heavy metals As, Cd, Cu, Cr, Pb and Hg are calculated based on annual mileage and emission factors.

PAH
The particles emitted from tyre wear contain PAH. Emissions are calculated based on emission factors and annual mileage.

3.2.4.8.1.3 Activity data

Annual mileage is used for calculating the emissions from tyre wear. Annual mileage is given by the road traffic model, see section 3.2.4.2.

3.2.4.8.1.4 Emission factors

Particles

The emission factors used for calculating the emission of particles are given by TNO (Institute of environmental and energy technology 2002 and 2008). The emission factors are based on several Dutch and British studies. Recommended emission factors for TSP and PM_{10} are taken from TNO (2002). Emission factor for $PM_{2.5}$ was previously set to be zero. A new report TNO (2008) presents emission factors for all three fractions of particulate matter. The emissions factors for TSP and PM_{10} are in the same range as the emissions factors given in TNO (2002). In the Norwegian inventory it has been chosen to include $PM_{2.5}$ emissions using the same ratio between PM_{10} and $PM_{2.5}$ in the Norwegian inventory as the ratio between PM_{10} and $PM_{2.5}$ from TNO (2008). The emission factors used are given in table 3.12.

Table 3.12. Emission factors for particles from tyre wear. kg/mill. km

	TSP	PM_{10}	$PM_{2.5}$
Private cars	69	3.45	0.69
Van	90	4.5	0.9
Heavy duty vehicles	371,25	18.563	3.71
MC	34,5	1.725	0.35

Source: TNO (Institute of environmental and energy technology 2002)).

Heavy metals

The emission factors used for the heavy metals As, Cd, Cu, Cr and Pb are derived from a particle-heavy metal distribution given by Dutch studies (van den Brink 1996). The content of heavy metals in the particles, given by this distribution, is multiplied by the PM_{10} emission factor (table 3.12). This gives the emission factors for the heavy metals As, Cd, Cu, Cr and Pb from tyre wear (table 3.13).

Table 3.13. Emission factors for heavy metals from tyre wear. g/mill. km

	As	Cd	Cu	Cr	Pb
Private cars	0.003	0.007	1.691	0.014	0.552
Van	0.005	0.009	2.205	0.018	0.720
Heavy duty vehicles	0.019	0.037	9.096	0.074	2.970
MC	0.002	0.003	0.845	0.007	0.276

The emission factor used for the estimation of the emissions of Hg is 0.079 g/ mill. km. This emission factor is derived from a study of heavy metal content in tyres (Bækken 1993) and an estimate of the amount of tyre in Norway in 1993 of 6000 tonnes (Finstad *et al.* 2001).

PAH

Emission factors for PAH are given in Finstad *et al*. (2001), but there is no information about how much of the emissions that are emitted to air, and how much that goes to soil and to water. All emissions are therefore supposed to be emitted to air. There is also no PAH profile available, so in lack of other data the same PAH profile as for burning of tyres is used (EPA 1998). PAH emission factors for tyre wear are given in table 3.14.

Table 3.14. Emission factors for PAH from tyre wear. g/mill. km

	PAH
Light duty vehicles	10.4
Heavy duty vehicles	0.1

Source: Finstad *et al*. (2001).

3.2.4.8.1.5 Uncertainties

The calculation of emissions from tyre wear is uncertain. First, the emission factors for

particles used are based on international studies and not on Norwegian conditions. There is also uncertainty concerning how much of the particles that are emitted to air. According to a Dutch judgement, all particles emitted to air are PM_{10}. This is however only a judgement, and not based on scientific research. PAH emissions have been held constant since 1998.

The heavy metal emission factors are based on the particle emission factors for PM_{10}, and since this factor is uncertain, the heavy metal emission factors will also be uncertain. The content of heavy metals in the particles emitted from tyre wear is based on a Dutch study and can therefore differ from Norwegian conditions and type of tyres used.

3.2.4.8.1.6 Completeness

Tyre wear also leads to emissions of other heavy metal components, such as zinc, nickel etc., but these components are not included in the Norwegian emission inventory.

Until 2004, different methods for calculating the emissions of heavy metals from tyre wear were used. One method was used for calculating emissions of Pb, Cd and Hg (Finstad *et al.* 2001) and another for calculating emissions of Cu, Cr and As (Finstad and Rypdal 2003). From 2004 the same method has been used for all the heavy metal components.

3.2.4.8.1.7 Source specific QA/QC

There is no specific QA/QC procedure for this source. See section 1.6 for the description of the general QA/QC procedure.

3.2.4.8.2 Brake wear

3.2.4.8.2.1 Description

Brake blocks will wear during braking and this generates dust containing various metals. In the inventory, emissions of particles and heavy metals are included from this source.

3.2.4.8.2.2 Method

Particles
Emissions of particles are calculated based on emission factors and annual mileage.

Heavy metals
Emissions of lead, copper and chromium are calculated after a method described in SLB (Stockholms luft- och bulleranalys 1998). The calculations are based on annual brake wear, driven kilometers and the brake blocks' metal content.

Brake wear, private cars and vans
To calculate emissions, brake wear first has to be estimated. It is assumed that private cars change brake blocks every fourth year. The background for this assumption is that private cars, by normal driving, change brake blocks at front after 3 000 - 4 000 thousand kilometers and at the back after 6 000-8 000 thousand kilometers. A private car drives in average 1 500 thousand kilometers each year. Assuming that the brake blocks are changed after 6 000 thousand kilometers, the car will be four years old when blocks first are changed.

The brake blocks at front weigh 0.13-0.15 kg and 0.09-0.11 kg at the back. It is assumed in the calculations that the brake blocks weigh 0.15 kg at the front and 0.11 kg at the back, that the brake blocks are worn 70 per cent before they are changed and that the front and back blocks are changed after 4 000 and 6 000 thousand kilometers, respectively. This gives

equations (3.4) and (3.5):

*(3.4) Front brake blocks (private cars): 0.7*4*0.15/4000*driven thousand kilometer*

*(3.5) Back brake blocks (private cars): 0.7*4*0.11/6000*driven thousand kilometer*

The same method is used for calculating emissions from brake wear for vans and minibuses.

Brake wear, heavy duty vehicles
The number of brake blocks at a heavy duty vehicle varies with both brand and model. It is assumed that each front brake block weighs 2.5 kg and 3.5 kg at the back (Stockholms luft- och bulleranalys 1998). This means that a truck with four wheels have 12 kg of brake blocks. It is assumed that the blocks are changed after 10 000 thousand kilometers when the brake blocks are worn 70 per cent.

Metal content
The metal content in the brake blocks for cars have been tested (Stockholms luft- och bulleranalys 1998). For calculating the emissions from brake blocks, annual brake wear has been multiplied by the metal content. The metal content in the brake blocks in front of the car differs from the content in the brake blocks at the back (table 3.15). For heavy duty vehicles, the metal content is independent of age or type of brake block.

Table 3.15. Metal content in brake blocks. mg/kg

	Private cars		Heavy duty vehicles
	Front	Back	Front and back
Cr	137	73.4	165
Cu	117941	92198	9031
Pb	9052	18655	457

How much of the heavy metal emissions that are emitted to air were investigated by Sternbeck *et al*. (2001). Tunnel experiments showed that approximately 20 per cent of the brake wear emissions were emitted to air. This result is used in the calculations of brake wear emissions.

3.2.4.8.2.3 Activity data

For calculating the emissions of particles, are annual mileage given by the road traffic model, see section 3.2.4.2.

For calculating the emissions of heavy metals, annually driven kilometres are also given by the road traffic model.

3.2.4.8.2.4 Emission factors

Particles
Emission factors recommended by TNO (Institute of environmental and energy technology 2002), based on different European studies, are used (table 3.16).

Table 3.16. Particle emission factors for brake wear. kg/mill. km

	$PM_{2.5}$	PM_{10}	TSP
Private cars (BM1+DM1)	6	6	6
Van (BN1+DN1)	7.5	7.5	7.5
Heavy duty vehicles	32.25	32.25	32.25
MC	3	3	3

Source: TNO (Institute of environmental and energy technology 2002).

Heavy metals
Emission factors for Cr, Cu and Pb are derived based on the above information and are given in table 3.17.

Table 3.17. Heavy metal emission factors for brake wear. g/mill. km

	Private cars and vans	Heavy duty vehicles
Cr	0.36	14.82
Cu	342.33	303.44
Pb	38.16	40.95

3.2.4.8.2.5 Uncertainties
There is high uncertainty in different steps in the emission calculations of heavy metals from brake wear, since many assumptions have been done. For example, there is uncertainty connected to the weight and the metal content of the brake blocks, and to the number of driven kilometres before blocks are changed.

3.2.4.8.2.6 Completeness
Brake wear also leads to emissions of other heavy metal components, such as zinc, nickel etc., but these components are not included in the Norwegian emission inventory.

No other major emission components are assumed missing.

3.2.4.8.2.7 Source specific QA/QC
There is no specific QA/QC procedure for this source. See section 1.6 for the description of the general QA/QC procedure.

3.2.4.9 Automobile road abrasion
NFR 1A3bvii
Last update: 29.01.13

3.2.4.9.1 Description
Asphalt dust is emitted to air while using studded tires. The abrasion layer on asphalt roads can contain approximately 90 per cent stones (rock/minerals) and 5 per cent filler. The rest is bitumen. During studded tyre abrasion, stone materials are worn down to minor particles and will together with detached filler and bitumen whirl up and become airborne. How much dust/particles studded tires generate depends on:

- Weight of the stud
- The road surface resistance against abrasion
- Vehicle velocity
- Share of heavy vehicle
- If the road surface is dry, wet or ice coated

A great share of the dust from studded tyres will bind up to the water film when the road surface is wet. Some of it will however whirl up again when the road surface dries up. This is

not included in the calculation.

Bitumen is a mixture of a great number of organic components, including PAH components. The emissions of PAH from road abrasion are calculated and included in the emission inventory. Calculated emissions of Cd are also included.

PM emissions from road abrasion are declining due to implementation of measures. In the largest cities there is a tax to pay when you drive with studded tyres in the city. This, together with information about problems caused by PM from the authorities, has reduced the numbers of cars with studded tyre both in the cities and all over the country. In addition, the weight of the stud has been reduced and hence also the emissions of PM. Consequently, the emissions are decreasing even though the annual total driving length is increasing. In contrast, emissions from automobile tyre and brake wear are calculated by multiplying the driving length with the emission factor, not taking into account the type of tyres. Since the driving length is increasing the emissions increase.

3.2.4.9.2 Method

Particles

PM_{10}

The method is prepared by TI/SINTEF and documented in Bang *et al.* (1999). For calculating average emission Q (ton/year) of PM_{10} formula (3.6) is used:

$$(3.6) \quad Q_{PM10}\,(ton/year) = \sum_{\text{All vehicle categories}} SPS * n * l * m * p * w * \alpha / 10^6$$

SPS: The specific wear of studded tyres (SPS). Gives an estimate of how much of the road surface that is worn off on one road kilometer of a vehicle with studded tyres

n: Number of cars of a vehicle category in the area

l: Annual mileage for a vehicle category in the area

m: Part of the year with studded tyres in the area (between 0 and 1)

p: Share of the vehicle category using studded tyres

w: Correction factor for wet and frozen road surface. In the calculation of w, frozen surface is given 0, wet surface 0.5 and dry surface 1. If the mileage with studded tyres on a wet and frozen surface respectively is v and x, w = (0.05*v)+(1(1-v-x))

α: Share of the road dust in air that is PM_{10}. There is no data for this factor. The share of PM_{10} on ground is used as a reference. There is very varied data for the size of this factor (Hedalen 1994). Hedalen gives a PM_{10} share of 3-4 per cent. In the calculations 3 per cent is used as a first estimate. Hedalen (1994) states further that the $PM_{2.5}$ share of total road dust is 0.5-1 per cent.

The road surface has stronger wear resistance on roads with heavy traffic than on roads with little traffic. The SPS value can therefore vary with the amount of traffic. SPS values for different ÅDT[5] intervals were estimated based on analysis of track depths over the years 1988-1995 (Norwegian public roads administration 1996).

SPS is also dependent on the weight of the studs. The studs have in the recent years become lighter. The requirement in 1988 was that the stud on light vehicles should not exceed 2.0

[5] ÅDT = Average annual daily traffic

gram, in 1990 this was changed to 1.8 gram, and it changed again in 1992 to 1.1 gram (Norwegian public roads administration 1997). The so-called "light studs" has a weight on 0.7 gram. Studs used on tyres for heavy vehicles could until 1992 weigh 8.0 gram, but this demand was changed to 3.0 gram. There are also other factors influencing the SPS values, for example the road surface wear resistance and the quality of the stone materials used.

SPS values used in the calculations are given in table 3.18. The SPS values are divided on classes of ÅDT (Evensen, *pers. comm.*[6]). Values are given for 1993-1997 and a prediction for 2002. For the years in between a moving average is calculated. For the years after 2002 the 2002 SPS values are used. In the calculations average values for SPS, weighted after the size of traffic load on roads with different ÅDT, are used. The values are given in g/km and are valid for all vehicles. To estimate how much of the emissions that originate from heavy vehicles, it is provided that heavy vehicles wear 5 times more than light vehicles. The vehicle velocity is not given as an own factor, since it is included in the calculation of SPS.

Table 3.18. SPS values. g/km

ÅDT	1973-1980	1981-1987	1988-1992	1993-1997	2002
0-1500	22	20	20	18	16
1500-3000	20	20	18	16	14
3000-5000	16	15	14	12	10
>5000	14	12	11	10	9
Average[1]	17.1	15.6	14.7	13.1	11.6

[1] Weight after traffic load on roads with differerent ÅDT.
Source: Evensen, *pers.comm.*6

Annual traffic load (trafikkarbeid) ($n \bullet l$ in the formula) used in the calculations are annual mileage given by the road traffic model, see section 3.2.4.2.

Use of studded tyres is forbidden in Norway from the first Monday after Easter and until 31st of October. There is an exception from this rule in the three northern counties, Nordland, Troms and Finnmark. In these counties, use of studded tyres is forbidden between 1st of May to 15th of October. It is assumed in the calculations that studded tyres are used the whole period when it is allowed. This means that *m* is 6.5/12 in the northern counties and 5.5/12 for rest of the country.

Shares of traffic load on studded tyres in the five largest towns in Norway are given in table 3.19. There has been a decrease in use of studded tyres in Norway during the latest years. The factor *p* in the formula will therefore vary from one year to another. Information regarding the share of studded tyres originates from the Norwegian Public Roads Administration. There is also national data on share of the car fleet with studded tyres. The data material is based on interviews of car drivers (Norwegian public roads administration 1995a, b, 1998). The questionnaires were given out at daytime and caused that most of the answers were from local car drivers. Accordingly, the survey included too many car drivers with annual mileage over 20 000 km. The survey from 1997 was however done differently. In the calculation program, the studded tyre share was decided to be 0.2. This value was adjusted by the different local road administrations, based on interviews or other available knowledge. In 2000, the Norwegian Public Roads Administration made a new investigation over local use of studded tyre (Johansen and Amundsen 2000). In 2006, Gjensidige made a survey over the use of studded tyres in different counties in Norway, winter 05/06 (Vaaje 2006). For 2001-2004 averages of the two investigations are calculated for the counties. For the five largest cities

[6] Evensen, R. (2007). Note for Johnny Johansen. 14/12 1997. Bærum: ViaNova.

data from the Norwegian Public Roads Administration was used also for 2001-2005, but for the rest of the country the results from Gjensidige (Vaaje 2006) was used. The data are given in table 3.20. For the period 1973-1990 is it assumed that the studded tyre share was 90 per cent.

Table 3.19. Use of studded tyres in five prioritized communities. Share of traffic load with studded tyres. Light duty vehicles

	1998/ 1999	1999/ 2000	2000/ 2001	2001/ 2002	2002/ 2003	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008	2008/ 2009	2009/ 2010
Oslo	51.9	32.4	21.2	31.3	29.2	28.4	24.0	19.9	20.3	17.0	16.4	14.3
Drammen	49.6	48.7	52.1	41.8	42.3	40.6	31.5	27.0	28.0	27.3	22.9	25.0
Stavanger	38.1	31.3	26.8	29.3	28.8	35.2	30.1	32.2	28.4	33.2	19.6	19.0
Bergen	37.0	29.4	28.3	31	30.7	30.4	30.3	29.6	21.4	10.5	14.7	14.3
Trondheim	67	64.4	62.1	44.4	40.2	38.8	38.1	32.9	31.2	19.4	28.6	28.6

	2010/ 2011	2011/ 2012	2012/ 2013
Oslo	14.4	16.1	15.2
Drammen	25.2	25.0	20.6
Stavanger	27.9	28.9	26.8
Bergen	12.3	18.0	16.6
Trondheim	25.8	28.4	35.3

Source: The Norwegian Public Roads Administration.

Table 3.20. Averaged studded tyre share in Norway weighted by traffic load in the different counties. Light duty vehicles

Year	
1990	0.90
1991	0.87
1992	0.88
1993	0.88
1994	0.87
1995	0.86
1996	0.83
1997	0.79
1998	0.70
1999	0.63
2000	0.58
2001	0.56
2002	0.55
2003	0.53
2004	0.51
2005	0.49
2006	0.48
2007	0.46
2008	0.45
2009	0,44
2010	0.43
2011	0.43
2012	0,42

Source: Statistics Norway based on data from the Norwegian Public Roads Administration and Gjensidige.

To calculate the correction factor for humid road surface, traffic load data is used. This is divided into different road conditions after Evensen *(pers. comm.[7])* (table 3.21). Share of wet and dry road surface will change some as a consequence of varied share of studded tyres. In the calculations for 1973-1997 a correction factor is used, based on the estimation that 80 per cent of light duty vehicles and 60 per cent of heavy duty vehicles use studded tyres.

[7] Evensen, R. (1997) Personal information, telephone call 20/11 1997. Bærum: ViaNova.

Table 3.21. Grouping of wet, dry and icy road surface

	In the Norwegian emission inventory
Wet	Wet
Dry	Dry
Slush	Wet
Loose snow	Wet[1]
Hard snow	Hard snow/ice
Bare tracks	80 per cent dry and 20 per cent wet[2]

[1] Assumption made of NILU and Statistics Norway.
[2] Assumption made by Evensen *(pers. comm.,7).*

TSP
Hedalen and Myran (1994) analysed road dust depots from Trondheim and found that 30 weight percentage of the particles were below PM_{10}. This gives a distribution where PM_{10} is 0.3*TSP. This distribution is used in the inventory.

Cd
Emissions of Cd are calculated based on emission factors from Bækken (1993) and annually generated road dust of $PM_{10.}$

PAH
Emissions of PAH are calculated based on emission factors from Larssen (1985) and annually generated road dust of $PM_{10.}$

3.2.4.9.3 Activity data
Cd and PAH
The activity data used for calculating the emissions of Cd and PAH are annually generated PM_{10} of road dust, see sectionr 3.2.4.9.2.

3.2.4.9.4 Emission factors
Particles
The emission factors can be derived from the factors given under 3.2.4.9.2. The emission figures are calculated as a product of SPS values for the given year, the number of kilometers driven, part of the cars with studded tyres, part of the year with winter season, correction for icy surface and the PM_{10} share of the emission (α).The emission factors do not reflect the whirl up of road dust. Heavy duty vehicles whirl up much more than light duty vehicles.

Cd
The Cd content in the bitumen is uncertain. According to Bækken (1993), the Cd content varies between 1.9 and 43 g Cd per tonne road dust. Statistics Norway has chosen an average emission factor of 22.5 g/ton, see table 3.22.

Table 3.22. PAH and Cd emission factors from road dust[1]. g/tonne. PM_{10} of road dust

	Emission factor (g/tonne PM_{10} from road dust)
Norwegian standard (PAH-total)	61.7
PAH-6	24.7
PAH-4	5.5
Cd	22.5

[1] Dry road surface.
Source: Finstad *et al*. (2001).

PAH
The PAH content in the bitumen is uncertain and can vary over time. According to Larssen (1985), the PAH content in airborne dust from wet roads is 330 ppm and 75 ppm from dry

roads. Statistics Norway has chosen 85 ppm. In table 3.17, the emission factor of 85 g/ton is converted to correspond to the PAH components included in NS9815. This gives an emission factor of 61.7 g/ton for PAH-total.

3.2.4.9.5 Uncertainties

Particle distribution of road dust has also been investigated by others than Hedalen and Myran, among them the Norwegain Institute for Air Research (NILU). The results from these measurements show another distribution than Hedalen and Myran, with a PM_{10}-fraction much lower than 30 weight percentage. In the calculation of PM_{10}, data from Hedalen and Myran (1994) are used, and for consistency reasons the same source is used for estimating TSP, despite the uncertainty and the discrepancy with NILUs estimations.

The value of α (PM_{10} share in road dust) is very uncertain. An average velocity is assumed in the calculations. This is further complicated when road surface on roads with high velocities have another wear resistance than other road surfaces.

The emission factor used for calculating Cd emissions is uncertain since it is based on two measurements.

The estimation of the PAH content in road dust from Larssen (1985) is very uncertain, since it is based on only one measurement in Oslo, but it is the only estimate available, and is used in lack of other data.

3.2.4.9.6 Completeness

Major missing emission sources are not likely.

3.2.4.9.7 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

3.2.5 Other sectors

NFR 1A4/1A5
Last update: 28.01.13

3.2.5.1 Description

The source category "Other sectors" includes *all* military combustion, *stationary* combustion in agriculture, forestry, fishing, commercial and institutional sectors and households, motorized equipment and snow scooters in agriculture and forestry, and ships and boats in fishing.

3.2.5.2 Activity data

Motorized equipment is described in section 3.2.4.7.

Households
Use of wood in households for the years after 2005 are based on responses to questions relating to wood-burning in Statistics Norway's Travel and Holiday Survey. The figures in the survey refer to quantities of wood *used*. The survey quarterly gathers data that cover the preceding twelve months. The figure used in the emission calculations is the average of five quarterly surveys. For the years before 2005 figures are based on the amount of wood burned from the annual survey on consumer expenditure. The statistics cover purchase in physical

units and estimates for self-harvest. The survey figures refer to quantities *acquired*, which not necessarily correspond to *use*. The survey gathers monthly data that cover the preceding twelve months; the figure used in the emission calculations (taken from the energy accounts), is the average of the survey figures from the year in question and the following year. Combustion takes place in small ovens in private households.

Figures on use of coal and coal coke are derived from information from the main importer. Formerly, Norway's only coal producing company had figures on coal sold for residential heating in Norway. From about 2000, this sale was replaced by imports from abroad. Figures for LPG are collected from the suppliers. Heavy fuel oil is taken from the sales statistics for petroleum products. As the consumption of each energy carrier shall balance against the total sales in the sales statistics, use of fuel oil, kerosene and heavy distillates in households is given as the residual after consumption in all other sectors has been assessed. Use of natural gas is based on sales figures reported to Statistics Norway from the distributors.

Agriculture
Data on energy use in hothouses are collected in surveys performed regularly. Sales figures are used to project the figures for consumption of oil products in the years between. For biofuels and LPG figures are interpolated for years not included in surveys. The Agricultural Budgeting Board has figures on the use of gasoline, auto diesel and fuel oil in agriculture excluding hothouses. A figure on the minor use of coal was previously collected annually from the only consumer. Since 2002, however, there has been no known use of coal in the Norwegian agricultural activities. Use of natural gas in agriculture, which has increased considerably since it first was registered in 2003, is based on sales figures reported to Statistics Norway from the distributors.

Fishing
Figures on the use of marine gas fuel, heavy distillate and heavy fuel oil are identical with the registered sales to fishing in the sales statistics for petroleum products. In addition to these figures on use in large fishing vessels, a minor figure on estimated use of gasoline in small fishing boats is also included.

Commercial and institutional sectors
Figures on energy use in wholesale and retail trade and hotels and restaurants, are based on a survey for 2000, performed by Statistics Norway. For the following years, figures from this survey have been adjusted proportionally to the development in employment in the industries in question. For earlier years, the figures are based on a survey from the mid-1980s (Sagen 1987). LPG figures for the whole period from 1990 have, however, been estimated separately after consultation with an oil company.

For most other commercial and institutional sectors, the total use of fuel oil appears as a residual after the use in all other sectors has been estimated; the distribution of this residual between sub-sectors is done by using figures on energy use per man-labour year from the energy survey from the mid-1980s.

Use of heating kerosene in commercial industries is calculated by projecting a figure on use from the mid-1980s proportionally with the registered sales to buildings in industrial industries outside the manufacturing industries. The estimated total amount is distributed between sub-sectors by using figures on energy use per man-labour year from the mid-1980s survey.

Use of natural gas is based on sales figures reported to Statistics Norway from the distributors.

Calculated emissions from combustion of biogas at a sewage treatment plant are included for all years since 1993.

Military
Figures on fuel oil are annually collected directly from the military administration, while figures from the sales statistics for petroleum products are used for other energy carriers.

3.2.5.3 Emission factor

Emission factors used are given in Appendix B.

Emission factors for fuel wood are based on data for different oven technologies. Ovens made in 1998 and later have significantly improved combustion and reduced emissions. The factors are weighted based on information from the surveys of the amount of wood burned in ovens with the different technologies. The yearly weighted factors are given in appendix B.

Table 3.23. Emission factors for fuelwood, g/kg dry matter

	Open fireplaces	Ovens -1997	Ovens 1998-
NO_x	1.3	0.97	0.97
CO	126.3	150	50.5
TSP	17.3	22.7	13.4
TSP large cities	17.3	17.4	12.2
PM_{10}	17.0	22.2	13.1
PM_{10}, large cities	17.0	17.1	12.0
$PM_{2,5}$	16.4	21.6	12.7
$PM_{2,5}$ large cities	16.4	16.5	11.6
PAH – total	17.4	52	0.0226
PAH – OSPAR	6.1	8.1	0.0045
PAH - 4	3	2.7	0.0025

Source: PAH : Finstad *et al* (2001), TSP, PM_{10} and $PM_{2.5}$: SINTEF (2013) other pollutants : Haakonsen and Kvingedal (2001).

3.2.5.4 Uncertainties

Uncertainty in *fishing* is described together with navigation in section. 3.2.4.5.5.

The method used for finding the use of fuel oil, kerosene and heavy distillates in households implies a great deal of uncertainty regarding the quality of these figures, particularly for fuel oil, which is the most important of these three energy carriers. Since the late 1990s it also has been necessary to adjust figures for other sectors in order to get consumption figures for households that look reasonable. Hopefully, new surveys will improve the quality of these figures in the future.

As the total use of the different oil products is defined as equal to the registered sales, use in some sectors are given as a residual. This applies to use of heating kerosene and heavy distillates in households, and total use of fuel oil in commercial and institutional sectors. Accordingly, these quantities must be regarded as uncertain, as they are not based on direct calculations. This uncertainty, however, applies only to the distribution of use between sectors - the total use is defined as equal to registered sales, regardless of changes in stock.

There have been large variations in annual sales of military aviation kerosene; as stock changes are not taken into account, the actual annual use is uncertain.

3.2.5.5 Completeness

Major missing emission sources are not likely.

3.2.5.6 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

3.2.6 International bunkers

NFR - memo item
Last update: 31.03.06

3.2.6.1 Description

Emissions from international bunkers (marine and aviation) have been estimated and reported separately from national estimates, in accordance with the IPCC Guidelines. Differences between the IEA (International Energy Agency) data and the data reported to UNFCCC in sectoral data for marine shipping and aviation are due to the fact that different definitions of domestic use are employed. In the Norwegian inventory, domestic consumption is based on a census in accordance with the IPCC good practice guidance. On the other hand, the IEA makes its own assessment with respect to the split between the domestic and the international market.

3.2.6.2 Shipping

3.2.6.2.1 Method

Emissions are calculated by multiplying activity data with emission factors. The sales statistics for petroleum products, which is based on reports from the oil companies to Statistics Norway, has figures on sales for bunkers of marine gas oil, heavy distillates and heavy fuel oil. The same emission factors as in the Norwegian national calculations are used.

3.2.6.2.2 Activity data

Sales figures for international sea transport from Statistics Norway's sales statistics for petroleum products are used for marine gas oil, heavy distillates and heavy fuel oil.

3.2.6.2.3 Emission factor

Emission factors used for *Shipping* are described under *Navigation* in section 3.2.4.5.

3.2.6.3 Aviation

3.2.6.3.1 Method

The consumption of aviation bunker fuel in Norway is estimated as the difference between total purchases of jet kerosene in Norway for civil aviation and reported domestic consumption. Figures on total aviation fuel consumption are derived from sales data reported to Statistics Norway from the oil companies. These data do not distinguish between national and international uses. Data on domestic fuel purchase and consumption are therefore collected by Statistics Norway from all airline companies operating domestic traffic in Norway. The figures on domestic consumption from airlines are subtracted from the total sales of jet kerosene to arrive at the total fuel sales for international aviation. The bottom-up approach of Norway is the detailed Tier 2 CORINAIR methodology. The methodology is

based on detailed information on types of aircraft and number of LTOs, as well as cruise distances.

3.2.6.3.2 Activity data

Statistics Norway annually collects data on use of fuel from the air traffic companies, including specifications on domestic use and purchases of fuel in Norway and abroad.

3.2.6.3.3 Emission factor

Emission factors used for *Aviation* are described under *Aviation* in section 3.2.4.1.

3.3 Energy production (fugitive emissions from fuels)

NFR 1B

3.3.1 Overview

Emission sources included in the inventory from the sector *Fugitive emissions from fuels* are fugitive emissions from coal mining and handling, and from oil and natural gas.

Fugitive emissions from oil and natural gas include emissions from loading and refining of oil, gasoline distribution, and fugitive emissions from the gas terminals on shore. There are also fugitive emissions in connection with venting and flaring offshore.

3.3.2 Fugitive emissions from coal mining and handling

NFR 1B1
Last update: 12.12.2013

3.3.2.1 Description

There are today two coal mines at Spitsbergen (the largest island in the Svalbard archipelago) operated by a Norwegian company. The second mine was opened in 2001. As the Norwegian GHG inventory, according to official definitions, shall include emissions from all activities at Svalbard, also emissions from Russian coal production have been estimated. Until 1998, there was production in two Russian coal mines, Barentsburg and Pyramiden, but since then, production takes place only in the Barentsburg mine. The Norwegian mines and Pyramiden are defined as surface mines, whereas Barentsburg is an underground mine. Russian production has in recent years been considerably smaller than the Norwegian production, and due to a fire that started in 2008 the production in 2008 and 2009 was very small. In autumn 2010, ordinary production was restarted. Russian activity data are more uncertain than the Norwegian, which causes a correspondingly higher uncertainty in the emission figures.

At Svalbard there was a smouldering fire in Pyramiden, the Russian mine that was closed down in 1998. At an inspection in 2005, no emissions were registered, which indicates that the fire had burnt out. Due to lack of data, emissions for earlier years from this fire have not been estimated. However, Norwegian authorities assume that these emissions are limited.

In the most recent emission inventory, emissions from NMVOC and particles from handling of coal are included for the first time.

3.3.2.2 Method

NMVOC
NMVOC emissions from handling of coal are estimated by multiplying the amount of coal extracted (raw coal production) with Tier 2 emission factors from EMEP/EEA Guidebook

2013.

Particles
Emissions of particles from handling of coal are estimated by multiplying the amount of coal extracted (raw coal production) with Tier 1 emission factors from EMEP/EEA Guidebook 2013.

3.3.2.3 Activity data

Figures on Norwegian production (raw coal production) are reported by the plant to Statistics Norway. Russian figures are reported to the Norwegian authorities on Svalbard; these figures are, however, regarded as highly uncertain, consisting of a mixture of figures on production and shipments.

3.3.2.4 Emission factors

NMVOC
Emission factors for NMVOC are taken from EMEP/EEA Guidebook 2013. The Tier 2 factors used are 3 kg NMVOC per tonne coal for surface mines and 0.2 kg NMVOC per tonne coal for underground mines.

Particles
Emission factors for particles are taken from EMEP/EEA Guidebook 2013. The same Tier 1 factors are used for both surface and underground mines. The factors are 0.089 kg particles per tonne coal for TSP, 0.042 kg particles per tonne coal for PM_{10} and 0.005 kg particles per tonne coal for $PM_{2.5}$.

3.3.2.5 Uncertainties

The uncertainty in the activity data concerning Norwegian coal production is regarded as being low. The uncertainty in Russian data is considerably higher.

3.3.3 Fugitive emissions from uncontrolled combustion and burning coal dumps

NFR 1B1
Last update: 07.06.11

3.3.3.1 Description

In 2005, a fire broke out in one of the Norwegian coal mines at Spitsbergen, causing minor emissions.

3.3.3.2 Method

Emissions have been calculated by multiplication of the quantity of coal combusted by standard emission factors for combustion of coal.

3.3.3.3 Activity data

The company operating the mine has provided an estimate on the quantity of coal combusted in the fire.

3.3.3.4 Emission factors

Emission factors for direct-fired furnaces, as given in Appendix B, have been used in the

calculations.

3.3.3.5 Uncertainties

The uncertainty in the activity data, that is the quantity of coal combusted, is unknown. However, as the emissions are small, the uncertainty is insignificant.

3.3.3.6 Completeness

The only fire in a Norwegian coal mine since 1990 is included. Emissions from a smouldering fire in a Russian mine, which is supposed to have lasted for several years, are not included in the emission inventory, due to lack of data. The same applies to another fire in 2008. These emissions are, however, probably insignificant.

3.3.3.7 Source specific QA/QC

There is no specific QA/QC procedure for this source.

3.3.4 Oil and natural gas

NFR 1B2
Last update: 30.05.11

3.3.4.1 Description

1B2a covers emissions from loading and storage of crude oil, refining of oil and distribution of gasoline. Loading, unloading and storage of crude oil on the oil fields off shore and at oil terminals on shore cause emissions of NMVOC. Non-combustion emissions from Norway's two oil refineries (a third was closed down in 2000) include NO_x, NMVOC, SO_2 and particulates. Gasoline distribution causes emissions of NMVOC. Especially from 2007 there has been a shift in the consumption of fuels for road traffic from gasoline to auto diesel. This is mainly due to the introduction of a CO2 tax on passenger cars (PC) from January 1st 2007. This resulted in diesel driven cars becoming less expensive than gasoline driven cars. From 2007 approximately 70 % of all new PCs were diesel driven. This has led to a reduction in the distributed amount of gasoline, and consequently of the NMVOC emissions from this source.

1B2b covers fugitive emissions of NMVOC from gas terminals on shore.

1B2c covers fugitive emissions from venting and flaring. Venting emissions include emissions of NMVOC from exploration and production drilling of gas and oil. The major source is cold vent and leakage of NMVOC from production drilling.

Most of the emissions in *1B2c* come from flaring of natural gas offshore (during both well testing, extraction and pipeline transport) and at gas terminals and flaring of refinery gas at the refineries. This flaring causes emissions of NO_X, NMVOC, SO_2, CO, particulates, PAH and dioxins. There is also some flaring of oil in connection with well testing - amounts flared and emissions are reported to NPD (the Norwegian Petroleum Directorate) and the Norwegian Environment Agency.

The major source in sector 1B2 is flaring of natural gas on the Norwegian continental shelf. Table 3.24 gives an overview over the calculations of the fugitive emissions of NMVOC.

Table 3.24. Fugitive emissions from oil and natural gas. Emission sources, compounds, methods, emission factors and activity data included in the Norwegian GHG Inventory

B Fugitive emissions from fuels	NMVOC	Method	Emission factor	Activity data
1.B.2.a Oil				
i. Exploration	IE	Tier II	CS	PS
ii. Production	IE	Tier II	CS	PS
iii. Transport	R/E	Tier II	CS	PS
iv. Refining/Storage	R	Tier I/II	CS	PS
v. Distribution of oil products	R/E	Tier I	C/CS	CS/PS
vi. Other	NO			
1.B.2.b Natural gas				
i. Exploration	IE	IE	IE	IE
ii. Production/Processing	IE	IE	IE	IE
iii. Transmission	IE	IE	IE	IE
iv. Distribution	IE	Tier II	OTH	CS/PS
v. Other leakage				
industrial plants, power stations	R	Tier II	CS	PS
residential/commercial sectors	NO			
1.B.2.c				
Venting				
i. Oil	IE	Tier II	CS/PS	PS
ii. Gas	IE	Tier II	CS/PS	PS
iii. Combined	R/E	Tier II	CS/PS	PS
Flaring				
i. Oil (well testing)	R/E	Tier II	CS	PS
ii. Gas				
Gas and oil fields	R/E	Tier II	CS	PS
Gas terminals	R/E	Tier I	CS	CS
Refineries	E	Tier I	CS	CS
iii. Combined	IE	Tier I	CS	CS

R = emission figures in the national emission inventory are based on figures reported by the plants. E = emission figures are estimated by Statistics Norway (Activity data * emission factor). IE = Included elsewhere, NO = Not occurring, CS = Country specific, PS = Plant specific, Tier = the qualitative level of the methodology used, C=Corinair, OTH=Other.

3.3.4.2 Method

Loading and storage of crude oil off shore and on shore
NMVOC

From 2003, emission of NMVOC from loading and storage of crude oil on shuttle tankers included in the GHG inventory are based on reported emission figures from the oil companies. Emissions, activity, and to some extent emission factors, are reported from each field operator into the database *Environmental Web*. The database is operated by NPD, the Norwegian Environment Agency and The Norwegian Oil Industry Association (OLF). In addition the field operators each year deliver a report where they describe the activities during the last year.

Before 2003, the emissions of NMVOC were calculated by Statistics Norway. The calculation was based on the field specific amounts of crude oil loaded and stored multiplied with field specific emission factors. Field specific activity data and emission factors (the latter only to the Norwegian Environment Agency) used in the calculation were annually reported by the field operators to Statistics Norway and the Norwegian Environment Agency. Since year 2000 an increasing share of the shuttle tankers have had installed vapour recovery units (VRU), and emissions from loading of crude oil on shuttle tankers with and without VRU were calculated separately for each field. In addition, emission figures were annually reported to the Norwegian Environment Agency and used in the QC of the calculated emission figures.

Only emissions from loading and storage of the Norwegian part of oil production are included

in the inventory. For the Norwegian oil terminals on shore, the emissions from loading of crude oil are reported annually from the terminals to the Norwegian Environment Agency. At one of the terminals VRU for recovering NMVOC was installed in 1996. The calculation of the emissions of NMVOC at the terminals is based upon the amount of crude oil loaded and oil specific emission factors dependent on the origin of the crude oil loaded.

Oil refineries
NO_x, NMVOC, SO_2 and particulates
Emission figures from the oil refineries are reported to the Norwegian Environment Agency, and are after QA/QC procedures used in the emission inventory.

NMVOC emissions are based on measurements carried out by Spectracyne in 2002 and 2005.

Gasoline distribution
NMVOC
Emissions from gasoline distribution are calculated from figures on amounts of gasoline sold and emission factors for, respectively, loading of tanker at gasoline depot, loading of tanks at gasoline stations and loading of cars.

Gas terminals
NMVOC
Fugitive emissions of NMVOC from gas terminals are annually reported from the terminals to the Norwegian Environment Agency.

The emissions are calculated based on the number of sealed and leaky equipment units that is recorded through the measuring and maintenance program for reducing the leakage. The number of sealed and leaky equipment units is collected two times a year and the average number of the countings is used in the calculation. It is assumed in the calculation that a leakage has lasted the whole year if not the opposite is documented.

Measurements of the total emissions were carried out in 2002 and 2003.

Venting
NMVOC
Emissions of NMVOC from cold venting and diffuse emissions for each field are reported annually to the Norwegian Environment Agency from the field operator. The emissions are mostly calculated by multiplying the amount of gas produced with an emission factor for each emission source identified at the field.

Flaring
NO_X, NMVOC, CO, particulates, PAH and dioxins
Emissions from flaring of natural gas off shore are calculated by Statistics Norway on the basis of field specific gas consumption data and emission factors. For NO_X, NMVOC and SO_2, calculated emissions are used in the inventory for the years until 2002. From 2003, emissions of these pollutants from flaring offshore have been reported by the oil companies to NPD and the Norwegian Environment Agency are used in the inventory. The same method is used in the calculation of emissions from flaring in connection with well testing.

Emissions of NO_X from flaring at gas terminals are reported for all years. For NMVOC, emissions are calculated for one gas terminal and reported figures used for the others. Other

emissions from the gas terminals are based on activity data and emission factors.

3.3.4.3 Activity data

Loading and storage of crude oil off shore and on shore
The amount of oil buoy loaded and oil loaded from storage tankers is reported by the field operators in an annual report to the Norwegian Environment Agency and the Norwegian Petroleum Directorate (NPD). The amount of oil loaded on shuttle tankers with or without VRU is separated in the report.

Before 2003, Statistics Norway gathered data on amounts of crude oil loaded at shuttle tankers and stored at storage vessels from the NPD. The data from each field are reported monthly by the field operators to NPD on both a mass and a volume basis. The allocation of the amount of crude oil loaded at shuttle tankers and stored at storage vessels with or without VRU is from the annually report the field operators are committed to deliver to the Norwegian Environment Agency and NPD.

The amount of oil loaded at on shore oil terminals is also reported to the Norwegian Environment Agency and NPD.

Oil refineries
The crude oil throughput is annually reported by the plant to the Norwegian Environment Agency.

Gasoline distribution
Gasoline sold is annually collected in Statistics Norway's sales statistics for petroleum products.

Gas terminals
Activity data that the terminals use in their emission calculations are sampled through the terminals measuring and maintenance program, whose aim is to reduce leakage.

Venting
Amounts of gas produced or handled at the platforms are reported from NPD and used in the QC of the reported emissions.

Flaring
Amounts of gas flared at offshore oil and gas installations are reported monthly by the operators to the Norwegian Petroleum Directorate (NPD). Amounts flared at the gas terminals are reported to NPD and the Norwegian Environment Agency. Amounts of refinery gas flared are found by distributing the total amounts between different combustion technologies by using an old distribution key, based on data collected from the refineries in the early 1990s. This distribution was confirmed in 2003.

3.3.4.4 Emission factors

Loading and storage of crude oil offshore and on shore
For the years before 2003, emission factors used in the calculation of NMVOC emissions offshore are field specific and were reported to the Norwegian Environment Agency and NPD in an annual report. The Norwegian Environment Agency forwarded the emission factors to Statistics Norway. From 2003 the emission figures reported by the field operators are used in the inventory.

The evaporation rate varies from field to field and over time, and the emission factors are dependent on the composition of the crude oil as indicated by density and Reid vapour pressure (RVP). The VOC evaporation emission factors are obtained from measurements, which include emissions from loading and washing of shuttle tankers. For some fields the emission factors are not measured, only estimated. The CH_4 content of the VOC evaporated is also measured so that total emissions of VOC are split between CH_4 and NMVOC.

The emission factors that the field operators use in their calculations are reported to the Norwegian Environment Agency and NPD. They report emissions factors with and without VRU and the split between CH_4 and NMVOC.

Loading on shore: The emission factors are considerably lower at one of Norway's two oil terminals than at the other, because the oil is transported by ship and therefore the lightest fractions have already evaporated. At the other terminal the oil is delivered by pipeline. The latter terminal has installed VRU, which may reduce NMVOC emissions from loading of ships at the terminal by about 90 per cent. NMVOC emissions at this terminal are estimated to be more than 50 per cent lower than they would have been without VRU. However, the VRU technology is not designed to reduce methane and ethane emissions.

Oil refineries
The emission factor used in the calculation of methane emissions from the largest refinery is based upon measurements performed by Spectracyne in 2002 and 2005. The EF is deduced from the measured methane emissions and the crude oil throughput in 2005.

Gasoline distribution
The emission factor for NMVOC from refuelling of gasoline in cars (1.48 kg NMVOC/tonne gasoline) is taken from EEA (2001).

Venting
The emission factors used are listed in table 3.25.

Table 3.25. Emission factors for cold vents and leakage at gas fields offshore

	NMVOC Emission factor	Calculation method
Emission source	[g/Sm3]	
Glycol regeneration	0.065	
Gas dissolved in liquid from K.O. Drum	0.004	
Gas from produced water system	0.03	
Seal oil systems	0.015	
Leaks through dry compressor gaskets	0.0014	
Start gas for turbines[1]	0.4	Tonne per start up
Depressurisation of equipment	0.005	
Instrument flushing and sampling	0.00021	
Purge and blanket gas [1]	0.032	
Extinguished flare	0.014	
Leaks in process	0.007	
Depressurisation of annulus	0.0000005	
Drilling	0.55	Tonne per well

[1] The gas source is standard fuel gas.
Source: Aker Engineering (1992).

Flaring

NO_X: A NO_X emission factor at 1.4 g NO_X/Sm^3 flared gas at off shore installations is based upon studies conducted by (SINTEF 2008). In the study two new experimental laws have been compared with DIAL-measurements of NO_X emissions made on onshore flares.

PM_{10}: The emission factor is based on (McEwen and Johnson 2011). In fig. 7, this paper gives a regression formula for the emission factor as a function of the heating value (GCV) as EF = 0.0578(HV) – 2,09. For Norwegian offshore flaring a heating value of 48 MJ/Sm^3 is suggested in (Bakken *et al.* 2008). This gives an emission factor of 0.856 g PM_{10}/Sm^3.

Other emission factors from flaring of gas are shown in appendix B. The same factors are used for flaring of gas in connection with *well testing*. For flaring of *oil*, the emission factors are shown in the following table.

Table 3.26. Emission factors for flaring of oil in connection with well testing

Compounds (unit)	unit/tonnes flared oil	Source
NO_X (tonnes)	0.0037	(The Norwegian oil industry association 2009)
NMVOC (tonnes)	0.0033	
CO (tonnes)	0.018	
TSP (tonnes)	0.025	Measurements (OLF[1])
PM_{10} (tonnes)	0.0215	Use the same distribution as for combustion of heavy fuel oil in industry (EPA 2002)
$PM_{2.5}$ (tonnes)	0.014	
PAH (kg)	0.012	(The Norwegian oil industry association 1991)
PAH-OSPAR (kg)	0.0024	
PAH-4 (kg)	0.00024	Use the same distribution as for combustion of heavy fuel oil in industry (EPA 1998)
Dioxins (mg)	0.01	Measurements (OLF)

[1]The Norwegian Oil Industry Association (OLF).

3.3.4.5 Uncertainties

The uncertainty in the emission factors for NMVOC (Rypdal and Zhang 2001) from *oil loading* is estimated to be ± 40 per cent and in the activity data ± 3 per cent.

The uncertainty in the amount of gas flared is in regarded as being low, ±1.4 per cent, based on data reported in the emission trading scheme (Climate and Pollution Agency 2011a) and assumptions in Rypdal and Zhang (2000). The uncertainty in NMVOC emissions from venting is much higher than for flaring.

The emission factors for both storage and transmission of natural gas are uncertain, since Austrian factors are used in lack of country specific Norwegian factors.

All uncertainty estimates for this source are given in Appendix C.

3.3.4.6 Source-specific QA/QC and verification

Statistics Norway gathers activity data on oil and gas activities from the Norwegian Petroleum Directorate (NPD). These data are reported monthly by the field operators to NPD. The activity data are quality controlled by comparing them with the figures reported in the field operator's annual report to the Norwegian Environment Agency and NPD. The emissions calculated by Statistics Norway for 1990-2002 are compared with the emission data that the field operators report to the Norwegian Environment Agency and NPD. From 2003, Statistics Norway estimate emissions based on activity data that the field operators monthly report to

NPD, and reported emission factors. When discrepancies are found between the two sets of data these are investigated and corrections are made if appropriate. If errors are found, the Norwegian Environment Agency contacts the plant to discuss the reported data and changes are made if necessary.

The reported emissions from the gas terminals are compared with previous years' emissions.

Statistics Norway collects the activity data used for venting and flaring in the calculation from the NPD. The figures are quality controlled by comparing them with the figures reported in the field operators' annual report to the Norwegian Environment Agency and NPD, and time series are checked.

The calculated emissions are compared with the emission data the field operators have reported to the Norwegian Environment Agency and NPD, before 2003. From 2003 reported emissions are checked by the Norwegian Environment Agency and Statistics Norway. Statistics Norway calculates emissions from reported emission factors and activity data collected monthly by the office of statistics in NPD. When discrepancies are found between the two sets of data this is investigated and corrections are made if appropriate. If errors are found, the Norwegian Environment Agency contacts the plant to discuss the reported data, and changes are made if necessary.

Statistics Norway and the Norwegian Environment Agency perform internal checks of the reported data for venting from the field operators. Some errors in the time-series are usually found and the field operators are contacted and changes are made. The same procedure is followed to check the amount of gas reported as flared. The quality of the activity data is considered to be high, due to the fact that there is a tax on gas flared offshore. NPD has a thorough control of the amount of gas reported as flared.

4 INDUSTRIAL PROCESSES (NFR sector 2)

NFR 2

4.1 Overview

This chapter provides descriptions of the methodologies employed to calculate emissions of greenhouse gases and long-range transboundary air pollutants from industrial processes. Only non-combustion emissions are included in this chapter. Emissions from fuel combustion in the manufacturing industries are reported in the Energy chapter. Emission figures are either reported by plants to the Norwegian Environment Agency or calculated by Statistics Norway, based on emission factors and activity data. The emission factors are collected from different sources, while the activity data used in calculations carried out by Statistics Norway mainly come from official statistics collected by Statistics Norway.

Figure 4.1 shows the trends for the emissions for most of the long-range transboundary air pollutants from industrial processes, relative to 1990. With the exception of NH3, the emissions of all pollutants have decreased since 1990.

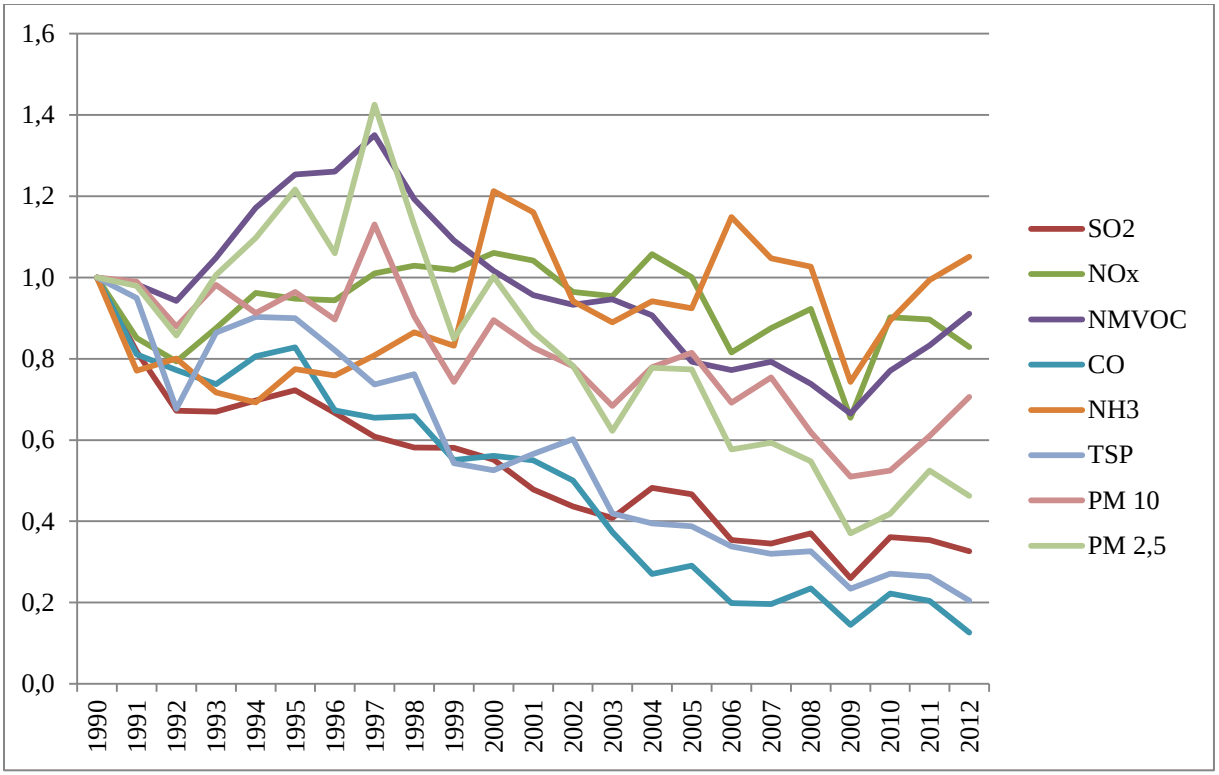


Figure 4.1. Trends for the emissions for most of the long-range transboundary air pollutants from industrial processes (1990 = 1).

4.2 Mineral products

NFR 2A

Last update: 07.02.14

The sector category Mineral products in the Norwegian inventory include emissions from thirteen different products (see table 4.1). SO_2, NOx, NH_3, particles, heavy metals and dioxins are components that are emitted during the production of mineral products and included in the inventory. Table 4.1 shows the various components emitted from the different activities, and

for which components the emission figures in the national inventory are based on figures reported by the plants (R) and for which the figures are estimated by Statistics Norway (E).

Table 4.1. Mineral products. Components emitted and included in the Norwegian inventory[1]

Mineral products	SO_2	NO_x	NH_3	Particles	Heavy metals	Dioxins
-- Cement production	R	NA	NA	R	R	R
-- Lime production	NA	NA	NA	R	R	NA
-- Limestone and dolomite use	NA	NA	NA	R	NA	NA
-- Concrete pumice stone	R	NA	NA	R	NA	NA
-- Rock wool production	NA	R	R	R	R	NA
-- Glass and glass fibre	NA	R	R	R	R	NA
-- Ore mines	R	NA	NA	R	NA	R
-- Mining and extraction of stones and minerals	NA	NA	NA	R	NA	NA
-- Production of mineral white	NA	NA	NA	R	R	NA
-- Construction /repairing of vessels - Sandblasting	NA	NA	NA	R	NA	NA
-- Sandpit and rock-chrushing plants	NA	NA	NA	E	NA	NA
-- Construction and building	NA	NA	NA	E	NA	NA
-- Leather preparing	NA	NA	R	NA	NA	NA

[1] R means that emission figures in the national emission inventory are based on figures reported by the plants. E means that the figures are estimated by Statistics Norway (Activity data * emission factor). NA = Not Applicable.

4.2.1 Cement production

NFR 2A1
Last update: 07.02.14

4.2.1.1 Description

Two plants in Norway produce cement. Production of cement gives rise to both non-combustion and combustion emissions of SO_2. The emission from combustion is reported in chapter 3 Energy. The non-combustion emissions originate from the raw material calcium carbonate ($CaCO_3$). The resulting calcium oxide (CaO) is heated to form clinker and then crushed to form cement. The emissions of SO_2 from non-combustion are reported to The Norwegian Environment Agency.

SO_2 from cement production is emitted from sulphur in the fuel (reported under Energy) and in the raw materials, especially pyrite in limestone. Only the SO_2 from the raw materials should be counted as non-combustion emissions. Particles as well as heavy metals are emitted during the production process. More than 90 per cent of the emission of mercury is due to mercury in the limestone while the emissions of Pb, Cd, Cu, Cr and As originate both from processes and combustion of fuel. Emissions of dioxins are due to the thermal process in the clinker production.

4.2.1.2 Method

SO_2
The plants annually report emissions of SO_2 to the Norwegian Environment Agency. Figures are based on measurements at the plants.

SO_2 emissions from production of cement come from energy carriers like e.g. coal and oil and from limestone. The sulphur from the energy carriers is to a large extent included in the clinker during the process. The emissions are distributed between combustion and non-combustion emissions based on studies conducted by Institute for Energy Technology in 1970 and 1999. Both studies indicate that 80-99 per cent of the sulphur from energy carriers is included in the clinker.

The total SO_2 emissions from the two plants are based on measurements. When the SO_2 emissions reported from the plant are not distributed between combustion and non-combustion emissions, the Norwegian Environment Agencydistributes the total emissions, using the same percentage distribution as in the last year with reported distributed SO_2 emissions. The production technology is to some extent different for the two plants. In the last years, the distribution between combustion and non-combustion emissions is about 10/90 for one plant and 18/82 for the other plant. The difference is assumed to be due to the fact that one plant has a ”by-pass” system where some of the flue gas is not in contact with the raw materials.

The amount of energy carriers used in cement production is subtracted from the energy balance to avoid double counting, see section 3.2.1.2.

Particles
Emissions have been reported to the Norwegian Environment Agency since 1991 for one plant and since 1992 for the other. It is believed that the reported figures also include emissions from combustion. Therefore emissions from combustion of coal, coke and waste oil used in cement production are not calculated, to avoid double counting. The plants have installed particle filter.

Particle size distribution for emitted particles from cement production is found in TNO (Institute of environmental and energy technology 2002). In the Norwegian emission inventory, PM_{10} and $PM_{2.5}$ are assumed to be 85 and 30 per cent of TSP, respectively.

Heavy metals and POPs
Emission figures for heavy metals are reported to the Norwegian Environment Agency. It is believed that these figures also include emissions from combustion. Therefore emissions from combustion of coal, coke and waste oil used in cement production are not calculated, to avoid double counting.

Dioxin figures are reported to the Norwegian Environment Agency. It is also here assumed that the reported figures include emissions from fuel combustion, therefore emissions from combustion are not calculated.

4.2.1.3 Uncertainties
Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

Reported emission figures for particles have varied a great deal as a result of changes the plants have undergone to reduce emissions. There are also uncertain measurements due to annual variations.

Regarding the heavy metals, it has varied when the two plants started reporting the various components, and therefore estimations have been necessary for the years when reporting have been insufficient. The reported figures also vary from a year to another due to process technical conditions, variations in the metal content in the limestone used and uncertain measurements.

4.2.1.4 Completeness
Major missing emission components are not likely.

4.2.2 Lime production

NFR 2A2
Last update: 07.02.14

4.2.2.1 Description

One lime producing plant in Norway reports emissions of particulate matter to the Norwegian Environment Agency.

4.2.2.2 Method

Particles
For one plant, emission figures for particulate matter have been reported to the Norwegian Environment Agency since 1990. Emission figures from 1990 to 1995 are based on calculations, using emission factors and production volume. Since 1996, the figures are a result of measurements at the plant. The plant has installed particle filter.

In the inventory, a particle size distribution suggested by TNO (Institute of environmental and energy technology 2002) is used. PM_{10} is 0.4*TSP while $PM_{2.5}$ is 0.08*TSP.

4.2.2.3 Activity data

The activity data is the input of limestone and dolomite; these amounts are annually reported by the plants to the Norwegian Environment Agency. For two of the plants, the input of limestone is determined by adding up the production volumes of lime (weighed on a scale for trucks). Analysis of the contents of CaO in lime is then used to calculate the input of limestone. For the third plant, the amounts of limestone and dolomite going into the production process are weighed in batches. The weights of these batches are then added to get an annual figure.

4.2.2.4 Uncertainties

The particle distribution used is not specified for the plants, and the particles emitted might therefore have another distribution than the one suggested from TNO (Institute of environmental and energy technology 2002).

4.2.2.5 Completeness

Major missing emission components are not likely.

4.2.2.6 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.3 Limestone and Dolomite Use

NFR 2A3
Last update: 07.02.14

4.2.3.1 Description

One plant report emission of particulate matter from limestone and dolomite use to the Norwegian Environment Agency.

4.2.3.2 Method

Particles
Emissions have been reported to the Norwegian Environment Agency since 2000. Reported figure for 2000 have been used for all years since 1990

Statistics Norway has decided to use the same particle size distribution for production of cement as given in TNO (Institute of environmental and energy technology 2002). PM_{10} and $PM_{2.5}$ are assumed to be 85 and 30 per cent of TSP, respectively.

4.2.3.3 Uncertainties
Uncertainty estimates are given in Appendix C.

4.2.3.4 Completeness
Major missing emission components are not likely.

4.2.3.5 Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.4 Concrete pumice stone
NFR 2A7iii
Last update: 07.02.14

4.2.4.1 Description
Two factories produced concrete pumice stone until 2004 when one of them was closed down. The plants report emissions of SO_2 and particles to the Norwegian Environment Agency. Non-combustion emissions of SO_2 originate from the clay used in the production process.

4.2.4.2 Method
SO_2
Emission figures for SO_2 are reported to the Norwegian Environment Agency, based on measurements at the two manufacturing plants in Norway. The plants have installed flue gas desulphurisation equipment.

Particles
The plants have reported emissions of particles to the Norwegian Environment Agency since 1990. It is assumed that the reported figures include both process and combustion emissions, so emission calculations from fuel combustion are not done for these two plants. The plants have installed particle filters.

No information concerning particle size is found in national or international literature, but the Norwegian Environment Agency assumes that most of the particles emitted from these plants are smaller than PM_{10}. Statistics Norway has decided to use the same particle size distribution for production of cement as given in TNO (Institute of environmental and energy technology 2002). PM_{10} is therefore assumed to be 0.85*TSP and $PM_{2.5}$ is 0.3*TSP.

4.2.4.3 Uncertainties
The particle size distribution used is not specific for production of concrete pumice stone, but

used due to lack of specific size distribution data for this source. The particle size distribution can therefore only be seen as an estimate.

4.2.4.4 Completeness

Particles often contain heavy metals, but type of metals and volumes will depend on the origin of the particles. Metals might therefore be emitted during production of concrete pumice stone. Statistics Norway and the Norwegian Environment Agency have, however, no data available for calculating emissions of heavy metals from this source.

4.2.4.5 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.5 Rock wool production

NFR 2A7iii
Last update: 07.02.14

4.2.5.1 Description

Three plants in Norway produced rock wool until 2003 when one of them was closed down. In the inventory, emission figures for NH_3, particles and heavy metals are included. Particles originate from the cutting of the mineral wool and from fuel used in the production. The emissions of heavy metals are partly due to use of coal/coke, but mainly due to the stone used in the production. Emissions of dioxins and PAHs are neither reported nor calculated since emissions of these components are minor or not occurring.

4.2.5.2 Method

NH_3
Emission figures are reported to the Norwegian Environment Agency. Figures exist from 1992. It is assumed in the inventory that emission figures for 1990 and 1991 are the same as the reported figure in 1992.

Particles
Emission figures are reported to the Norwegian Environment Agency. Most of the emissions come from the spin chamber, and the particle size is assumed to be less than 1 μm. Particles emitted from the fabric filter are also assumed to be smaller than 1 μm. All emissions are therefore set to be smaller than $PM_{2.5}$. All assumptions are made by the Norwegian Environment Agency in accordance with the industry. It is assumed that the reported figures include both non-combustion and combustion emissions. Combustion emissions of particles are therefore not calculated.

Heavy metals and POPs
Emission figures for Pb, Cd, As and Cr have been reported annually from one of the plants to the Norwegian Environment Agency since 1999. The figures are based on measurements. It is assumed that the reported figures include combustion emissions, and emission calculations from fuel combustion are not done for these heavy metals. Statistics Norway has calculated the emission figures for missing years (1990-1998) based on reported figures in 1999 and production rates for previous years. For the two plants not reporting, Statistics Norway calculates emissions based on derived emission factors from the one plant that reports and

production volumes at each plant.

4.2.5.3 Activity data

Production volumes of rock wool are annually reported from the plants to the Climate and Pollution Agency.

4.2.5.4 Emission factors

Heavy metals

A default emission factor is derived for each component (Pb, Cd, As and Cr) based on the annually reported emission figures and production rates from the one plant reporting. The derived emission factors are used to calculate emissions from the two other plants (one of these were closed down in 2003) (table 4.2).

Table 4.2. Emission factors for Pb, Cd, As and Cr from production of rock wool. g/tonne produced rock wool

Component	Emission factors (g/tonne produced rock wool)
Lead (Pb)	0.164
Cadmium (Cd)	0.001
Arsenic (As)	0.031
Chromium (Cr)	0.703

Source: The Norwegian Environment Agency and calculations at Statistics Norway.

4.2.5.5 Uncertainties

Activity data

The activity data is assumed to be of good quality since this is production rates reported from each plant to the Climate and Pollution Agency.

Emission factors

Several conditions influence the emission of heavy metals, such as production rates and raw materials, and these factors can vary from one plant to another. To derive emission factors based on one plant's reported emission figures and production volume and use these factors to estimate emissions at other plants is therefore quite uncertain.

4.2.5.6 Completeness

Major missing emission components are not likely.

4.2.5.7 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.6 Glass and glassfibre production

NFR 2A7iii

Last update: 07.02.14

4.2.6.1 Description

Five plants producing glass or glass fibre are included in the emission inventory, based on emission reports to the Norwegian Environment Agency. A sixth plant also reports emissions of particles to the Norwegian Environment Agency but these emissions are very small and are therefore not included in the inventory. PAH and dioxin emissions are neither calculated nor measured although glass production might be a dioxin.

4.2.6.2 Method

NO_X
The two glass fibre producing plants annually report emission figures for NO_X to the Norwegian Environment Agency. The emission figures are based on calculations.

NH_3
The two glass fibre producing plants annually report emission figures for NH_3 to the Norwegian Environment Agency. The emission figures are based on measurements.

Particles
The two plants producing glass fibre have reported emission figures since 1990 to the Norwegian Environment Agency. The one glass-producer with particle emissions has reported since 1995. Emission figures from 1990 to 1994 were therefore assumed to be the same as reported figures in 1995. This plant was however closed down in 1999.

TNO (Institute of environmental and energy technology 2002) suggests using a particle size distribution of the emissions where $PM_{2.5}$ is 80 per cent of TSP and PM_{10} is 90 per cent of TSP, and this size distribution is used in the Norwegian inventory.

Heavy metals and POPs
Emission of lead has been reported from two glass-producers to the Norwegian Environment Agency. One of them was closed down in 1999. The emission of lead is due to the lead content in the raw material used. Emission of arsenic was reported in the early nineties when one of the plants used raw materials containing arsenic. No arsenic emissions were reported in the period 1993-2004. In 2005, a minor figure was reported, which also has been used for the following years. Emissions of other heavy metals are not reported, so we assume there are not significant emissions.

4.2.6.3 Uncertainties

For the years where reported emission figures for particles do not exist, Statistics Norway has assumed that emissions are in the same order of magnitude as for the first year of reporting. This is uncertain and only an estimate, since it does not consider annual changes in raw materials, production rates, nor possible cleaning devices.

4.2.6.4 Completeness

Production of glass can be a source for dioxin emissions, but no reported figures are available. Emission factors are found in literature, but since activity data (production rate) is not available and it is assumed that the emission factor is dependent on type of glass produced, emissions are not calculated.

Emissions of particles are also reported from three other glass-producers in Norway, but since annual emissions are low (less than 1 tonne), they are not included in the inventory.

4.2.6.5 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.7 Ore mines

NFR 2A7i
Last update: 07.02.14

4.2.7.1 Description

Three ore mines are included in the Norwegian Inventory, but one of the mines was closed down in 1996. Emission figures of SO_2, particles and dioxins are included. The treatment of ore generates emissions of SO_2, and particles are also emitted. Dioxin emissions are due to the thermal process during the pellet production. The ore mine which closed down in 1996, had large dioxin emissions due to the thermal process during the pellet production.

4.2.7.2 Method

SO_2
The ore mine which was closed down in 1996, reported emission figures for SO_2 to the Norwegian Environment Agency. None of the two other ore mines report any non-combustion SO_2 emissions.

Particles
All the three ore mines report emission figures for particles to the Norwegian Environment Agency. Emissions for the two existing ore mines are reported from respectively 1994 and 1996 and it is assumed by Statistics Norway, in accordance with the Norwegian Environment Agency, that emissions for previous years have been in the same order of size.

The size distribution used in the Norwegian inventory is according to TNO (Institute of environmental and energy technology 2002) (table 4.3).

Table 4.3. Particle size distribution for particles emitted from ore mining. Ratio X[1]/TSP

Component	Particle size distribution (ratio)
TSP	1
PM_{10}	0.49
$PM_{2.5}$	0.07

[1] X is either $PM_{2.5}$, PM_{10} or TSP.
Source: TNO (Institute of environmental and energy technology 2002).

Dioxins
Emissions of dioxins are registered only for the ore mine which was closed down in 1996. Emission figures were first reported to the Norwegian Environment Agency in 1994 and emissions for previous years have been assumed by Statistics Norway, in accordance with the Norwegian Environment Agency, to be in the same order of size as the reported figure in 1994.

4.2.7.3 Uncertainties

For years where reported emission figures do not exist for particles and dioxins, Statistics Norway has assumed, in accordance with the Norwegian Environment Agency, that the emissions are in the same order of size as for the first year of reporting. This is uncertain and a result of lack of better data. The size of the particles emitted from ore mining will also depend on the type of ore and production process. The particle size distribution used in the inventory does not consider these differences.

4.2.7.4 Completeness

SO_2 emissions are only included in the inventory for the ore mine that was closed down in

1996. The SO_2 emissions from the two other ore mines are not included in the inventory.

4.2.7.5 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.8 Mining and extraction of stones and minerals

NFR 2A7i
Last update: 07.02.14

4.2.8.1 Description

Mining and extraction of stones and minerals are done by several plants. Particles are emitted during these processes.

4.2.8.2 Method

Particles
Emission figures are reported to the Norwegian Environment Agency. Reported figures exist from 1992. Emission figures for 1990 and 1991 are assumed by Statistics Norway, in accordance with the Norwegian Environment Agency, to be the same as reported figures in 1992. An exception is one plant, which only reported emissions for 1992. For this plant, Statistics Norway has calculated emissions based on production rates for previous and later years.

It is given for most plants that they use fabric filter or textile fibre to clean their particle emissions. It is assumed by the Norwegian Environment Agency that the particles emitted are larger than PM_{10}. The Norwegian inventory uses the size distribution recommended by TNO (Institute of environmental and energy technology 2002) for sandpits and rock-crushing plants (table 4.4).

4.2.8.3 Uncertainties

For years where reported emission figures do not exist, Statistics Norway has assumed that emissions are in the same order of size as for the first year of reporting. This is uncertain and a result of lack of better data. The size of the particles emitted from mining and extraction will also depend on the type of stone/mineral and production process. The particle size distribution used in the inventory does not consider these differences.

4.2.8.4 Completeness

Emission of particles is often a source of heavy metal emissions since particles often contain heavy metals. Type of metals will however depend on the origin of the particles. Metals might therefore be emitted during mining and extraction of stones and minerals. There are, however, no data available for calculating emissions of heavy metals.

4.2.8.5 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.9 Production of mineral white (plaster)

NFR 2A7iii
Last update: 07.02.14

4.2.9.1 Description

Two plants producing mineral white in Norway are included in the inventory with their emissions of mercury and particles. The mercury content in the raw materials leads to emission of mercury, and during the production process, particles are emitted.

4.2.9.2 Method

Particles

Emission figures are reported to the Norwegian Environment Agency. Reported emission figures exist since 1992 and figures for 1990 and 1991 are assumed by Statistics Norway, in accordance with the Norwegian Environment Agency, to be the same as the figures reported in 1992. The particles are purified through a fabric filter, and it is assumed by the Norwegian Environment Agency that the particles emitted after the filter are smaller than PM_{10}.

According to TNO (Institute of environmental and energy technology 2002), $PM_{2.5}$ is 30 per cent of TSP, while PM_{10} is assumed to be the same as TSP. The Norwegian inventory uses this distribution.

Heavy metals

The plants have reported emission figures to the Norwegian Environment Agency since 2000. For one of the plants, historical emissions are based on reported figures for 2000 and production volumes. For the other plant, emission figures for 1990-1999 are assumed to be the same as the reported figure for 2000, due to lack of production data for previous years. Annual emissions are assumed to be low.

4.2.9.3 Activity data

Production volumes for calculation of historical emissions of mercury for one of the plants are reported to the Norwegian Environment Agency.

4.2.9.4 Emission factors

Emission factors for mercury are derived from historical calculations for one plant, based on reported figures for the first year of reporting and production volumes.

4.2.9.5 Uncertainties

Historical emissions of mercury for both plants are uncertain. For one plant, the emission figures are based on a derived emission factor and production volumes and do not take into account changes in raw materials and possible cleaning devices. For the other plant, it is assumed, due to lack of historical production data, that the historical emissions are the same as the reported figures for 2000. This is just an estimate and does not consider annual changes in raw materials, production rates, or possible cleaning devices.

The particle size distribution used in the inventory is not specific for the plants. The particles emitted might therefore have another distribution than the one suggested by TNO, which is used in the inventory.

4.2.9.6 Completeness

Major missing emission components are not likely.

4.2.9.7 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.10 Construction and repairing of vessels - Sandblasting

NFR 2A7iii
Last update: 07.02.14

4.2.10.1 Description

Five plants constructing and repairing vessels are included in the inventory with their particle emissions. One of the plants was closed down in 2000. Emission of particles is due to the different processes during construction and repairing of vessels, but most of the particles are emitted from sandblasting.

4.2.10.2 Method

Particles
Emission figures are reported to the Norwegian Environment Agency.

For four of the five plants, there are no information regarding cleaning device, but it is assumed by the Norwegian Environment Agency that they have fabric filter and/or wet washer. For the last one, particle emissions are purified in cyclones, and the size of the particles emitted is larger than PM_{10}.

It is difficult to decide particle size of the particles emitted based on the above information. It is however assumed by the Norwegian Environment Agency that most of the particles are larger than PM_{10} and therefore all particles are assumed to be TSP.

4.2.10.3 Uncertainties

The size of the particles emitted is uncertain and will depend on the cleaning device used at each plant. The different activities during construction and repairing can also result in emission of particles of different sizes.

4.2.10.4 Completeness

Emission of particles is often a source of heavy metal emissions since particles often contain heavy metals. Type of metals will however depend on the origin of the particles. Metals might therefore be emitted during sandblasting and repairing/construction of vessels. There are however no data available for calculating emissions of heavy metals.

4.2.10.5 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.11 Sandpit and rock-crushing plant

NFR 2A7iii
Last update: 01.09.05

4.2.11.1 Method

Particles will be emitted during crushing of rocks and at sandpits. In the inventory, emissions

are estimated based on the production of sand and crushed stone from the production statistics at Statistics Norway, and emission factors recommended by Fontelle *(pers. comm.[8]).*

4.2.11.2 Activity data

The production of sand and crushed stone is annually given by Statistics Norway's production statistics.

4.2.11.3 Emission factors

The emission factors used are based on Fontelle (*pers. comm.*[8]) (table 4.4).

Table 4.4. Particle emission factors for sandpits and rock-crushing plants. Ratio X[1]/TSP

Component	g/tonne produced
TSP	160
PM_{10}	60
$PM_{2.5}$	0

[1] X is either $PM_{2.5}$, PM_{10} or TSP.
Source: Fontelle *(pers. comm.[8]).*

4.2.11.4 Uncertainties

This emission source is highly uncertain since the emissions will vary from one place to another depending on the different processes in use, type of raw materials and of course the activity level. Little information is available in the literature. The emission factors used are only based on one source and are uncertain. In addition, there is uncertainty regarding the activity data. The PRODCOM codes used in the production statistics include total production of sand and crushed stone in Norway, but some of it might not be relevant for these calculations.

4.2.11.5 Completeness

Emission of particles is often a source of heavy metal emissions since particles often contain heavy metals. Type of metals will however depend on the origin of the particles. Metals might therefore be emitted during crushing at sandpits and rock-crushing plants. There are however no data available for calculating emission of heavy metals.

4.2.11.6 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.12 Construction and building

NFR 2A7ii
Last update: 01.09.05

4.2.12.1 Description

Construction and building includes a lot of different activities that will generate particle emissions.

4.2.12.2 Method

Particles
Emission factors and activity data are used to estimate the Norwegian emissions.

[8] Fontelle, J.P. (2002). Personal information (e-mail correspondence), April 2002, CITEPA.

4.2.12.3 Emission factors

The emission factors used are based on an evaluation the French institute CITEPA made of different emission factors from this source and their calculation of average emission factors for TSP, PM_{10} and $PM_{2.5}$ (table 4.5).

Table 4.5. Particle emission factors for building and construction. Tonne/hectare/year

Component	Tonne/hectare/year
TSP	9.79
PM_{10}	1.52
$PM_{2.5}$	0.52

Source: Fontelle (*pers.comm.*[8]).

4.2.12.4 Activity data

The activity data used is the annual area of completed buildings from the building statistics at Statistics Norway.

4.2.12.5 Uncertainties

The particle emissions depend on climate conditions as well as building traditions and building materials. Since the emission factors used are based on surveys in other countries than Norway, these factors might not be ideal for Norwegian conditions.

4.2.12.6 Completeness

Building of roads, railways, tunnels and demolition of buildings is also a source of particle emissions, but no emission factors are found in the literature, and therefore such emissions are not included in the inventory.

4.2.12.7 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.2.13 Leather preparing

NFR 2A7iii
Last update: 07.02.14

4.2.13.1 Method

NH_3

NH_3 is used to adjust the pH level in the fattening and colouring process in leather preparing. This means that NH_3 is dissolved in an aqueous solution to feed fatty substances to leather. One plant reports emission figures for NH_3 to the Norwegian Environment Agency. Emission figures are available from 1994. Emissions for the years 1990-1993 are assumed by Statistics Norway and the Norwegian Environment Agency to be the same as the reported figure for 1994. The emission of NH_3 reported by the plant is equal to the consumption of NH_3.

4.2.13.2 Uncertainties

It is not clear if it is correct to assume that all NH_3 consumed is emitted to air. This assumption may have to be revised.

4.2.13.3 Completeness

Major missing emission components are not likely.

4.2.13.4 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3 Chemical Industry

NFR 2B
*Last update: 07.02.*14

In the Norwegian emission inventory, there are 14 different activities included under chemical industry. Nearly all emission figures from this industry included in the inventory are reported from the plants to the Norwegian Environment Agency. Production of carbides causes emissions of many components, but most of the other activities within the sector chemical industry cause only emissions of one or two components (table 4.6).

Table 4.6. Chemical industry. Components emitted and included in the Norwegian inventory

	CO	NO_X	NMVOC	SO_2	NH_3	PM	HM	POP
Production of:								
Ammonia	NA	IE[1]	NA	NA	NE	NA	NA	NA
Nitric acid	NA	R	NA	NA	R	R	NA	NA
Other fertilisers ..	NA	R	NA	NA	R	NA	NA	NA
Silicon carbide ...	E	NA	R	R	NA	R	R	R
Calcium carbide .	NA	R	R	NA	NA	R	R	NA
Methanol	NA	NA	R	NA	NA	NA	NA	NA
Titanium dioxide..	NA	NA/R	NA	R	NA	R	R	NA/R
Sulphuric acid	NA	NA	NA	R	NA	NA	NA	NA
Plastic	NA	NA	R	NA	R	R	NA	R
Explosives	NA	R	NA	NA	NA	NA	NA	NA
Chloralkali	NA	NA	NA	NA	NA	NA	R	NA
Pigments	NA	NA	NA	NA	NA	NA	R	NA
Soap	NA	NA	NA	NA	NA	R	NA	NA
Paint/varnish.....	NA	NA	NA	NA	NA	R	NA	NA

E = Figures estimated by Statistics Norway.
R = Figures reported by the plant to the Norwegian Environment Agency.
NA = Not Applicable.
IE = Included Elsewhere.
[1] Included in reported figures for nitric acid and other fertilisers.

4.3.1 Production of fertilisers

4.3.1.1 Ammonia Production

NFR -
*Last update: 07.02.*14

NO_X
During the production of ammonia there are some non-combustion emissions of NO_X. These emission figures are included in the reported NO_X emission from nitric acid production and production of other fertilisers.

4.3.1.2 Production of nitric acid

NFR 2B2
Last update: 27.05.10

4.3.1.2.1 4.3.1.2.1. Description

There are two plants in Norway where nitric acid is produced. Nitric acid is used as a raw material in the manufacture of nitrogenous-based fertiliser. The production of nitric acid (HNO_3) generates NO_x as by-products of high temperature catalytic oxidation of ammonia (NH_3). The production of nitrogenous-based fertiliser also leads to emissions of particles.

4.3.1.2.2 4.3.1.2.2. Method

NO_2 and NO_x

The two plants report the emissions of NO_X to the Norwegian Environment Agency.

NH_3
Emission figures for NH_3 are annually reported to the Norwegian Environment Agency.

Particles
Both plants report emission figures to the Norwegian Environment Agency and have done so since 1990 and 1992. One of the plants has also reported emissions from combustion, but since it is only 1 per cent of the non-combustion emissions, these figures are included in the figures for non-combustion emissions. For this plant, there is no information regarding cleaning devices and size of the particles emitted, but the Norwegian Environment Agency assumes that the particles are smaller than PM_{10}. For the other plant, a fabric filter was installed in the beginning of the 1990s.

In lack of plant specific information regarding particle size distribution of the emitted particles, Statistics Norway uses the distribution given by TNO (Institute of environmental and energy technology 2002) for production of nitrogenous-based fertilisers where PM_{10} is 0.8*TSP and $PM_{2.5}$ is 0.6*TSP.

4.3.1.2.3 Uncertainties
Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

There is uncertainty regarding the size of the particles emitted since there is no plant specific information available. The distribution recommended by TNO is used in lack of other data.

4.3.1.2.4 Completeness
Major missing emission components are not likely.

4.3.2 Carbide production
NFR 2B4
Last update: 07.02.14

4.3.2.1 Description
Silicon carbide was produced at three plants until 2006 when one plant was closed down. Previously, calcium carbide was produced at one plant. This plant was closed down in 2003.

4.3.2.2 Silicon carbide

4.3.2.2.1 Description
Silicon carbide (SiC) is produced by reduction of quartz (SiO_2) with petrol coke as a reducing agent.

(4.2) $SiO_2 + 3C \rightarrow SiC + 2CO$
$CO \xrightarrow{O_2} CO_2$

In the production of silicon carbide CO are released as by-products from the reaction between quartz and carbon. Sulphur, NMVOCs, particles, heavy metals and PAH may also be emitted during the production process. Sulphur originates from the petrol coke.

4.3.2.2.2 Method

NMVOC
Emission figures are reported to the Norwegian Environment Agency by the plants. The emissions are calculated by multiplying annual production of silicon carbide by an emission factor. From 2007 and onwards, the emission factor is based on measures made once a year. For previous years, an average of the measured emissions in 2007 and 2008 is applied.

CO
The emissions of CO are calculated by Statistics Norway from the consumption of petrol coke and an emission factor in accordance with the IPCC Guidelines (IPCC 1997a).

SO_2
Emission figures are reported to the Norwegian Environment Agency by the plants. The emissions are calculated from the consumption of petrol coke in dry weight and the sulphur content in the coke. It is assumed that 3 per cent of the sulphur is left in the product or as wastage.

Particles
Emission figures for particles are reported to the Norwegian Environment Agency. Two of the plants have reported since 1990 while the third has reported since 1991. Emission figures for 1990 for this plant are assumed by Statistics Norway and the Norwegian Environment Agency to be the same as the reported figure for 1991. For one of the plants, reported figures have not been used in the inventory for 1990-1993, since the plant means these emission figures are not representative, but a result of different measurement and calculation methods. For this plant, reported emission figures for 1994 have been used for 1990-1993.

There is no detailed information about the particle size distribution for the emissions from silicon carbide production. The Norwegian Environment Agency assumes the emissions have the same particle size distribution as emissions of particles from production of ferroalloys, where all particles are expected to be smaller than $PM_{2.5}$. This is however an uncertain estimate. This leads to a distribution where $TSP=PM_{10}=PM_{2.5}$.

Heavy metals
Emission figures have been reported to the Norwegian Environment Agency since 1999/2000. For Pb, Hg and Cd, historical emissions are based on emission factors derived from reported emission figures and production rates for the first year of reporting. Using these emission factors for each plant together with production rates for previous years, historical emissions have been calculated. Cd is reported from one plant for the years after 1992. The calculations for Pb and Cd have been corrected for dust regulations, while emissions of mercury are not affected by these regulations.

Historical emissions of Cu, Cr and As are based on dust emissions for each plant. This has been recommended by the Norwegian Environment Agency, since historical production rate data lack for some years and because changes in emissions will be easier to find when installation of dust control systems reduces the emissions of these metals. Emissions of As are reported to the Norwegian Environment Agency from one plant. Reported figures exist since 1992, and emissions in 1990 and 1991 are assumed to be the same as reported figures in 1992.

Emission figures for Cu, Cr and Pb are annually reported for all the three plants. In 1999, the plants also reported Hg and Cd due to a heavy metal investigation under the leadership of the Norwegian Environment Agency. After 1999, the plants have not been required to report

these metals due to low emissions. Still, one of the plants have reported Cd and Hg figures for all following years, whereas another has reported only Cd; for this plant the 1999 figure for Hg has been used for all later years. For the plant which now has been closed down, the 1999 figures for both Cd and Hg have been used for all later years when the plant still was operating.

POPs
Emission figures for PAH are reported from the plants to the Norwegian Environment Agency. Two of the plants have reported emissions since 1991, while the third one has only reported since 1997. Historical emissions back to 1990 have been calculated based on production rates and an emission factor derived from the first year of reporting and production rate for that year. No PAH profile is available for this source, so lacking of other information, the same profile as for aluminium production is used (table 4.7). No emissions of dioxins are reported or calculated.

Table 4.7. Distribution of PAH emissions from silicon carbide production. Ratio X[1]/PAH

Component	Distribution of PAH emissions (ratio)
PAH (Norwegian standard)	1
PAH-6 (OSPAR)	0.3
PAH-4 (CLRTAP)	0.15

[1] X is either PAH, PAH-6 or PAH-4.
Source: Finstad *et al*. (2001).

4.3.2.2.3 Activity data
The activity data used by the plants for the calculation of SO_2 emissions is the consumption of petrol coke in dry weight. The activity data used by Statistics Norway for the calculation of CO emissions is the consumption of petrol coke reported to Statistics Norway. Historical calculations of particle emissions are based on annual production rates and dust emission figures reported to the Norwegian Environment Agency.

4.3.2.2.4 Emission factors

CO
CO emissions are calculated from the consumption of petrol coke, using a factor of 0.4 tonnes CO/tonnes petrol coke, as recommended by Rosland (1987).

NMVOC
From 2007 and onwards the emission factor is based on measurements made once a year. The emission factors for 2007 are 10.906 tonne NMVOC/kilotonne Sic for one of the plants in operation and 10.84 tonne NMVOC/kilotonne Sic for the other. For previous years, the emission factor for the latter plant has been more or less constant whereas the emission factor for the first plant varies.

4.3.2.2.5 Uncertainties
Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

Heavy metals
The historical calculations for heavy metals are based on derived emission factors for each plant and either production or dust data for previous years, and can only be seen as estimates. The emission figures reported also vary from one year to another, and this is assumed to be, in addition to differences in raw materials, a result of few and uncertain measurements. For the one plant that has not reported emission figures for Hg and Cd since 1999, the same emission

figures as those reported in 1999 are used for later years. For the other plant, emissions of Cd have been reported for all years since 1992. Emission figures for Hg have not been reported since 1999. The emission figure for 1999 is used for later years. This is also highly uncertain, but the emission figures are very small and have only marginal impact on the total emissions of these metals.

Particles
The particle size distribution used is not specific for production of silicon carbide, but used due to lack of specific size distribution data for this source. The particle size distribution can therefore only be seen as an estimate. For the years where reported emission figures do not exist, Statistics Norway has assumed that emissions are in the same order as the first year of reporting. This is uncertain and a result of lack of better data.

4.3.2.2.6 Completeness
Major missing emission components are not likely.

4.3.2.3 Production of calcium carbide
NFR 2B4
Last update: 07.02.14

4.3.2.3.1 Description
One plant in Norway was producing calcium carbide until 2003. The production of calcium carbide generates CO_2 emissions when limestone is heated and when petrol coke is used as a reducing agent. The process can be described through the following equations:

(4.3) $CaCO_3 \rightarrow CaO + CO_2$
which takes place when limestone (calcium carbonate) is heated.

and
(4.4) $CaO + C\ (petrol\ coke) \rightarrow CaC_2 + CO$
(4.5) $CO \xrightarrow{O_2} CO_2$

where petrol coke is used as a reducing agent to reduce the CaO to calcium carbide.

Some of the carbon from petrol coke will be sequestered in the product, but not permanently. Thus, this carbon is included in the emission estimate. NMVOC originates from the use of petrol coke in the production process, and NO_x is mainly produced during the high temperature oxidation of nitrogen in the air. Particles are also emitted during the production process. Emission of heavy metals is a result of the heavy metal content in the raw materials.

4.3.2.3.2 Method

NO_x
Emission figures for NO_x were annually reported to the Norwegian Environment Agency. The reported values are based on calculations.

NMVOC
Reported figures were annually reported to the Norwegian Environment Agency, based on calculations.

Particles
Emission figures for particles were reported from 1992. Figures for 1990 and 1991 are assumed to be the same as for 1992. It does not exist any detailed information about the particle size distribution of the emissions from calcium carbide production. The Norwegian Environment Agency assumes that the emissions are in the same order as emission of particles from production of ferroalloys, where all particles are expected to be smaller than $PM_{2.5}$. This is however an uncertain estimate. A particle size distribution where PM_{10} and $PM_{2.5}$ is expected to be the same as TSP, is used in the Norwegian Inventory.

Heavy metals and POPs
Emission figures for heavy metals were reported to the Norwegian Environment Agency from 1999. Historical emissions are calculated based on production rates for Pb, Cd and Hg, and based on particle emissions for As, Cu and Cr (see section 4.3.2.3.3).

No emission figures for PAH or dioxins are available.

4.3.2.3.3 Activity data
Particle emissions used in the calculations of As, Cu and Cr have been reported to the Norwegian Environment Agency.

4.3.2.3.4 Uncertainties
Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

Heavy metals
Historical emissions are based on a derived emission factor for the first year of reporting (1999) and calculated with production/particle emission figures for previous years. This is uncertain and only an estimate in lack of other data.

Particles
The particle size distribution used is not specific for production of calcium carbide, but used due to lack of specific size distribution data for this source. The particle size distribution can therefore only be seen as an estimate. For the years where reported emission figures do not exist, Statistics Norway has assumed that emissions are in the same order of magnitude as for the first year of reporting. This is uncertain and a result of lack of better data.

4.3.2.3.5 Completeness
Major missing emission components are not likely.

4.3.3 Manufacture of other inorganic chemicals
NFR 2B5
Last update: 07.02.14

4.3.3.1 Production of methanol

4.3.3.1.1 Description
One plant in Norway produces methanol. Natural gas and oxygen are used in the production of methanol. The conversion from the raw materials to methanol is done in various steps and on different locations at the plant. NMVOC are emitted during the production process. Emissions from flaring of natural gas in connection with production of methanol are now reported under 2B5, as recommended by IPCC's review team.

4.3.3.1.2 Method

The plant reports emission figures for NMVOC and NO_x, to the Norwegian Environment Agency. The reported emissions are based on measurements. Emissions from flaring of natural gas are estimated by multiplying the amount of gas flared with the emission factors shown in table 4.8.

Table 4.8. Emission factors for flare

Component	Flare natural gas
	kg/1000 Sm^3
SO_2	0
CO	1.5
NO_x	[2]
Particles	0.0018
NMVOC	0.06
	mg/tonne
Pb	0.25
Cd	1.7
Hg	1
Cu	16
Cr	21
As	3.8
Dioxins	0.00005
PAH	15.3
PAH-4	0
PAH-Ospar	0.85

[1] Reported to the Norwegian Environment Agency since 2000. [2] Reported to the Norwegian Environment Agency.

4.3.3.1.3 Uncertainties

Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

4.3.3.1.4 Completeness

Major missing emission components are not likely.

4.3.3.2 Production of titanium dioxide

NFR 2B5
Last update: 07.02.14

4.3.3.2.1 Description

One plant in Norway produces titanium dioxide. The ore is crushed and pulverized in mills. The crushed raw material is separated in various steps. Ilmenite and the by-product magnetite are cleaned during acid treatment and flotation. The ilmenite concentrate is drained and the water content is reduced to approximately 3.5 per cent. Emissions of SO_2, heavy metals and particles from the plant are included in the inventory. The particle emissions are a result of the crushing of the ore in the mills and from the annealing furnace, while the heavy metal emissions are due to the metal content in the raw material used.

Another plant produces titanium dioxide slag and also pig iron as a by-product. The raw material is the mineral ilmenite, and coal is used as a reducing agent. SO_2 originates from the sulphur in the reducing agent used, while NO_x is produced primarily by the high temperature oxidation of nitrogen in the air. Heavy metal emissions are due to the metallurgical melting process and the content of heavy metals in the raw materials used.

4.3.3.2.2 Method

SO_2
The emission figures for SO_2 are based on calculations and are reported annually to the Norwegian Environment Agency.

NO_x
The emission figures for NO_x for the plant producing titanium dioxide slag are estimated and reported to the Norwegian Environment Agency.

Particles
Since 1990, emissions of particles have been reported annually to the Norwegian Environment Agency. The particles are assumed to be of a size less than $PM_{2.5}$.

Heavy metals and POPs
Both plants report emission figures to the Norwegian Environment Agency. One plant reported emission figures for Pb, Cd and Hg for the period 1990 to 1999. After 1999, there has not been any reporting, as a result of very small emission figures. No emissions of persistent organic pollutants are reported or calculated.

The other plant reports emission figures for Pb, Cd, Cr, Cu, As and Hg. Emissions exist from 1990, 1992 or later, depending on type of heavy metal. For dioxins and PAH, reported figures have only been available from 1999. In lack of production rate data for previous years, it has been assumed that yearly emissions are the same as in the first year of reporting.

4.3.3.2.3 Uncertainties
Heavy metals and POPs
Reported emission figures vary from one year to another, partly due to differences in raw materials, but mainly as a result of uncertain measurements. The reported figures are based on a limited number of measurements, and the emissions will vary from minute to minute, since the production of pig-iron is a non-continuous process. For the years where reported emission figures do not exist, Statistics Norway has assumed that emissions are in the same order as the first year of reporting. This is uncertain and a result of lack of better data.

Particles
The particle size distribution used is only an assumption, and we can not preclude that the distribution is different from the one used in the inventory.

4.3.3.2.4 Completeness
Major missing emission components are not likely.

4.3.3.2.5 Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.3.3 Production of sulphuric acid
NFR 2B5
Last update: 07.02.14

4.3.3.3.1 Description
Three plants in Norway produced sulphuric acid until March 2006 when one of them was closed down. The production of sulphuric acid leads to emissions of SO_2. All the three plants report the emissions from the production to the Norwegian Environment Agency, but only one plant have specified that the emissions come from the production of sulphuric acid. For the two other plants, the emissions have been included in the reported emissions from the plants' main production (production of nickel and zinc, respectively).

4.3.3.3.2 Method
The plant reports annually emission figures for SO_2 to the Norwegian Environment Agency. The reported figures are based on measurements.

4.3.3.3.3 Uncertainties
No source specific uncertainty is known.

4.3.3.3.4 Completeness
Major missing emission components are not likely.

4.3.3.3.5 Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.3.4 Production of plastic
NFR 2B5
Last update: 07.02.14

4.3.3.4.1 Description
Three plants report emissions to the Norwegian Environment Agency under this source category. One of the plants produces ethylene, one propylene and polyethylene and the third plant has vinyl chloride production. Two of the reporting plants were merged up to 2001.

Various components are emitted during the production of plastic. NMVOC emissions are from leakages in the process.

During the production process of ethylene and vinyl chloride there is an oxide chloride step for production of ethylene chloride, followed by cracking to vinyl chloride monomer and hydrochloric acid. Various chloride components are produced during these processes, including dioxins. However, most of the dioxins end up in the EDC-tar, which is combusted in an own chloride recycling installation. Particles (PVC-dust) are also emitted during the production of vinyl chloride.

Emissions from flaring of fuel gas in connection with production of plastic are now reported under 2B5.

4.3.3.4.2 Method

NH_3 and NMVOC
Emission figures are annually reported to the Norwegian Environment Agency. Reported NMVOC emissions are based on measurements. The emissions of NH_3 are regarded as equal to use. As some of the ammonia is stored in the product, the emissions are probably somewhat overestimated.

Particles
Emission figures have been reported to the Norwegian Environment Agency since 1992. Emission figures for 1991 and 1990 are assumed to be the same as reported figures in 1992. The particle emissions have decreased since 1996 as a result of installation of cleaning devices. The emissions are purified in cyclones, but there is no available information regarding particle size. In lack of plant specific information, the distribution

TSP=PM_{10}=$PM_{2.5}$, as in TNO (Institute of environmental and energy technology 2002), is used in the calculation.

Dioxins
The plant producing vinyl chloride reports dioxin emission figures. Figures are reported since 1990 except for 1992 and 1994. Emission figures for 1992 and 1994 are based on the reported data for 1991 and 1993.

4.3.3.4.3 Uncertainties
It is difficult to measure leakages of NMVOC and therefore the uncertainty is regarded as being high.

The particle size distribution used is not specific for the plants, and the particles emitted might therefore have another distribution than the one suggested by TNO.

4.3.3.4.4 Completeness
Major missing emission components are not likely.

4.3.3.4.5 Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.3.5 Production of explosives
NFR 2B5
Last update: 07.02.14

4.3.3.5.1 Description
There has been one plant in Norway producing explosives, but the plant was closed down in 2001. Nitric acid was used as a raw material in the manufacture of explosives, and during the production of nitric acid, NO_x was emitted.

4.3.3.5.2 Method
NO_x
Emission figures were annually reported to the Norwegian Environment Agency, and the figures were based on calculations.

4.3.3.5.3 Uncertainties
No source specific uncertainty is known.

4.3.3.5.4 Completeness
Particles
Reported emission figures to the Norwegian Environment Agency exist only for 1997-1999. Annual emissions were so low that they have not been included in the Norwegian inventory.

4.3.3.5.5 Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.3.6 Chloralkali production
Last update: 07.02.14

4.3.3.6.1 Description
One plant in Norway produced chloralkali until 2005. Before 1997, mercury was used in the chloralkali production and emitted during the process. In 1997, the plant changed its production process and stopped using mercury, but in the following years there were still some mercury emissions.

4.3.3.6.2 Method
Hg
Emission figures were reported to the Norwegian Environment Agency.

4.3.3.6.3 Uncertainties
No source specific uncertainty is known.

4.3.3.6.4 Completeness
Major missing emission components are not likely.

4.3.3.6.5 4.3.3.6.5. Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.3.7 Production of pigments
Last update: 07.02.14

4.3.3.7.1 Description
Two plants are included in the inventory. One plant produces copper oxide for bottom paint and emits copper to air during the production process. Emissions of Cd and Pb have been reported since 2002. Emissions for 1990-2001 are set to be the same as the reported figure in 2002. Also minor amounts of arsenic and chromium are emitted. The other plant produces zinc chromate, and chromium is emitted.

4.3.3.7.2 Method
Emission figures are reported to the Norwegian Environment Agency.

4.3.3.7.3 Uncertainties
Reported emission figures for 1990 and 1991 for the plant producing zinc chromate are not occurring. In the inventory, the same figure as reported for 1992 is used for 1990 and 1991.

4.3.3.7.4 Completeness
Major missing emission components are not likely.

4.3.3.7.5 Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.3.8 Production of soap

4.3.3.8.1 Method
Two plants producing soap have reported emission figures for particles to the Norwegian Environment Agency. One of the plants has only reported for 1990 and 1991. The plant has after 1991 had a temporary permission without reporting requirements and is therefore not included after 1991 due to lack of data. The other plant reported figures for 1992-1994. Emissions for 1990 and 1991 are assumed to be the same as reported figure in 1992, while

emissions for 1995-1997 are assumed to be the same as reported figure in 1994. Annual emission figures are low.

The particles have been purified through filters and scrubbers and the Norwegian Environment Agency assumes the sizes of the particles are smaller than $PM_{2.5}$.

4.3.3.8.2 Uncertainties

For the years where reported emission figures do not exist, Statistics Norway has assumed that emissions are in the same order as reported in one of the other years. This is uncertain and a result of lack of better data.

4.3.3.8.3 Completeness

Major missing emission components are not likely.

4.3.3.8.4 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.3.3.9 Paint and varnish production

Last update: 07.02.14

4.3.3.9.1 Method

One plant producing paint has reported emission figures for particles to the Norwegian Environment Agency since 1995, after first getting an emission permit in 1994. Annual emissions are small. It is assumed by the Norwegian Environment Agency that the particles emitted are smaller than $PM_{2.5}$.

4.3.3.9.2 Uncertainties

No source specific uncertainty is known.

4.3.3.9.3 Completeness

Major missing emission components are not likely.

4.3.3.9.4 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure QA/QC procedure

4.4 Metal production

NFR 2C
Last update: 130.01.14

Metal production in Norway includes plants producing iron and steel, ferroalloys, aluminium, nickel and zinc and also magnesium until spring 2006. Production of anodes is also included in this chapter. As shown in table 4.9, most of the figures in the national inventory are from the plants' annual reports to the Norwegian Environment Agency.

Table 4.9. Metal production. Components emitted and included in the Norwegian inventory

	SO_2	NO_X	NH_3	NMVOC	CO	PM	HM	POP
Production of:								
2C1 Iron and steel	NA	NA	NA	NA	NA	R	R	R
2C2 Ferroalloys	R	R	NA	E	NA	R	R	R
2C3 Primary aluminium	R	E	NA	NA	NA	R	R	R/E
2C4 Secondary aluminium	NA	NA	R	NA	NA	R	R	R
2C4 Magnesium	R	NA	NA	NA	R	R	R	R
2C5 Nickel	R	R	R	NA	NA	R	R	NA
2C5 Zinc	R	NA	NA	NA	NA	R	R	NA
2C5 Anodes	R	R	NA	NA	NA	R	R	R

E = Figures estimated by Statistics Norway (Activity data * emission factor). R = Figures reported by the plant to the Norwegian Environment Agency. NA = Not Applicable.

4.4.1 Production of iron and steel

NFR 2C1
Last update: 07.02.14

4.4.1.1 Description

Three plants producing iron and steel are included in the Norwegian inventory, one of these report only emission figures for particles. One plant producing titanium dioxide slag also produces pig iron as a by-product. All emissions from this plant are registered under 2B5.

Heavy metal emissions are due to the metallurgical melting process and the content of heavy metals in the raw materials used. Particles are also emitted during the process.

4.4.1.2 Method

Particles
One plant has reported figures since 1990 while the other only has reported since 1998. For this plant, historical emissions in the period 1990-1997 have been assumed to be the same as the reported figure in 1998, since production rate data for previous years are not available.

The Norwegian Environment Agency assumes that the particles emitted in the production of iron and steel are smaller than $PM_{2.5}$. We can, however, not disregard that some of the particles emitted are larger than $PM_{2.5}$.

Heavy metals and POPs
One plant reports emission figures to the Norwegian Environment Agency. Reported figures for heavy metals (Pb, Cd, Cr, Cu, As and Hg) exist from 1990, 1992 or later, depending on type of heavy metal. For dioxins and PAH, reported figures have only been available from 1997 and 1999. Diffuse emissions have been included from one plant. In lack of production rate data for previous years, it has been assumed that yearly emissions are the same as in the first year of reporting.

4.4.1.3 Uncertainties

Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

Heavy metals and POPs
Reported emission figures vary from one year to another, partly due to differences in raw materials, but mainly as a result of uncertain measurements. The reported figures are based on a limited number of measurements, and the emissions will vary from minute to minute, since the production of iron and steel is a non-continuous process. For the years where reported emission

figures do not exist, Statistics Norway has assumed that emissions are in the same order as the first year of reporting. This is uncertain and a result of lack of better data.

Particles
The particle size distribution used is only an assumption, and we can not preclude that the distribution is different from the one used in the inventory. For the years where reported emission figures do not exist, Statistics Norway has assumed that emissions are in the same order of magnitude as for the first year of reporting. This is an uncertain estimate due to lack of better data.

4.4.1.4 Source specific QA/QC

Annually reported emission figures are first controlled by the Norwegian Environment Agency and then by Statistics Norway.

Adjustments and recalculations have been done for years where reported emission figures seem to be unreasonably high or low compared with previous years. This is applicable when the variations in the reported emission figures do not have a natural explanation.

4.4.2 Production of ferroalloys

NFR 2C2
Last update: 07.02.14

4.4.2.1 Description

There were 12 plants producing ferroalloys in Norway in 2012. One plant closed down in 2001, two plants were closed down during 2003 and two in 2006. One plant was out of production in 2006, but started up again in 2007. Ferrosilicon, silicon metal, ferromanganese and silicon manganese are now produced in Norway. Ferrochromium was produced until summer in 2001. Ferrosilicon with 65 to 96 per cent Si and silicon metal with 98-99 per cent Si is produced. The raw material for silicon is quarts (SiO_2). SiO_2 is reduced to Si and CO using reducing agents like coal, coke and charcoal.

(4.6) $SiO_2 \rightarrow SiO \rightarrow Si + CO$

The waste gas CO and some SiO burns to form CO_2 and SiO_2 (silica dust).

Some of the CO generated from coal is sold for energy use to other industries. The amount of CO gas sold is hence subtracted from the emissions reported under this category and included in energy use in manufacturing industries and construction (NFR 1A2).

In ferroalloy production, raw ore, carbon materials and slag forming materials are mixed and heated to high temperatures for reduction and smelting. The carbon materials used are coal, coke and some biocarbon (charcoal and wood). Electric submerged arc furnaces with graphite electrodes or consumable Soederberg electrodes are used. The heat is produced by the electric arcs and by the resistance in the charge materials. The furnaces used in Norway are open, semi-covered or covered.

The CO stems from the production process. In open or semi-closed furnaces the CO reacts with air and forms CO_2 before it is emitted. This is due to high temperature and access to air in the process. In a closed furnace the CO does not develop to CO_2 as there is no access to air (oxygen) in the process. The waste gas is then led from the furnace and used as an energy

source or flared, and is reported under the relevant energy sectors. The technical specification of the furnaces is irrelevant since emissions are calculated using a mass balance or calculated by multiplying the amount of reducing agents in dry weight with country specific emission factors

Several components are emitted from production of ferroalloys. SO_2 originates from the sulphur in the reducing agent used, while NO_x is produced primarily by the high temperature oxidation of nitrogen in the air. NMVOC emissions originate from the use of coal and coke in the production processes by producing ferrosilicon and silicon metal. Heavy metals are emitted from the raw materials (ore) during the metallurgical process, and the particles emitted are mainly silica dust generated during the production process.

4.4.2.2 Method

SO_2

Each plant annually reports emission figures to the Norwegian Environment Agency. Some of the sulphur is trapped in the product. For production of ferromanganese and silicon manganese, 98-99 per cent of the sulphur is trapped, while for other ferroalloys it is assumed that about 5 per cent is trapped. The emissions are calculated from the consumption of reducing agents and electrodes and the content of sulphur in the materials.

NO_x

Emissions of NO_X originate from production of ferrosilicon and silicon metal. Ferromanganese, ferrochrome and silicomanganese do not have significant emissions of NO_X. Emission figures are annually reported by each plant to the Norwegian Environment Agency. The reported emissions are calculated either from the production of metal and metal specific emission factors, see table 4.11, or on the basis of continuous measurements.

NMVOC

The emissions are estimated by Statistics Norway from the consumption of reducing agents and an emission factor.

Particles

All plants producing ferroalloys report emission figures to the Norwegian Environment Agency. Some have reported since 1990, others since 1992. For plants reported since 1992, emission figures from 1990 and 1991 have been assumed to be the same as reported figures in 1992. According to the ferroalloy industry, particles emitted are smaller than $PM_{2.5}$ (Eikeland, *pers.comm.*[9]). This is, however, an assumption, and we can not preclude that some of the particles might be larger than $PM_{2.5}$. In the inventory, we have decided to use this distribution for all particles emitted from the production of ferroalloys. This means that TSP=PM_{10}= $PM_{2.5}$.

Heavy metals

Emission figures for heavy metals are reported from all plants producing ferroalloys after the Norwegian Environment Agency in 1999 imposed larger metallurgical plants to map their emissions of heavy metals. Most plants have therefore reported figures to the Norwegian Environment Agency since 1999, but some reported for the first time in 2000 and 2001. An emission factor has been derived for each plant, based on the emission figure and production rate for the first year of reporting. These emission factors have been used together with

[9] Eikeland (2002): Personal information, e-mail dated 29/05 2002. Elkem@elkem.no

production rates for each year to calculate the emissions back to 1990 for each plant.

Dioxins
All plants producing ferrosilicon report emission figures for dioxins to the Norwegian Environment Agency. It varies, however, when the plants started reporting, so calculations of historical figures back to 1990 have been necessary. An emission factor was derived for each plant based on reported emission data and production rates, and this factor was used to calculate historical emissions based on production rates for each year.

None of the four plants producing ferromanganese and ferrochromium[10] report emission figures for dioxins to the Norwegian Environment Agency. The reason is probably that the emissions are so small that they are not measured and therefore not reported (the Norwegian Pollution Control Authority, *pers. comm.*[11]). Instead, the emissions are calculated by Statistics Norway based on the general emission factor for combustion of coke and coal in the industry (table 4.15).

PAH
Emissions of PAH from the production of ferroalloys are reported to the Norwegian Environment Agency for plants producing ferrosilicon and silicon metal. All these plants have reported emission figures since 2000. Historical emissions back to 1990 have been calculated based on production rates for each year and an emission factor derived for each plant based on reported figures for 2000, 2001 and 2002. Reported figures and historical calculations are only done for plants producing ferrosilicon and silicon metal. This is based on the assumption that these alloys are produced in open ovens and therefore cause larger emissions of PAH compared to other alloys that are produced in closed ovens, and are assumed to cause no or minor emissions of PAH.

The PAH emission figures are reported according to Norwegian Standard, but no PAH profile is available. In lack of other data, the same profile as for aluminium production is used.

Table 4.10. Distribution of PAH emissions from production of ferroalloys

Component	Distribution of PAH emissions (ratio)
PAH (Norwegian standard)	1
PAH-6 (Ospar)	0.3
PAH-4 (CLRTAP)	0.15

Source: Finstad *et al*. (2001).

4.4.2.3 Activity data

NMVOC
The amounts of reducing agents that are used for the calculation of NMVOC emissions are annually reported to Statistics Norway from each plant.

4.4.2.4 Emission factors

NO_X
The emission factors used by the ferrosilicon plants in the calculations are based on measurements carried out at three plants.

[10] The ferrochromium plant was closed down in 2003.

[11] Norwegian Pollution Control Authority (2001): Units for dioxins (dioxins.doc). Personal information C. Benestad, 13/03 2001, Oslo: Norwegian Pollution Control Authority.

The emission factors in table 4.11 are based on several measuring campaigns at four different ferroalloy plants that were carried out from 1995 to 2007. Each measurement period lasted 4 to 8 hours with different operation conditions. Based on this, emission factors for different ferroalloys and operational conditions have been established. The measurements have been carried out by Det norske Veritas, Norsk Energi, SINTEF and TÜV.

The silicon plants have applied a new method. They have used online measurement instruments to measure the emissions of NO_x. The measurements were undertaken in 2010. The instrument applied is NEO laser gas and Testo 350 as a control of the results from the NEO laser gas device. So far there are only two plants where the online measurement devices are installed on a permanent basis. For the other plants the online measurement instruments are used periodically to derive emission factors. The following emission factors are used by four plants in one major ferroalloy producing company (kg NO_x/tonne metal produced): 27 (based on measuring campaigns), 34 and 39 (based on online measurements) and 45 (based on a combination of online measurements and campaigns).

The uncertainties associated with the measurements mainly come from measurement of off-gas flow and measurement of concentration of the NO_x in the off-gas. In addition, the periodical measurement campaigns will not include all variations in the emissions gained over time.

Table 4.11. Emission factors for production of ferrosilicon. Kg NO_X /tonne metal produced.

	Normal operations	Dryss -chargering	Dryss- chargering > 750 °C	Source
Ferrosilicon 75 per cent	15.3	7.0	8.3	Measured in 1995 at Rana Metal and the Thamshavn plant 2005
Ferrosilicon 65 per cent	6.0	4.0	5.0	Estimations [1]

[1] Estimations means that this emission factor is not measured but estimated by the plants based on general process experiences.

NMVOC

Statistics Norway uses an emission factor of 1.7 kg NMVOC/tonne coal or coke (EPA 1986) in the calculations.

Dioxins

The emission factors used by the plants in the calculations are given in table 4.12.

Table 4.12. Emission factors for production of ferroalloys. µg dioxin /tonne metal produced

	Normal operations	Dryss - chargering	Dryss- chargering > 750 °C	Source
Silicon metal	3	1.2	0.2	Measured in 1995 at the Fiskaa plant
Ferrosilicon 90 per cent	4	1.2	0.2	Estimations[1]
Ferrosilicon 75 per cent	5	1.2	0.2	Measured in 1995 at Rana Metall
Ferrosilicon 65 per cent	5	1.2	0.2	Estimations
Si96	3	1.2	0.2	Estimations

[1] Estimations means that this emission factor is not measured but estimated by the plants based on general process experiences.

Emission calculations of dioxins for plants not reporting figures to the Norwegian Environment Agency use an emission factor for combustion of coke and coal in the industry (table 4.13).

Table 4.13. Emission factor used by Statistics Norway to calculate dioxin emissions from production of ferro manganese/chromium

	Emission factor
Coal and coke	1.6 µg/tonne

Source: Bremmer *et al*. (1994) and Finstad *et al*. (2002b).

PAH

The emission factors used by the plants in the calculations are given in table 4.14.

Table 4.14. Emission factors for production of ferroalloys. g PAH /tonne metal produced

	Normal operations	Dryss - chargering	Dryss-chargering > 750 °C	Source
Silicon metal	3	2.6	1.6	Measured in 1995 at the Fiskaa plant
Ferrosilicon 90 per cent	2	2	1	Estimations[1]
Ferrosilicon 75 per cent	1.5	1.3	0.8	Measured in 1995 at Rana Metal and the Thamshavn plant
Ferrosilicon 65 per cent	1	1.3	0.8	Estimations
Si96	3	2.6	1.6	Estimations

[1] Estimations means that this emission factor is not measured but estimated by the plants based on general process experiences.

4.4.2.5 Uncertainties

Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

Particles

The inventory uses a particle size distribution which is an assumption from the ferroalloy industry and not based on measurements. We can therefore not preclude that some of the particles might be larger than $PM_{2.5}$.

Heavy metals and POPs

Historical emissions are based on derived emission factors for the first year of reporting, and calculated using production figures for previous years. This is uncertain since the calculation method does not consider quality changes of the raw materials or changes in the production profile at each plant that can have big impact on yearly emissions.

4.4.2.6 Source specific QA/QC

NO_X, NMVOC and CO

The reported emission figures for NO_X, NMVOC and CO are compared with calculations at Statistics Norway.

Emission figures for NMVOC are controlled by multiplying the amount of reducing agents with an emission factor recommended by EPA (1986).

PAH

In 2004, there was a quality improvement of the historical calculation of PAH. PAH was first included in the Norwegian Inventory in 2000, and at that time only two plants producing ferrosilicon and silicon metal reported emission figures to the Norwegian Environment Agency for the year 1999. The ferroalloy industry and the Norwegian Environment Agency therefore derived emission factors to estimate PAH emissions from the production of ferrosilicon and silicon metal (Benestad, *pers. comm.*[12]). It was then decided to use these

[12] Benestad, C. (2000): Personal information, e-mail dated 30/10 2000.

factors in the Norwegian inventory to calculate PAH emissions. From 2000, all plants producing ferrosilicon and silicon metal, however, started reporting emission figures to the Norwegian Environment Agency, and these figures have been used instead of the calculated emissions based on emission factors and activity data. In 2004, the historical emissions were recalculated. Based on the plants' reported emission figures for 2000, 2001 and 2002 and production volumes, a specific emission factor for each plant was derived. These factors were then used to recalculate the plants' historical emissions of PAH. A specific emission factor for each plant was considered better to use for historical emissions, instead of using a default emission factor for all plants. The specific emission factors derived for each plant with the new method were lower than those suggested by Benestad *(pers. comm.[12])*, and this caused approximately 2-12 per cent lower yearly PAH emissions from 1990 to 1999 from this source.

4.4.3 Production of primary aluminium

NFR 2C3
Last update: 07.02.14

4.4.3.1 Description

There are seven plants in Norway producing aluminium. Both prebaked anode and the Soederberg production methods are used.

In the Soederberg technology, the anodes are baked in the electrolysis oven, while in the prebaked technology the anodes are baked in a separate plant. In general, the emissions are larger from the Soederberg technology than from the prebaked technology. There has been a shift from Soederberg to prebaked technology. In 1990, 57 per cent of the aluminium production in Norway was produced with prebaked technology and the share of aluminium production from prebaked increased to 92 per cent in 2009. Two new plants with prebaked technology were established in 2002 and two plants using Soederberg technology were closed down in 2001 and 2003. Since 2007 three plants using Soederberg technology have been closed down, one in 2007, one in 2008 and one in 2009. There is now only one plant left where Soederberg technology is used.

Production of aluminium leads to emissions of various components, such as SO_2, NO_x, heavy metals and persistent organic pollutants. The emission of SO_2 are from the sulphur in the reducing agents used. NO_X is primarily produced by the high temperature oxidation of nitrogen in the air. All plants also report emissions of particles, heavy metals and PAH. Emissions of heavy metals are due to the metal content in the raw materials used and the reducing agents.

4.4.3.2 Method

SO_2
The plants report emission figures of SO_2 to the Norwegian Environment Agency. The figures are estimated by each plant based on the amounts of reducing agents used and their sulphur content. All plants have installed flue gas treatment, like, for example, sea water scrubber.

NO_x
NO_x emissions are estimated by Statistics Norway from the level of production and an emission factor derived from measurements at two Norwegian plants. The figure is rather uncertain.

Particles

Emission figures have been reported to the Norwegian Environment Agency since 1990. The Norwegian Environment Agency assumes that the particles emitted are smaller than PM_{10}. According to TNO (Institute of environmental and energy technology 2002), PM_{10} is 97 per cent of TSP, and $PM_{2.5}$ is 43 per cent of TSP. The Norwegian inventory uses the particle size distribution suggested by TNO (Institute of environmental and energy technology 2002).

Heavy metals
The plants report emission figures to the Norwegian Environment Agency. The first requirement for reporting came in 1999, so emission figures before that are insufficient. The concentrations of heavy metals in the air emissions are very low and therefore impossible to measure. Emissions are therefore calculated at each plant, based on the mass flow.

Dioxins
Since the process uses coal and coke as reducing agents, it is assumed that production of primary aluminium gives dioxin emissions. Reported figures for dioxins are not available. The emissions are believed to be so small that reporting is not necessary. Emissions are therefore calculated based on the combustion factor for coal in the industry.

PAH
The reported emission data are assumed to be according to Norwegian standard (NS9815). It is further assumed by the Norwegian Environment Agency that the emissions are due to emissions from the use of the Soederberg method. Historical emission figures have been calculated based on changes in production of aluminium after the Soederberg method.

The PAH profile has been measured at three plants. These profiles show little variation. Based on these profiles it is believed that PAH-4 accounts for 15 per cent and PAH-OSPAR 30 per cent of total PAH emissions from production of aluminium after the Soederberg method (table 4.15).

Table 4.15. Distribution of PAH emissions from production of primary aluminium. Ratio

Component	Distribution of PAH emissions (ratio)
PAH (Norwegian standard)	1
PAH-6 (Ospar)	0.3
PAH-4 (CLRTAP)	0.15

4.4.3.3 Activity data

NO_X
The activity data for the NO_X calculation are production figures, which are reported annually from the plants to the Norwegian Environment Agency.

Dioxins
The calculation of emissions of dioxins is based on consumption of raw materials. The figures are reported annually from the plants to Statistics Norway.

4.4.3.4 Emission factors

NO_X
Statistics Norway uses the emission factor 0.00071 tonnes NO_X/ tonne produced aluminium in the calculations. This emission factor is assumed by the Norwegian Environment Agency and is based on measurements.

Dioxins
Emissions of dioxins are calculated based on the consumption of coal and an emission factor from Bremmer *et al*. (1994).

Table 4.16. Emission factor used to calculate dioxin emissions from aluminium production

	Emission factor	Source
Coal and coke	1.6 µg/tonne	Bremmer *et al*. (1994)

4.4.3.5 Uncertainties
Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

Particles
The particle size distribution are not reported by the plants. Actual emissions are propably somewhat different from those estimated with the size distribution from TNO (Institute of environmental and energy technology 2002).

4.4.3.6 Completeness
Major missing emission components are not likely.

4.4.3.7 Source specific QA/QC
PAH
The Norwegian Environment Agency had recently audits at all aluminium plants to check their system for monitoring of emissions of PAH. It will be considered whether similar audits should have climate gases as the main target.

Heavy metals
First requirement for reporting of heavy metals was given in 1999, and the reported figures were that year based on concentration measurements. The concentration of heavy metals in the air emissions are very low and therefore subject to high degree of uncertainty. The reported emission figures showed large differences from plant to plant, also in the cases where the raw materials came from the same supplier. The Norwegian Environment Agency has had a long discussion with the aluminium industry to find a better method to estimate heavy metals from aluminium production. In 2001 it was decided that reported figures should be based on calculations. New calculations have shown that earlier calculations gave too high emissions of heavy metals. It was therefore recommended by the Norwegian Environment Agency to recalculate historical reported data based on the new calculation method. Recalculation of historical data are normally based on production rate data, but due to very low emissions and relative stable production rates, historical data are set to be the same as the first year of reporting.

4.4.4 Production of secondary aluminium
NFR 2C3
Last update: 07.02.14

4.4.4.1 Description
One open mill in Norway is handling secondary aluminium production. Heavy metals and persistent organic pollutants (dioxins and PAH) are emitted in the production of secondary aluminium due to the remelting process. Particles are also emitted during the production process. For earlier years there have also been some emissions of NH_3 and SF_6 from another plant which closed down in 2001.

4.4.4.2 Method

NH_3
For the years 1993-2001, emissions of NH_3 were reported from one plant. This plant closed down in 2001.

Particles
The plant has reported emission figures to the Norwegian Environment Agency from 1993. Emission figures for 1990 to 1992 are in the inventory assumed to be the same as the reported figure in 1993. The following particle size distribution is assumed and used in the Norwegian inventory; PM_{10} is 0.8*TSP and $PM_{2.5}$ is 0.32*TSP (Institute of environmental and energy technology 2002).

Heavy metals and POPs
The figures are reported annually to the Norwegian Environment Agency. Emission figures exist since 1993, and emissions before 1993 have been supposed to be the same as reported figures in 1993.

The emission figures for heavy metals are based on metal analyses of dust samples. Figures of Pb, Cd and Cr have been reported since 1997. Annual figures can vary a lot from one year to another, and therefore we have used mean values for years when the changes can not be explained by the industry. We have assumed that the emission figures for 1990-1996 are the same as reported figures in 1997, since there are no reported figures of heavy metals and PAH before 1997.

4.4.4.3 Uncertainties

Heavy metals and POPs
The reported figures for heavy metals are estimated based on heavy metal content in the dust samples. The metal content were only analysed for a few dust samples yearly and the reported figures are therefore only a presumption of yearly emission figures. Calculation of emission figures before 1997 are assumed to be the same as reported figures in 1997, and this gives highly uncertain figures since raw materials and production variations may have changed during the period.

The reported emission figures for dioxins and particles vary from one year to another, and it is assumed that this is due to uncertain measurements and process readjustments.

4.4.4.4 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.4.5 Production of magnesium

NFR 2C5
Last update: 07.02.14

4.4.5.1 Description

There has been one magnesium producing plant in Norway. The plant closed down the production of primary magnesium in 2002. The production of cast magnesium continued, but this production has no CO_2 emissions from processes. During 2006 also the production of remelting Mg stopped. From the mid-1970s, both the magnesium chloride brine process and

the chlorination process were used for magnesium production. Since 1991, only the chlorination process was in use.

Production of magnesium leads to non-combustion CO emissions. During the calcination of dolomite ($MgCa(CO_3)_2$) to magnesium oxide, CO_2 is emitted. During the next step, magnesium oxide is chlorinated to magnesium chloride, and coke is added to bind the oxygen as CO and CO_2. SO_2 is emitted due to the sulphur in the reducing agent used.

4.4.5.2 Method

CO

Emission figures of CO were reported annually to the Norwegian Environment Agency. These emissions disappeared when the plant closed down the production of primary magnesium in 2002.

SO_2

The SO_2 emissions were estimated from the amounts of reducing agent used (coke) and their sulphur content and reported from the plants to the Norwegian Environment Agency.

Particles

The plant reported emission figures for particles for the first time for the year 1992. Emissions of particles for 1990 and 1991 are assumed to be larger than the reported figure in 1992, since a cleaning device was installed in 1992. Statistics Norway has no information that can be used to estimate emissions in 1990 and 1991, so the inventory uses the reported emission figure for 1992 also for 1990 and 1991. The Norwegian Environment Agency assumes that reported figures also include emissions from combustion.

No information is found regarding the particle size distribution for particles emitted during magnesium production. In lack of other data, we use the same distribution as for aluminium production (PM_{10} is 97 per cent of TSP, and $PM_{2.5}$ is 43 per cent of TSP).

Heavy metals and POPs

Emission of heavy metals is due to the metal content in the reducing agent used. Emission data of Hg, As, Cr and dioxins were reported to the Norwegian Environment Agency. When the plant closed down the production of primary magnesium in 2002, the emissions of As disappeared. Reported figures of heavy metals have only been available since 2000. Emission figures are calculated back to 1990 based on the production rate for each year.

During the chlorination process and the use of coke as a reducing agent, dioxins are emitted. Emission figures for dioxins were reported to the Norwegian Environment Agency from 1990.

4.4.5.3 Uncertainties

Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

Particles

For years where reported emission figures do not exist, Statistics Norway has assumed that emissions are in the same order as that of the first year of reporting. This is uncertain and a result of lack of better data. The particle size distribution used is not specific for production of magnesium, but used due to lack of specific size distribution data for this source. The particle size distribution can therefore only be seen as an estimate.

Heavy metals
Historical emissions are based on a derived emission factor for the first year of reporting and calculated with production figures for previous years. This is uncertain and only an estimate since it does not consider annually changes in raw materials nor possible cleaning devices.

4.4.5.4 Completeness

Major missing emission components are not likely.

4.4.5.5 Source specific QA/QC

The latest reported emission data from the plant were compared with previous reported data and the emissions were compared with the production.

4.4.6 Other metals

NFR 2C5
Last update: 07.02.14

In addition to the metals in the previous chapters, nickel and zinc are also produced in Norway.

4.4.6.1 Production of nickel

4.4.6.1.1 Description

One plant in Norway produces nickel. During the production of nickel SO_2, NO_x, NH_3, particles and heavy metals are emitted. CO_2 is emitted in the production of nickel, due to the soda from the production of nickel carbonate and use of coke as a reducing agent, while SO_2 is a result of the sulphur content in the coke used. NO_x is produced primarily by the high temperature oxidation of nitrogen in the air. Emission of heavy metals is due to the metal content in reducing agent used. Particles are also emitted during the production process. PAHs and dioxins are not reported or calculated.

4.4.6.1.2 Method

SO_2
Emission figures of SO_2 are reported from the plant to the Norwegian Environment Agency based on continuous measurements. Flue gas treatment is installed at the plant.

NO_x
Emission figures of NO_x are annually reported from the plant to the Norwegian Environment Agency. The emission figures are based on calculations.

NH_3
Emission figures based on calculations are annually reported from the plant to the Norwegian Environment Agency.

Particles
Emission figures for particles have been reported to the Norwegian Environment Agency since 1992. Emissions in 1990 and 1991 are assumed to be the same as the reported figure in 1992. The emission permit sets requirements to emissions from the melting furnace, transport, crushing and packing of the raw materials and products. The Norwegian Environment Agency assumes that the particles emitted are smaller than $PM_{2.5}$. This means that $TSP=PM_{10}=PM_{2.5}$ is used in the inventory.

Heavy metals and POPs
Emission figures for Cu have been reported to the Norwegian Environment Agency since 1990. Reported figures for Cd, Hg and Pb were available from 1990-1994, but because of low emissions the plant stopped reporting these metals.

4.4.6.1.3 Uncertainties
Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

Particles
The particle size distribution used is only an assumption and we can not preclude that the distribution might be different than the one suggested. The particle size distribution can therefore only be seen as an estimate.

4.4.6.1.4 Completeness
Major missing emission components are not likely.

4.4.6.1.5 Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.4.6.2 Production of zinc
Last update: 07.02.14

4.4.6.2.1 Description
One plant in Norway produces zinc. SO_2, particles and heavy metals are emitted during the process. Emission of SO_2 originates from the sulphur in the reducing agent used.

4.4.6.2.2 Method
SO_2
The plant reports emission figures to the Norwegian Environment Agency. The SO_2 emissions are estimated from infrequent measurements combined with calculations.

Particles
Emission figures for particles have been reported since 1991. Emissions for 1990 are assumed to be the same as the reported figure for 1991. It is assumed that of the particles emitted, 90 per cent is PM_{10} and 80 per cent is $PM_{2.5}$ (Institute of environmental and energy technology 2002) and this particle size distribution is used in the Norwegian inventory.

Heavy metals and POPs
The plant reports emission figures for Cd, Pb, Hg, Cu, Cr and As. Reported figures exist since 1992, and emissions in 1990 and 1991 are assumed to be the same as reported figures in 1992.

Figures are not reported for PAH and dioxins.

4.4.6.2.3 Source specific QA/QC
There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.4.7 Manufacture of anodes
NFR 2C5

Last update: 07.02.14

4.4.7.1 Description

Four plants in Norway produce anodes. Three plants produce prebaked anodes and one plant produced coal electrodes. These are alternatives to the use of coal and coke as reducing agents in the production process for aluminium and ferroalloys. The anodes and coal electrodes are produced from coal and coke. The production of anodes and coal electrodes leads to emissions of NO_x, SO_2, PAH and heavy metals.

4.4.7.2 Method

SO_2 and NO_x

Emission figures of SO_2 are based on measurements while NO_X emissions are calculated by the plants and reported to the Norwegian Environment Agency.

Particles

Production of anodes leads to emission of particles. One of the plants has reported emissions since 1990, while the other one has reported since 1992. Emission figures for 1990 and 1991 are assumed to be the same as the reported figure in 1992 for this plant. The Norwegian Environment Agency assumes that the particles emitted are smaller than PM_{10}, but also expects some to be smaller than $PM_{2.5}$. No information has been found regarding the particle size distribution, so in lack of other data we use the same distribution profile as used for production of aluminium where PM_{10} is 97 per cent of TSP and $PM_{2.5}$ is 43 per cent of TSP.

PAH

Emission figures for PAH are based on measurements and reported from both plants to the Norwegian Environment Agency. One plant has developed a new and better method for measuring PAH. This method is used for the period 1992 to 2003. The reported figures of PAH are assumed to be according to the Norwegian standard (NS9815). Measurements from production of Soederberg paste (at three Norwegians plants) and a PAH-profile of baked anodes from EPA are used to derive a PAH-profile to find the emission of PAH-OSPAR and PAH-4. Based on these profiles it is assumed that PAH-OSPAR and PAH-4 account for respectively 25 per cent and 5 per cent of the total PAH emissions (table 4.17).

Table 4.17. Distribution of PAH emissions from production of anodes. Ratio

Component	Distribution of PAH emissions (ratio)
PAH (Norwegian standard)	1
PAH-6 (Ospar)	0.25
PAH-4 (CLRTAP)	0.05

Source: Norwegian pollution control authority (1999b).

Heavy metals

Production of anodes leads to emission of heavy metals due to the metal content in the reducing agents (coke and coal). Emission figures are based on measurements and are reported for arsenic and mercury from one plant since 2001, and for lead since 2004. Emission figures have not been measured or reported before 2001 for As and Hg and before 2004 for Pb and are therefore not available for previous years. Historical emission figures back to 1990 are assumed to be the same as reported figures for 2001 for As and Hg and 2004 for Pb.

4.4.7.3 Uncertainties

Historical calculations of heavy metals from 1990 to 2001 are very uncertain since they are

assumed to be the same as reported figures for the first year of reporting (2001). Annual changes in production volumes, coke quality and the amount of heavy metals in the reducing agents are not taken into account, and the historical emissions can only be seen as an estimate in lack of better data.

4.4.7.4 Completeness

Major missing emission components are not likely.

4.4.7.5 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.5 Other production

NFR 2D

4.5.1 Pulp and paper

NFR 2D1
Last update: 07.02.14

4.5.1.1 Description

Pulp and paper production has three major processing steps; pulping, bleaching and paper production. Kraft (sulphate) pulping is the most widely used pulping process and is generally used to produce strong paper products. The Kraft pulping process includes bleaching, chemical recovery and by-products recovery. The sulphite pulping is another chemical pulping process. It produces a weaker paper than some other types of pulping, but the pulp is less coloured, making it more suitable for printing, often with little bleaching. In Norway, SO_2 and particles are reported emitted from production of pulp and paper. In the Kraft pulping process, sodium sulphide and sodium hydroxide are used to chemically dissolve the lignin that binds the cellulose fibres, and in the acid sulphite pulping process, sulphurous acid solution is used. SO_2 is emitted in these processes.

4.5.1.2 Method

SO_2
Emission figures are reported from producers of chemical pulp to the Norwegian Environment Agency. SO_2 is measured continuously and emission estimates are made from these measurements.

Particles
Four plants producing pulp and paper, report non-combustion emissions of particles to the Norwegian Environment Agency. Two of these plants have not reported emission figures from combustion and it is assumed that the reported non-combustion emission figures include emissions from combustion. It varies when the plants started reporting emission figures for particles, and due to lack of data, emission for those years is assumed to be the same as in the first year of reporting.

Two of the plants state that they clean the emissions by electric filter and wet scrubbers, and it is assumed by the Norwegian Environment Agency that the particles emitted are smaller than $PM_{2.5}$. The other two clean their emissions using only wet scrubbers, and it is assumed the particles are smaller than PM_{10}. According to TNO (Institute of environmental and energy technology 2002), $PM_{2.5}$ is 20 per cent of PM_{10} and PM_{10} is the same as TSP.

4.5.1.3 Uncertainties

The particle size distribution used is not plant specific and might therefore be different from the one suggested by TNO.

4.5.1.4 Completeness

Major missing emission components are not likely.

4.5.1.5 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

4.5.2 Food and Drink

NFR 2D2
Last update: 07.02.14

4.5.2.1 Description

4.5.2.2 This source category includes NMVOC emissions from production of bread and beer. Emissions from spirit manufacture are considered insignificant (for example, emissions in 2011 are estimated to be 20 tonnes) and are not included in the inventory.**Production of bread and beer**

4.5.2.2.1 Method

NMVOC
Production of bread and beer (and other similar yeast products) involves fermentation processes that lead to emission of NMVOC (ethanol). Emissions are calculated based on production volumes and emission factors.

4.5.2.2.2 Activity data

Production volumes of bread and beverages are annually reported to Statistics Norway.

4.5.2.2.3 Emission factors

The emission factors are taken from EEA (1996).

Table 4.18. NMVOC emission factors from production of bread and beverage

	Emission factor	Unit
Production of bread	0.003	tonnes/tonnes produced
Production of beverage	0.2	kg/1000 litres

Source: EEA (1996).

4.5.2.2.4 Uncertainties

The emission factors used are recommended by EEA (1996) and are not specific for Norwegian conditions.

4.5.2.2.5 Completeness

Major missing emission components are not likely.

4.5.2.2.6 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.
recalculation.

5 SOLVENT AND OTHER PRODUCT USE (NFR sector 3)

5.1 Overview

This chapter describes emissions from solvents and other products. Use of solvents and products containing solvents result in emissions of non-methane volatile organic compounds (NMVOC).

In addition to solvents emitting NMVOC, there are other products that emit other volatile components. Creosote treated materials and tarry jointing paste cause emissions of PAH (poly-aromatic hydrocarbons). PAH and dioxins are also emitted during production of asphalt. Emissions of mercury from mercury-containing products as well as emissions from combustion of tobacco are also included in the Norwegian inventory.

5.2 Solvent losses (NMVOC)

NFR 3A, 3B, 3C and 3D
Last update: 07.02.14

5.2.1 Method

Our general model is a simplified version of the detailed methodology described in chapter 6 of the EMEP/CORINAIR Guidebook 2007 (EEA 2007). It represents a mass balance *per substance*, where emissions are calculated by multiplying relevant activity data with an emission factor. For better coverage, point sources reported from industries to the Norwegian Environment Agency and calculated emissions from a side model for cosmetics are added to the estimates. For a detailed description of method and activity data, see Holmengen and Kittilsen (2009).

It is assumed that all products are used the same year as they are registered, and substances are not assumed to accumulate in long-lived products. In other words, it is assumed that all emissions generated by the use of a given product during its lifetime take place in the same year as the product is declared to our data source, the Norwegian Product Register. In sum, this leads to emission estimates that do not fully reflect the actual emissions taking place in a given year. Emissions that in real life are spread out over several years all appear in the emission estimate for the year of registration. However, this systematic overestimation for a given year probably more or less compensates for emissions due to previously accumulated amounts not being included in the estimate figures.

No official definition of solvents exists, and a list of substances to be included in the inventory on NMVOC emissions was thus created. The substance list used in the Swedish NMVOC inventory (Skårman *et al.* 2006) was used as a basis. This substance list is based on the definition stated in the UNECE Guidelines[13]. The list is supplemented by NMVOC reported in the UK's National Atmospheric Emissions Inventory (NAEI) (AEA 2007). The resulting list comprises 678 substances. Of these, 355 were found in the Norwegian Product Register for one or more years in the period 2005-2007.

Cosmetics

Cosmetics are not subject to the duty of declaration. The side model is based on a study in 2004, when the Norwegian Environment Agency calculated the consumption of

[13] "Volatile compound (VOC) shall mean any organic compound having at 293.15 degrees K a vapor pressure of 0.01 kPa or more, or having a corresponding volatility under the particular conditions of use."

pharmaceuticals and cosmetics (Norwegian pollution control authority 2005a). The consumption was calculated for product groups such as shaving products, hair dye, body lotions and antiperspirants. The consumption in tonnes each year is calculated by using the relationship between consumption in Norwegian kroner and in tonnes in 2004. Figures on VOC content and emission factors for each product group were taken for the most part from a study in the Netherlands (IVAM 2005), with some supplements from the previous Norwegian solvent balance (the previous NMVOC emission model).

5.2.2 Activity data

The data source is the Norwegian Product Register. Any person placing dangerous chemicals on the Norwegian market for professional or private use has a duty of declaration to the Product Register, and import, export and manufacturing is reported annually. The only exception is when the amount of a given product placed on the market by a given importer/producer is less than 100 kg per year.

The information in the data from the Product Register makes it possible to analyse the activity data on a substance level, distributed over product types (given in UCN codes; (The Norwegian product register 2007)), industrial sectors (following standard industrial classification (NACE), including private households (no NACE), or a combination of both. As a consequence, the identification of specific substances, products or industrial sectors that have a major influence on the emissions is greatly facilitated.

Cosmetics
The side model for cosmetics is updated each year with data on from the Norwegian Association of Cosmetics, Toiletries and Fragrance Suppliers (KLF).

Point sources
Data from nine point sources provided by the Norwegian Environment Agency are added to the emissions estimates. The point sources are reported from the industrial sector "Manufacture of chemicals and chemical products" (NACE 20). In order to avoid double counting, NMVOC used as raw materials in this sector are excluded from the emission estimates from the Product Register data.

5.2.3 Emission factors

Emission factors are specific for combinations of product type and industrial sector. Emission factors from the Swedish model for estimating NMVOC emissions from solvent and other product use (Skårman *et al.* 2006) are used. The emission factors take into account different application techniques, abating measures and alternative pathways of release (e.g. waste or water). These country-specific emission factors apply to 12 different industries or activities that correspond to sub-divisions of the four major emission source categories for solvents used in international reporting of air pollution (EEA 2007).

It is assumed that the factors developed for Sweden are representative for Norwegian conditions, as we at present have no reason to believe that product types, patterns of use or abatement measures differ significantly between the two countries. Some adjustments in the Swedish emission factors were made when the model was first developed (see Holmengen and Kittilsen (2009)) and several improvements of single emission factors have been made in the following years.

In accordance with the Swedish model, emission factors were set to zero for a few products that are assumed to be completely converted through combustion processes, such as EP-additives, soldering agents and welding auxiliaries. Quantities that have not been registered to

industrial sector or product type are given emission factor 0.95 (maximum). Emission factors may change over time, and such changes may be included in this model. However, all emission factors are at the moment constant for all years.

5.2.4 Uncertainties

Uncertainty in emission factors
The emission factors are more detailed in the new NMVOC model than in the previous model, as this model can take into account that emissions are different in different sectors and products, even when the substance is the same. However, for this to be correct, a thorough evaluation of each area of use is desirable, but not possible within a limited time frame. Thus, the emission factor is set with general evaluations, which leads to uncertainty.

The emission factors are taken from several different sources, with different level of accuracy. The uncertainties in emission factors depend on how detailed assessment has been undertaken when the emission factor was established. Some emission factors are assumed to be unbiased, while others are set close to the expected maximum of the range of probable emission factors. This, together with the fact that the parameter range is limited, gives us a non-symmetrical confidence interval around some of the emission factors. For each emission factor we thus have two uncertainties; one negative (n) and one positive (p). These are aggregated separately, and the aggregated uncertainty is thus not necessarily symmetrical.

Uncertainty in activity data
For the activity data, the simplified declarations and the negative figures due to exports lead to known overestimations, for which the uncertainty to a large extent is known. A more elaborate problem in calculations of uncertainty is estimating the level of omissions in declaration for products where the duty of declaration does apply. In addition, while declarations with large, incorrect consumption figures are routinely identified during the QA/QC procedure, faulty declarations with small consumption figures will only occasionally be discovered. There is however no reason to believe that the Product Register data are more uncertain than the data source used in the previous model (statistics on production and external trade), as similar QA/QC routines are used for these statistics.

The errors in activity data are not directly quantifiable. Any under-coverage in the Product Register is not taken into account. Skårman *et al*. (2006) found that the activity data from the Swedish Product register had an uncertainty of about 15 per cent. The Norwegian Product Register is assumed to be comparable to the Swedish, and thus the uncertainty in the activity data is assumed to be 15 per cent. For some products, simplified declarations give an indication of maximum and minimum possible amounts. In these cases, the maximum amount is used, and the positive uncertainty is set to 15 per cent as for other activity data, while the negative uncertainty is assumed to be the interval between maximum and minimum amount. All activity data are set to zero if negative.

For a detailed description of the uncertainty analysis, see Holmengen and Kittilsen (2009). The variance of total emission was estimated from the variance estimates obtained for emission factors and activity data, using standard formulas for the variance of a sum and the variance of a product of independent random variables.The aggregated uncertainties in level and trend are given in table 5.1 and 5.2.

Table 5.1. Uncertainty estimates for level of NMVOC emissions, 2005-2007. Tonnes and per cent

Uncertainty in level	Negative (n)	Negative (n) (per cent of total emissions)	Positive (p)	Positive (p) (per cent of total emissions)
2005	2 288	4.58	1 437	2.88
2006	1 651	3.70	1 103	2.47
2007	1 299	2.79	1 168	2.51

Table 5.2. Uncertainty estimates for trend in NMVOC emissions, 2005-2007. Tonnes

Uncertainty in trend	Negative (n)	Positive (p)	95% confidence interval for change
2005-2006	2 135	1 067	(-7 366 , -4 164)
2006-2007	1 420	947	(407 , 2 774)
2005-2007	1 882	1 076	(-5 286 , -2 328)

5.2.5 Completeness

No major missing emission sources are likely.

5.2.6 Source specific QA/QC

- Large between-year discrepancies in the time series of substance quantities are routinely identified and investigated, in order to correct errors in consumption figures.
- Large within-year discrepancies between minimum and maximum quantities in simplified declarations are routinely identified and investigated, in order to prevent overestimation for substances where consumption figures are given in intervals.
- Large within-year discrepancies between totals for industrial sectors (NACE) and totals for products (UCN) are routinely identified and investigated, in order to detect erroneous or incomplete industrial sectoral and product type distribution.

5.3 Use of solvents

IPCC -
NFR 3C
Last update: 01.09.05

5.3.1 Creosote-treated materials

5.3.1.1 Description

Creosote is mainly used in quay materials and conduction poles, but also in fence poles and roof boards. In Norway there is a requirement that all creosote in use should contain less than 50 mg/kg benzo(a)pyren (Miljøverndepartementet 2004). PAH-components will evaporate from the creosote-treated materials in hot weather. In addition, PAH-components will evaporate during impregnation. The smallest PAH-components, like naphthalene, are most volatile, but several components used in wood treatment will not evaporate.

5.3.1.2 Method

Emissions of PAH are calculated based on the import of creosote oil and emission factors. For simplicity, it is assumed that all PAH is emitted the same year as the materials are produced.

5.3.1.3 Activity data

Data on imported amounts of creosote oil are taken from Statistics Norway's statistics on external trade.

5.3.1.4 Emission factors

The emission factor used is taken from (Finstad *et al.* 2001). It is assumed that imported creosot oil contains on average 55 per cent PAH and that one per cent will evaporate during the lifetime of the creosot-treated materials.

5.3.1.5 Uncertainties

In the inventory it is assumed that all PAH is emitted the same year as the materials are used. This is however not the case, since PAH will be emitted as long as the creosote-treated materials are in use. However, most of it is likely to be emitted during the first years.

5.3.1.6 Completeness

No major missing emission components or sources are likely.

5.3.1.7 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

5.3.2 Tarry jointing paste

5.3.2.1 Description

Tarry jointing paste is resistant to oil and fuels, and is therefore used in concrete constructions where spills of such products can occur, e.g. in joints in bridges, auto repair shops and airports. Tarry jointing paste contains PAH-components that can evaporate to air.

5.3.2.2 Method

The Norwegian institute for air research (NILU) and the Norwegian institute for water research (NIVA) (1995) have estimated an annual emission of 125 kg PAH/year. This estimation is based on imported tarry paste and a tar content of 16 per cent. This kind of jointing paste is mainly used at airports. There is no available PAH-profile for this emission, and due to the lack of data, the same PAH-profile as that of asphalt production is used (table 5.3). The emission is assumed to be rather constant each year.

Table 5.3. Emission of PAH from use of tarry jointing paste[1]. kg PAH/year

Norwegian standard 9815	125
Borneff (PAH-6)	3
LRTAP (PAH-4)	0.0

[1] Emission factors are from production of asphalt.

5.3.2.3 Uncertainties

There is uncertainty regarding the PAH-profile since in lack of a specific profile, the same PAH-profile as for asphalt production is used.

5.3.2.4 Completeness

There are a couple of very minor sources of PAH that are not included in the Norwegian inventory. PAH-containing products are used in tar paper and fishing nets. According to NILU/NIVA (1995), the annual emissions are low. In Rypdal and Mykkelbost (1997), emission

factors of 0.3 g/tonnes and 28 g/tonnes are given for tar paper and fishing net respectively, but emissions from these sources are not included in the inventory.

Also anticorrosive paint used for treatment of ships and platforms is a potential source of PAH emissions. In Rypdal and Mykkelbost (1997), emission factors of 7.5 mg/ship/year at shipyard, 1.9 mg/ship/year at harbour and 96 mg/ship/year in service are given. This pre-supposes treatment every third year. The emissions are low compared to other sources, and are not included in the inventory.

5.3.2.5 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

5.4 Production of asphalt

IPCC -
NFR 3C
Last update: 01.09.05

5.4.1 Method

PAH
Most of the asphalt produced in Norway uses the batch-method (Haakonsen *et al.* 1998). Emissions are calculated by multiplying the amount of asphalt produced with an emission factor.

Dioxins
Asphalt preparations and asphalt recycling are supposed to be a possible dioxin source, especially in countries using extensive recycling, and that use salt on the roads during winter. A lot of salt is used on Norwegian roads during winter, and when this asphalt is heated during recycling, it is assumed to give emissions of dioxins (Hansen 2000).

5.4.2 Activity data

The activity data used is production of asphalt in Norway. In NILU/NIVA (1995), there is a figure of production of asphalt from 1991. The same figure is used for all years due to lack of better data.

5.4.3 Emission factors

PAH
NILU/NIVA (1995) estimated the emission of PAH to be 15 mg/tonne asphalt. This includes however naphthalene and other components not to be included in PAH after Norwegian standard (NS3815). However, if this emission factor is combined with speciation data from Jebsens miljøteknikk (1991), an emission factor of 2.8 mg/tonne is found. This agrees well with the emission factor 2.0 mg/tonne suggested by EPA (U.S. Environmental protection agency).

Dioxins
Two emission factors are found in the literature. OSPAR (The Oslo and Paris Convention) (Norwegian pollution control authority 2001) suggests an emission factor of 0.047 µg/tonne asphalt. This emission factor is however assumed to be very high since it is based on data from a plant only re-circulating old asphalt. Fyns Amt (2000) operates with a much lower emission factor, which probably reflects dioxin emissions from preparation of new asphalt. Since Norway

both makes new asphalt and recycles old asphalt it is assumed that an emission factor in between those suggested from OSPAR and Fyns Amt would be most correct for Norwegian conditions (table 5.4).

Table 5.4 Dioxin emission factor for asphalt production. µg I-TEQ/tonne produced asphalt

Source	Emission factor
OSPAR (Norwegian pollution control authority 2001)	0.047
Fyns Amt (2000)	0.0022
Emission factor chosen	0.025

5.4.4 Uncertainties

The activity data used are from 1991, and due to lack of better information, the same figure has been used for all years. The emission factors used, both for estimating PAH and dioxins, are also uncertain. The annual emissions are low however, and will not have any impact on the total level of these types of emissions.

5.4.5 Completeness

No major missing emission components are likely.

5.4.6 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

5.5 Other product use

IPCC 3D
NFR 3D
Last update: 07.02.14

5.5.1 Mercury-containing products

5.5.1.1 Method

Breakage of mercury-containing thermometers, fluorescent tubes and various measuring and analytical instruments leads to emissions of mercury. The emission estimates are based on an annual report from the Norwegian Environment Agency ("Miljøgifter i produkter"). The sale of mercury-containing thermometers and fluorescent tubes has decreased strongly since the mid-1990s, and the mercury content in these products has been reduced. A prohibition against the production, import and export of mercury-containing products entered into force in 1998, except for some thermometers for professional use, which were prohibited in 2001. Since these products have long operating life times, there will be emissions from these products for many years. In the calculations, however, it is assumed that the emissions occur the same year as the product is sold.

For thermometers, it is assumed that all mercury is emitted in hospitals, despite some breakage of mercury-containing thermometers that occur in households. For fluorescent tubes, all emissions are placed in households, although emissions occur in all sectors. For measuring and analytical instruments, all emissions are placed under research and development work.

5.5.1.2 Uncertainties

The emissions are assumed to be emitted the same year as the products are sold. This is not accurate, since most of these products have long operating life times. It is however impossible to predict the annual breakage and the mercury content in each of them.

5.5.1.3 Completeness

No major missing emission components are likely.

5.5.1.4 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

5.5.2 Tobacco

5.5.2.1 Method

NO_X, NMVOC, CO, particles, heavy metals and POPs

The emission components included from the combustion of tobacco are NO_X, NMVOC, CO, particles, heavy metals and POPs (Persistent organic pollutants). Emission figures have been calculated by multiplying the annual consumption of tobacco with emission factors for each pollutant. As recommended by the UNFCCC ERT (expert review team), emissions from use of tobacco are reported under NFR 3D.

5.5.2.2 Activity data

The total consumption of tobacco in Norway is given by the net import of tobacco from Statistics Norway's external trade statistics.

5.5.2.3 Emission factors

Table 5.5 gives emission factors used for tobacco combustion. For NO_X, NMVOC and CO the emission factors are calculated by Statistics Norway, based on values given in Directorate for Health (1990).

Table 5.5. Emission factors used for tobacco combustion

	Tobacco (unit/kg tobacco)	Source
NO_X (kg)	0.0034652	Statistics Norway, Directorate for Health (1990)
NMVOC (kg)	0.0048374	Statistics Norway, Directorate for Health (1990)
CO (kg)	0.1215475	Statistics Norway, Directorate for Health (1990)
TSP (kg)	0.04	TNO (Institute of environmental and energy technology 2002)
PM_{10} (kg)	0.04	TNO (Institute of environmental and energy technology 2002)
$PM_{2.5}$ (kg)	0.04	TNO (Institute of environmental and energy technology 2002)
Pb (g)	0.00005	Finstad *et al*. (2001)
Cd (g)	0.0001	Finstad *et al*. (2001)
Hg (g)	0.0001	Finstad *et al*. (2001)
As (g)	0.000159	Finstad and Rypdal (2003)
Cr (g)	0.000354	Finstad and Rypdal (2003)
Cu (g)	0.000152	Finstad and Rypdal (2003)
PAH (g)	0.00825	Finstad *et al*. (2001)
PAH OSPAR (g)	0.00125	Finstad *et al*. (2001)
Dioxins (µg)	0.0013	Finstad *et al*. (2002b)

5.5.2.4 Uncertainties

The emissions are assumed to be emitted the same year as the products are imported.

5.5.2.5 Completeness

Tobacco bought tax free abroad and tobacco smuggled are not included in the inventory.

5.5.2.6 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

6 AGRICULTURE (NFR sector 4)

NFR 4

6.1 Overview

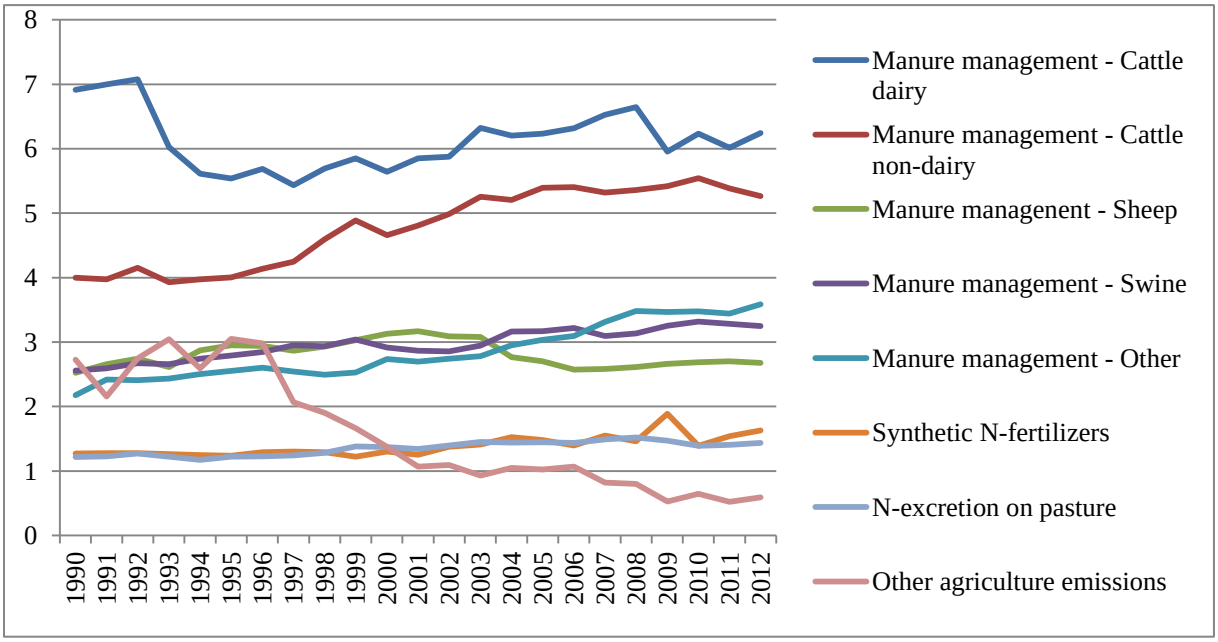
Agriculture is an important contributor to NH_3 emissions. Animal manure management, grazing animals and the use of fertiliser (manure, synthetic and sewage sludge) generate emissions of NH_3. Another source of NH_3 is treatment of straw using NH_3 as a chemical. Non-combustion emissions of particles in the agricultural sector are also calculated.

Additionally, there are some long-range transboundary air emissions arising from the burning of agricultural residues.

Table 6.1. Agriculture emissions as per cent of total emissions, 2012

Pollutant	Percent of emissions
NOX	0.1 %
NMVOC	0.2 %
SOX	0.1 %
NH3	91.6 %
PM2.5	0.5 %
PM10	0.4 %
TSP	0.3 %
CO	0.7 %
Diox	2.7 %
PAH-4	1.4 %

Figure 6.1. Trends for the NH3 emissions for agricultural sources. 1000 tonnes NH3. 1990-2012.



The total emissions of NH3 from agriculture have been relatively stable but with a slight increase since 1990. Figure 6.1 shows the NH3 trends for the different agriculture sources. More information is given in the trend chapter 2.1.4.

The emissions of other components is mainly from combustion of straw, and all have the same decreasing trend, mainly due to reduced amount of straw burned since 1990.

6.2 Domestic livestock categorization

Last update: 07.03.14

The main sources of the livestock statistics are the register of production subsidies (sheep for breeding, goats, breeding pigs, poultry for egg production and beef cows), statistics of approved carcasses (animals for slaughter) and the Cow Recording System at TINE BA[14] (heifers for breeding and dairy cows). These sources cover 90-100 per cent of the animal populations. The coverage in the register of production subsidies is shown in table 6.2.

Table 6.2. Estimated coverage of animal populations in the register of production subsidies 2012.

	Percentage covered in the statistics
The register of production subsidies	
Dairy cows	100
Beef cows	99.99
Sheep	99.8
Goats	99.9
Laying hens	99.2
Chics for breeding	99.99
Other poultry for breeding	89.8
Sows	99.0
Young pigs for breeding	98.4
Deer	99.9
Other (ostrich, lama…)	unknown

Source: Estimations by Statistics Norway

The statistics of approved carcasses covers close to 100 per cent of all slaughtered animals. Home slaughter is not included, but the extent of home slaughter is very low due to legal restrictions. Even animals consumed by producers are in most cases registeed at the slaughterhouses. The number of dairy cows and heifers for breeding derive from the Cow recording systems. Between 98 and 99 per cent of all dairy cows are registered here, and in addition, the number used in the inventory is adjusted for this missing part.

The registers are updated annually. In addition to the animals included in these registers, an estimate of the number of horses that are not used in farming is obtained from the Norwegian Agricultural Economics Research Institute (NILF). The number of reindeer is obtained from the Norwegian Reindeer Husbandry Administration.

[14] TINE BA is the sales and marketing organisation for Norway's dairy cooperative and covers most of the milk production and the meat production induced by milk production)

For some categories of animals not living a whole year, for instance lambs, lifetime is taken into account to get a yearly average for the number of animals. An expert judgment suggests an average lifetime of 143 days for lambs (UMB, *pers. comm*[15]). The formula for calculating the average figure for lambs will then be:

$$(6.1) \quad Lambs * \frac{143}{365}$$

For heifers and bulls for slaughter, animal numbers are based on data from statistics of approved carcasses which provide data on numbers slaughtered and slaughter weights. Combined with slaughter age from the Cow Recording System, this gives a precise estimation of animal life time for each animal slaughtered. One principal draw-back of this method for estimating animal population is that emissions in all stages of these animals' lives will be accounted for in the year of slaughter, even though the emissions of the early stages of the lives of these animals to a large extent took place in the previous year. In a stable population of animals, this error is automatically adjusted, and since animal populations are relatively stable, this error is considered much smaller compared to errors related to estimating animal year based on animal populations in the register of production subsidies which was previously used. The new data sources also ensure a better coherence between animal numbers, life time and weight.

The number of heifers bred for new milking cows is estimated correspondent to the method used for heifers and bulls for slaughter. The data source is the Cow Recording System, which provide data on the number, age and live weight of the young cows' at their first calving.

There are some differences between these numbers and the FAO statistics. The explanation is that the figures reported to the FAO are provided by the Norwegian Agricultural Economics Research Institute NILF. NILF makes an overall estimation for the agricultural sector, which is the basis for the annual negotiations for the economic support to the sector. This estimate includes a grouping of all agricultural activities, comprising area, number of animals and production data. This method is a little different from the one used by Statistics Norway. Differences include

- Different emphasis on the dates for counting, 31.07 and 31.12
- NILF does not register pigs under 8 weeks, whilst Statistics Norway does.

6.2.1 Uncertainties

Activity data

The uncertainty in the data is considered to be within ±5 per cent. There is also an uncertainty related to the fact that some animals are only alive part of the year and how long this part is.

6.2.2 Source specific QA/QC

In 2001, a project was initiated to improve the estimate of the number of animals. This was completed in 2002. In 2012, a further revision of the numbers of bulls and heifers was implemented. The revised data on animal populations form the basis for the emission calculations for all years.

[15] UMB (2001): Expert judgement by Department of Animal Science, Ås: Norwegian University of Life Sciences.

6.3 Emissions from manure management

NFR 4B

Last update: 14.02.14

6.3.1 Description

The relevant pollutant emitted from this source category are NH_3 (NFR 4B). Emissions from cattle are most important in Norway.

Emissions of NH_3 from manure depend on several factors, e.g. type of animal, nitrogen content in fodder, manure management, climate, time of spreading of manure, cultivation practices and characteristics of the soil. In the IPCC default method a NH_3 volatilisation fraction of 20 per cent is used for the total N excretion by animals in the country. However, in the Norwegian emission inventory, yearly updated NH_3 volatilisation values from Statistics Norway's NH_3 model are used, because this is expected to give more correct values for Norway. The estimated national volatilisation fractions have differed between 18-21 per cent since 1990. The IPCC default value is 20 per cent.

Forbedret metodebeskrivelse og forklaring av trender i AD og NH3 for 4B1a og 4B1b ønsket i review para 96 Henvise til trendkap.

6.3.2 Method

NH_3

In Norway, all animal excreta that are not deposited during grazing are managed as manure. Norwegian values for N in excreta from different animals are used according to table 6.3. Based on typical Norwegian feedstock ratios, the excretion of nitrogen (N) and phosphorous (P) were calculated by subtracting N and P in growth and products from assimilated N and P. The numbers were in some cases compared to numbers found in balance experiments. Norwegian values are also used for the fraction of total excretion per species for each management system (MS) and for pasture. The fractions are updated every year and are provided in table 6.4.

Table 6.3. N in excreta from different animals. 2012. kg/animal/year unless otherwise informed in footnote

	kg/animal/year[1]
Dairy cattle	125.0
Beef cattle	64.5
Replacement heifer[3]	84.6
Bull for slaughter[3]	65,5
Finishing heifer[3]	64,2
Horses	50.0
Sheep < 1 year	7.7
Sheep > 1 year	11.6
Goats	13.3
Pigs for breeding	23.5
Pigs for slaughtering[3]	3.2
Hens	0.670
Chicks bred for laying hens[3]	0.046
Chicks for slaughtering[3]	0.030
Ducks, turkeys/ goose for breeding[3]	2.0

Ducks, turkeys/ goose for slaughtering[3]	0.4
Mink	4.3
Foxes	9.0
Reindeer	6.0
Deer	12.0

[1] Includes pasture.
[2] Factors for excreted nitrogen apply for the whole life time of animals, but nitrogen is calculated only when animals are slaughtered/replaced. This is described in section 6.2.
[3] Per animal. For these categories, life time is less than a year. This means that the number of animals bred in a year is higher than the number of stalls (pens).
Source: Karlengen et al. (2012) and estimations by Statistics Norway.

Table 6.4. Fraction of total excretion per species for each management system and for pasture 2012

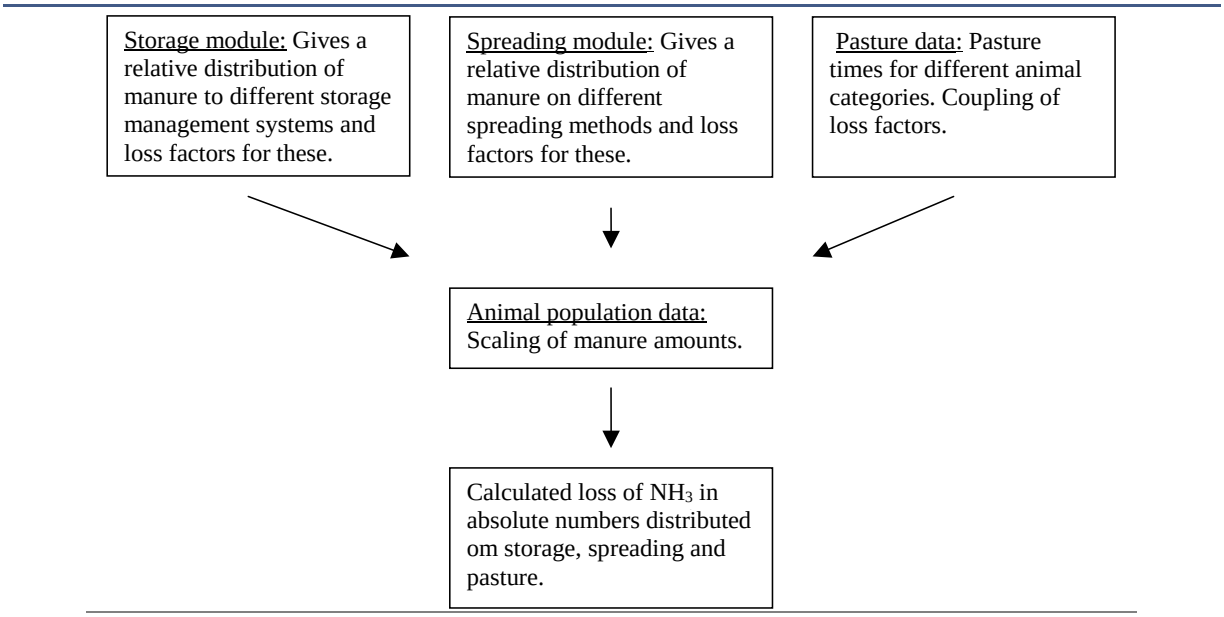
	Anaerobic lagoon	Liquid system	Solid storage and dry lot	Pasture range and paddock	Other manure management systems
Dairy cattle	0	0.76	0.06	0.18	0
Non-dairy cattle	0	0.64	0.05	0.31	0
Poultry	0	0.27	0.73	0	0
Sheep	0	0.25	0.30	0.45	0
Swine	0	0.88	0.12	0	0
Other animals	0	0.30	0.33	0.36	0

Source: Data for storage systems from Statistics Norway (2004) and Gundersen and Rognstad (2001) (poultry) and data for pasture times from (Tine BA *annually*) (Dairy cattle, goat), Statistics Norway's Sample Survey 2001 (Statistics Norway 2002) (non-dairy cattle, sheep) and expert judgements.

Statistics Norway's NH_3 model is used for calculating the emissions of NH_3 from manure management. The principle of the model is illustrated in figure 6.2.

The storage module in the NH_3 model gives the relative distribution of manure nitrogen to the different storage management systems. Total emissions from storage are estimated by multiplying the different emission factors for the storage systems by the amount of manure nitrogen for each storage system, and summarizing the results. The amount of nitrogen is estimated by the number of animals and nitrogen excretion factors for each type of animal (see table 6.3).

Figure 6.2. The principle of the NH_3 model



6.3.3 Activity data

NH_3

Activity data on storage systems are scarce, and the only source practically available is the Sample survey of agriculture and forestry 2003 (Statistics Norway 2004) and the Statistics Norway survey of different storage systems in 2000 (Gundersen and Rognstad 2001). Data on storage systems for other years are unavailable. Analyses and estimations of the effects on emissions of the assumed changes in storage systems since 1990 show that the assumed change is of little significance to the emissions. In addition, data on animal populations are used to estimate the amounts of manure. The method for estimating animal population is described in section 6.2.

The manure is distributed to the following storage systems categories:

- Manure cellar for slurry
- Manure pit for slurry
- Indoor built up/deep litter
- Outdoor built up/enclosure
- Storage for solid dung and urine

Each of these categories are possible for all combinations of the following regions and productions:

Regions:

- South-Eastern Norway
- Hedmark and Oppland
- Rogaland
- Western Norway
- Trøndelag
- Northern Norway

Production:

- Cattle
- Pigs
- Sheep and goats
- Poultry
- Horses, farm raised fur-bearing animals

6.3.4 Emission factors

NH_3

Emission factors vary with production and storage system; in the model there is no variation between regions. The factors are based on data from Denmark, Germany and Netherlands, since measurements of NH_3-losses in storage rooms have so far not been carried out in Norway. The factors are shown in table 6.5.

Table 6.5. Emission factors for various storage systems and productions. Per cent losses of N of ammonium N

	Storage system						
	Manure cellar for slurry	Open manure pit for slurry	Manure pit for slurry with lid	Open flag-stones	Indoor built up/deep litter	Outdoor built up/enclosure	Storage for solid dung and urine
	Gutter	Gutter		Drainage to gutter			
Cattle, milking cow:							
Loss from animal room	5	5	5	5	8	8	5
Loss from storage room	2	9	2	2	15	15	15
Total loss	7	14	7	7	23	23	20
Pigs:							
Loss from animal room	15	15	15	15	15	15	20
Loss from storage room	4	6	2	2	25	25	30
Total loss	19	21	17	17	40	40	50
Sheep and goats:							
Loss from animal room	5	5	5	5	8	8	5
Loss from storage room	2	6	2	2	10	10	10
Total loss	7	11	7	7	18	18	15
Poultry:							
Loss from animal room	12	10	12	12	25	25	25
Loss from storage room	15	15	15	15	25	25	25
Total loss	27	25	27	27	50	50	50
Other animals:							
Loss from animal room	5	0	0	0	15	15	15
Loss from storage room	10	0	0	0	15	15	15
Total loss	15	0	0	0	30	30	30

Source: Morken et al (2005)

The factors are combined with the activity data in the Statistics Norway survey of different storage systems in 2000 (Gundersen and Rognstad 2001) and the Sample survey of agriculture

and forestry 2003 (Statistics Norway 2004), and emission factors for NH_3 emissions from storage of manure and stalled animals are calculated for production and region (table 6.6). To estimate losses, these emission factors are in turn multiplied with the amount of manure (based on number of animals and N-factors per animal, table 6.3).

Table 6.6. Average emission factors for the manure storage systems used, distributed on type of animal production and region. Per cent of ammonium N

	South-Eastern Norway	Hedmark/ Oppland	Rogaland	Western Norway	Trøndelag	Northern Norway
Cattle	10.1	8.4	8.0	8.0	7.7	7.9
Pigs	26.2	22.1	19.8	20.3	21.0	21.2
Sheep and goats	13.3	12.6	9.2	11.4	11.9	11.5
Poultry	47.0	46.4	38.7	37.3	41.7	44.5
Other animals	25.7	24.7	17.1	19.1	23.5	21.6

Source: Statistics Norway, NH_3-model estimations.

6.3.5 Uncertainties

Uncertainty estimates are provided in Appendix C.

6.3.5.1 Activity data

NH_3

Emissions are estimated from the animal population. The data for the number of animals are considered to be known within ±5 per cent.

For the emissions of NH_3 from manure management, Norwegian data for N in excreta are used. The nitrogen excretion factors are uncertain, but the range is considered to be within ±15 per cent (Rypdal 1999). The uncertainty has not yet been estimated for the revised nitrogen excretion factors used in the 2013 reporting, and in the key category analysis the uncertainty estimate for the country specific nitrogen excretion factors from 1999 is still used as the best available estimate. This can be considered as a conservative estimate of the uncertainty since it is expected that the new nitrogen excretion factors have a lower uncertainty. The uncertainty is connected to differences in excretion between farms in different parts of the country, that the survey farms may not have been representative, general measurement uncertainty and the fact that fodder and fodder practices have changed since the factors were determined.

There is also an uncertainty connected to the division between different storage systems for manure, which is considered to be within ±10 per cent, and the division between storage and pasture, which is considered to be within ±15 per cent.

6.3.5.2 Emission factors

NH_3

Ammonia emissions from agriculture are estimated based on national conditions. There are uncertainties in several parameters (fraction of manure left on pastures, amount of manure, conditions of storage, conditions of spreading and climate conditions. An uncertainty analysis for the revised NH_3 model, which has been in use since 2003, has not been performed. However, the revision of the model is believed to have reduced the uncertainty. Also the new estimations of nitrogen excretion from animals (Karlengen et al. 2012) are believed to have reduced uncertainty further.

6.3.6 Completeness

Major missing emission sources are not likely.

6.3.7 Source specific QA/QC

Statistics Norway, in cooperation with the Norwegian University of Life Sciences (NMBU), made improvements in 2003 in the calculation model for NH_3 emissions from the agricultural sector. Data sources used for the recalculations in the revised NH_3 model are coefficients from the Norwegian University of Life Sciences, and two surveys from Statistics Norway; a manure survey (Gundersen and Rognstad 2001) and the sample survey of agriculture and forestry (2001) (Statistics Norway 2002).

Statistics Norway's detailed manure survey gave more extended activity data which are better related to emission source categories, for manure management and spreading. New loss factors for different manure management categories are also used in the revised NH_3-model. These factors are closer connected to specific activities.

6.4 Direct and indirect emissions from agricultural soils

NFR 4D
Last update: 31.01.13

6.4.1 Description

The use of synthetic fertilisers, animal excreta nitrogen and sewage sludge used as fertiliser, and droppings on pastures result in emissions of NH_3.

6.4.2 Method

6.4.2.1 Synthetic fertiliser

NH_3
Statistics Norway's NH_3 model (described in section 6.3.2) is used for calculating the emissions of NH_3 from the use of synthetic fertiliser. The calculations of NH_3 emissions from the use of synthetic fertiliser are based on the amounts of nitrogen supplied and emission factors for the percentage of nitrogen emitted as NH_3 during spreading. The amount of nitrogen supplied is estimated based on data for total annual amount of fertiliser sold in Norway and its nitrogen content, corrected for the amount of synthetic fertiliser applied in forest. The resulting amount is expected to be the amount applied on agricultural fields.

6.4.2.2 Manure applied to soils

NH_3
Statistics Norway's NH_3 model is used for calculating emissions of NH_3 from spreading of manure on cultivated fields and meadow. The principle for the model is given in figure 6.2 in section 6.3.2. A spreading module in the NH_3 model gives the relative distribution of manure spread as fertiliser, distributed on different spreading methods. Total emissions from spreading are estimated by emission factors for each different spreading method multiplied by the amount of manure nitrogen. The total amount of manure nitrogen is estimated by the number of animals and nitrogen excretion factors for each type of animal.

6.4.2.3 NH_3 emissions from industrial and urban wastes

NH_3
To calculate NH_3 emissions from sewage sludge used as fertiliser, the fraction of N in manure lost as NH_3 is used (fracgasm). The loss equals to total N in sewage sludge multiplied by fracgasm.

6.4.2.4 NH_3 emissions from grazing animals

NH_3

Statistics Norway's NH_3 model is used for calculating the emissions of NH_3 from pastures. Animal population data, data for pasture times, and factors for the nitrogen amount in excreta for different animal categories give the nitrogen amounts for the animal categories on pastures. Specific emission factors by animal category are used.

6.4.3 Activity data

NH_3

Synthetic fertiliser

The Norwegian Food Safety Authority calculates a total value for annual consumption of synthetic fertilisers in Norway based on sales figures. These data are corrected for the amount of fertiliser used in forests, which is provided by silviculture statistics from Statistics Norway. The silviculture statistics provides the weight of the fertiliser used on wet forest land (moor) and on dry forest land annually. An expert judgement has been made, which concludes that almost only NPK (nitrogen, phosphorus, potassium) with a nitrogen content of 15 per cent is used on wet forest land. On dry forest land it is assumed that half of the used synthetic fertiliser is NPK and the other half is fertiliser with a nitrogen content of 30 per cent (Rypdal *et al.* 2005).

For the calculation of the emission of NH_3 we need a specification of the use of different types of synthetic fertiliser. This is given by the Norwegian Food Safety Authority for the years from 2000. Due to lack of data for the years before 2000, we have to assume that the percentual distribution between the usage of different fertiliser types is the same as in 1994 for these years.

Animal manure applied to soil and pasture

There are several sources of activity data on spreading of manure in the NH_3-model. The main sources are the manure survey in 2000 by Statistics Norway (Gundersen and Rognstad 2001), various sample surveys of agriculture and forestry 1990-2007 and the animal population. Animal population is updated annually. The animal population estimation methodology is described in section 6.2.3. Data from the manure survey do only exist for 2000, while the data from the sample surveys have been updated for several, but not all, years.

Data for time on pasture and share of animals on pasture are collected from the Sample Survey in Statistics Norway 2001 and from TINE BA (TINE BA is the sales and marketing organisation for Norway's dairy cooperative and covers most of the milk production). The data from TINE BA comprises pasture data for goats and milking cows and are updated annually. All other pasture data are from the Statistics Norway Sample survey 2001. The parameters used in the calculations and their sources are shown in table 6.7.

Table 6.7. Parameters included in the estimation of NH_3 emissions from manure

Parameters (input)	Sources
Number of animals	Statistics Norway (applications for productions subsidies), no. and weight of approved carcasses), The Cow Recording System at TINE BA)
Nitrogen factors for manure	Various sources, compiled by Statistics Norway
Area where manure is spread, split on cultivated field and meadow.	Statistics Norway (Sample Surveys of Agriculture, various years), Gundersen and Rognstad (2001)
Area and amount where manure is spread, split on spring and autumn.	Gundersen and Rognstad (2001)
Amount of manure is spread, split on spring and autumn.	Statistics Norway (Sample Surveys of Agriculture, various years)
Addition of water to manure	Gundersen and Rognstad (2001), expert judgements, Statistics Norway's Sample Survey 2007
Spreading techniques	Gundersen and Rognstad (2001), expert judgements,
Usage and time of harrowing and ploughing.	Statistics Norway (Sample Surveys of Agriculture), Gundersen and Rognstad (2001), expert judgements,
Pasture times for different animal categories	(Tine BA *annually*) (Dairy cattle, goats), Statistics Norway's Sample Survey 2001 (Statistics Norway 2002) (non-dairy cattle, sheep), expert judgements.

6.4.4 Emission factors

NH_3

Synthetic fertiliser

Different types of synthetic fertilisers are being used, resulting in different emissions of NH_3. Their respective share is based on sales statistics provided annually by the Norwegian Food Safety Authority for the years from 2000. For earlier years the distribution is based on data from 1994. The NH_3 emission factors (per cent loss of N) for the different types of fertilisers are shown in table 6.8.

Table 6.8. Emission factors for NH_3-N for different fertilisers. Per cent loss of applied N.

Fertiliser	Emission factor (per cent of applied N)
Urea	15
Ammonium sulphate and Ammonium nitrate	5
Calcium nitrate	0
Calcium ammonium nitrate	1
NPK (Nitrogen, phosphorus, potassium)	1
Other	1

Source: ECETOC (1994) and Norsk Hydro, *pers. comm.*[16]

Animal manure applied to soil and pasture

Emission factors for spreading of stored manure vary with spreading method (Gundersen and Rognstad 2001), water content (Statistics Norway 2007), type and time of treatment of soil (Gundersen and Rognstad 2001), time of year of spreading (Gundersen and Rognstad 2001; Statistics Norway 2007), cultivation, and region. The basic factors used are shown in table 6.9.

[16] Norsk Hydro (1995): Personal information, Kaarstad, Norsk Hydro.

Table 6.9. Emission factors for NH_3-N for various methods of spreading of manure. Per cent of ammonium N

			Western and northern Norway			Southern and eastern Norway		
			Spring	Summer	Autumn	Spring	Summer	Autumn
Meadow								
Surface spreading			0.5	0.6	0.4	0.5	0.6	0.4
Injection			0.1	0.1	0.05	0.1	0.1	0.05
Water mixing			0.3	0.3	0.2	0.3	0.3	0.2
Dry manure			0.04	0.1	0.1	0.04	0.1	0.1
Open fields								
Method	Time before down-moulding	Type of down-moulding						
Surface spreading	0-4 hrs	plow	0.2		0.2	0.15		0.3
Surface spreading	+ 4 hrs	plow	0.5		0.35	0.4		0.4
Surface spreading	0-4 hrs	harrow	0.4		0.35	0.35		0.35
Surface spreading	+ 4 hrs	harrow	0.5		0.45	0.45		0.45
Water mixing	0-4 hrs	plow	0.1		0.1	0.1		0.15
Water mixing	+ 4 hrs	plow	0.25		0.2	0.2		0.25
Water mixing	0-4 hrs	harrow	0.2		0.2	0.2		0.2
Water mixing	+ 4 hrs	harrow	0.3		0.25	0.25		0.25
Dry manure			0.04		0.1	0.04		0.1

Source: Morken and Nesheim (2004).

Table 6.10. Average NH_3 emission factors for cultivated fields and meadows after time of spreading and region. 2012. Per cent of ammonium N.

	South-Eastern Norway		Hedmark/ Oppland		Rogaland		Western Norway		Trøndelag		Northern Norway	
	Field	Meadow	Field	Meadow	Field	Meadow	Field	Meadow	Field	Meadow	Field	Meadow
Spring	32.9	44.4	35.3	44.3	23.2	48.2	4.0	40.2	28.4	46.9	5.1	47.6
Autumn	28.6	33.3	28.9	33.2	21.3	34.4	10.0	28.9	30.9	34.4	11.0	33.2

Source: Statistics Norway, NH_3-model estimations.

The factors in table 6.9 are combined with the activity data in the Sample survey of agriculture and forestry 2007 (Statistics Norway 2007) and a time series on mixture of water in manure, and emission factors for NH_3 emissions from spreading of manure distributed to meadow and cultivated fields, time of season and region are calculated (see table 6.10). These factors are in turn connected to activity data that are updated in the years since 1990, i.e. number of animals (amount of manure), time of spreading and type of cultivation of the areas where the manure is spread.

The emission factors used for the calculation of the NH_3 emissions from grazing animals are shown in table 6.11. These are the same as the emission factors used in Germany (Dämmgen *et al.* 2002) and Denmark (Hutchings *et al.* 2001).

Table 6.11. NH_3 emission factors from droppings from grazing animals on pasture. Per cent of ammonium N applied.

	N-loss/N applied
Cattle	7.5
Sheep and goats	4.1
Reindeer	4.1
Other animals	7.5

Source: Dämmgen *et al*. (2002), Hutchings *et al*. (2001).

6.4.5 Uncertainties

6.4.5.1 Activity data

There are several types of activity data entering the calculation scheme:

Sales of nitrogen fertiliser: The data are based on sales figures during one year (The Norwegian Food Safety Authority). The uncertainty in the sales figures is within ±5 per cent (Rypdal and Zhang 2000). In addition comes a possible error due to the fact that sales do not necessarily equal consumption in a particular year, due to storage. The share of the various types of nitrogen fertiliser is assumed to be the same as in an investigation in 1994, and the error connected to this approach has probably increased over the years.The effect for the uncertainty in activity data due to these two factors has not been quantified, but it is assumed that it can be more important than the uncertainty in the sales figures.

NH_3 losses from fertiliser containing ammonium (NH_4) are related to soil pH. This could probably also lead to uncertainty, but Norwegian soils are very dominated by soils with low pH, which leads to small losses of this type.

Amount of nitrogen in manure: The figures are generated for each animal type, by multiplying the number of animals with a nitrogen excretion factor. The nitrogen excretion factors are uncertain. The range is considered to be within ±15 per cent (Rypdal 1999). The uncertainty is connected to differences in excreted N between farms in different parts of the country, that the survey farms may not have been representative, general measurement uncertainty and the fact that fodder and feeding practices have changed since the factors were determined. The uncertainty has not yet been estimated for the revised nitrogen excretion factors used in the 2013 reporting, and in the key category analysis the uncertainty estimate for the country specific nitrogen excretion factors from 1999 is still used as the best available estimate. This can be considered as a conservative estimate of the uncertainty since it is expected that the new nitrogen excretion factors have a lower uncertainty.

The uncertainty connected to the estimate of the amount of manure is higher than for the amount of synthetic fertiliser used.

Fate of manure: There is significant uncertainty connected to the allocation of manure between what is used as fertiliser and droppings on pastures.

Atmospheric deposition of NH_3: The data are based on national NH_3 emission figures. These are within ±30 per cent (Rypdal 1999).

6.4.5.2 Emission factors

NH_3

The uncertainty in the estimate of emissions of NH_3 from use of fertiliser is assessed to be about ±20 per cent (Rypdal and Zhang 2001). This uncertainty could be lower if better data on fertiliser composition were obtained. The uncertainty is higher for animal manure (±30 per cent (Rypdal and Zhang 2001)). This is due to uncertainties in several parameters (fraction of manure left on pastures, amount of manure, conditions of storage, conditions of spreading and climate conditions) (Rypdal and Zhang 2001). Other factors that could lead to uncertainty are variation in storage periods, variation in house types and climate, and variation in manure properties.

6.4.6 Completeness

All sources described in the IPCC reporting guidelines are included in the estimates. However, the emission factors might not be reflecting national conditions.

6.4.7 Source specific QA/QC

Statistics Norway, in cooperation with the Norwegian University of Life Sciences (NMBU), made improvements in 2003 in the calculation model for NH_3 emissions from the agricultural sector. Data sources used for the recalculations in the revised NH_3 model are coefficients from the Norwegian University of Life Sciences, and two surveys from Statistics Norway; a manure survey (Gundersen and Rognstad 2001) and the sample survey of agriculture and forestry (2001). New factors for nitrogen excretion from animals and a revision of animal statistics has been made in 2012, to better reflect the actual nitrogen excretion from each animal category and to have a more correct linkage between the nitrogen excretion factors used and the different animal categories.

6.5 Emissions from agricultural residue burning (agricultural wastes)

NFR 4F
Last update: 30.11.10

6.5.1 Description

Burning of agricultural residues gives emissions of a large range of standard combustion products. Emissions of NO_X, CO, NH_3, NMVOC, SO_2, particles and the heavy metals Pb, Cd, Hg, As, Cu and Cr, and PAH and dioxins are included in the inventory.

6.5.2 Method

The emissions from the burning of crop residues are being calculated in accordance with a Tier 1 approach (EEA 2009):

$E_{Pollutant} = AR_{residue\_burnt} * EF_{Pollutant}$

$E_{Pollutant}$ = emission (E) of pollutant
$AR_{residue\_burnt}$ = activity rate (AR), mass of residue burnt (dry matter)
$EF_{Pollutant}$ = emission factor (EF) for pollutant

6.5.3 Activity data

The annual amount of crop residue burned on the fields is calculated based on crop production data for cereals and rapeseed from Statistics Norway, and estimates of the fraction burned made by the Norwegian Crop Research Institute and Statistics Norway . The fraction of crop residue burned on field was updated in 2012 by the Norwegian Agricultural Authorities[17]. This reduced the fraction for 2011 from 7.5 to 4 per cent. For cereals a water content of 15 per cent is used (IPCC 1997a) and the water content for rapeseed is set to 9 per cent (Swedish environmental protection agency 2005). The activity data are consistent with the data used in the estimations of N_2O from crop residues.

[17] Johan Kollerud, Norwegian Agricultural Authorities, unpublished material 2012.

6.5.4 Emission factors

Table 6.12. Emission factors for agricultural residue burning.

Components	Emission factors	Unit	Source
Precursors			
NO_X	2.4	kg/ tonnes crop residue (d.m.) burned	(EEA 2009)
CO	58.9	kg/ tonnes crop residue (d.m.) burned	(EEA 2009)
SO_2	0.3	kg/ tonnes crop residue (d.m.) burned	(EEA 2009)
NMVOC	6.3	kg/ tonnes crop residue (d.m.) burned	(EEA 2009)
NH_3	2.4	kg /tonnes crop residue (d.m.) burned	(EEA 2009)
Heavy metals			
Pb	0.865	g/ tonnes crop residue (d.m.) burned	(EEA 2009)
Hg	0.008	g/ tonnes crop residue (d.m.) burned	(EEA 2009)
Cd	0.049	g/ tonnes crop residue (d.m.) burned	(EEA 2009)
As	0.058	g/ tonnes crop residue (d.m.) burned	(EEA 2009)
Cr	0.22	g/tonnes crop residue (d.m.) burned	(EEA 2009)
Cu	0.354	g/ tonnes crop residue (d.m.) burned	(EPA 2002)
Particles			
TSP, PM_{10}	5.8	kg/ tonnes crop residue (d.m.) burned	(EEA 2009)
$PM_{2.5}$	5.5	kg/ tonnes crop residue (d.m.) burned	(EEA 2009)
POPs			
PAH-total	30.0	g/ tonnes crop residue (d.m.) burned	(Norwegian institute for air research and Norwegian institute for water research 1995), (EPA 1998)
PAH-6	13.9	g/ tonnes crop residue (d.m.) burned	(Norwegian institute for air research and Norwegian institute for water research 1995), (EPA 1998)
PAH-4	3.0	g/ tonnes crop residue (d.m.) burned	(Norwegian institute for air research and Norwegian institute for water research 1995), (EPA 1998)
Dioxins	17	iµg I-TEQ/tonnes crop residue (d.m.) burned	(Norwegian pollution control authority 2001)

Heavy metals and POPs

The emission factors recommended in EPA (2002) are used for Cu. For the other heavy metals default emission factors from the EMEP/EEA emission inventory guidebook are used (EEA 2009). The emissions of dioxins and PAH are calculated based on emission factors respectively from OSPAR (Norwegian pollution control authority 2001) and NILU/NIVA (Norwegian institute for air research and Norwegian institute for water research 1995). The emission profile used for PAH is the one presented for open burning of garden waste (EPA 1998).

6.5.5 Uncertainties

Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

6.5.6 Completeness

The main emission components from burning of agricultural residues are considered to be covered in the emission calculations.

6.5.7 Source specific QA/QC

In 2002, the emissions of NO_X, CO, Pb, Hg, Cd, PAHs and dioxins from agricultural residual burning were included in the Norwegian inventory, and in 2003, the emissions of particles, As, Cr and Cu were added. In 2011, also emissions of SO_2, NMVOC and NH_3 were included in the inventory. The time series were included but it should be noted that the figures for the earlier years have a higher uncertainty than the more recent years.

6.6 Other agricultural emission sources

NFR 4G
Last update: 15.02.11

6.6.1 Description

Straw treated with NH_3 to be utilised as fodder is a source of NH_3 emissions in Norway. Agricultural activities are also a source of non-combustion emissions of particles.

6.6.2 NH_3 emissions from treatment of straw

6.6.2.1 Method

Emissions of NH_3 from treatment of straw depend only on the amount of NH_3 used. The total amount of NH_3 used for treatment of straw in Norway is multiplied with the share of the NH_3 that is not integrated in the straw.

6.6.2.2 Activity data

The amount of NH_3 used per year is obtained from the Budget Committee for Agriculture (NILF 2010). The area of cultivated fields is annually updated from Statistics Norway's agriculture statistics.

6.6.2.3 Emission factor

It is estimated that 65 per cent of the NH_3 applied is not integrated with the straw, and is therefore emitted after the treatment (Morken 2003). The same estimation is being used in Denmark.

6.6.2.4 Uncertainties

Uncertainty in the estimate of emissions from NH_3 treatment of straw is rather low (±5 per cent) (Rypdal and Zhang 2001).

6.6.2.5 Completeness

Major missing emission components are not likely.

6.6.2.6 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

6.6.3 Particle emissions from the agricultural sector

Agriculture is responsible for various types of non-combustion emissions of particles. This is for example dust from crops that are harvested, soil dust from work with agricultural machines, wood particles from felling of trees etc.

6.6.3.1 Method

Due to the relatively few analyses of particle emissions from agriculture, the calculations from this source are limited. Emission figures for three types of non-combustion emissions of particles from the agriculture are calculated; emissions from reaper, and from loading and transport on the fields. The total grain cultivation area in Norway is multiplied with emission factors, which gives emissions per area unit. For other actual activities in the agricultural fields, no emission factors have been found.

6.6.3.2 Activity data

The total grain cultivation area in Norway is used as activity data. Data source used is statistics from Statistics Norway on the area on holdings used for grain seeds.

6.6.3.3 Emission factor

The emission factors used are shown in table 6.13. These factors refer to wheat cultivation, but they are used for all grain cultivation in Norway. The factors are based on measurements of particles with a diameter less than 7 µm. No measurements have been made for estimating the ratio between $PM_{2.5}$, PM_{10} and TSP. Therefore the estimation has been made that the calculated emission figures (in reality PM_7) is $PM_{10} = PM_{2.5} = TSP$.

Table 6.13. Emission factors for non-combustion emissions of particles from the agricultural sector. g/km^2

Emission source	
Reaper	170
Loading	12
Transport	110

Source: EPA (1998).

6.6.3.4 Uncertainties

No uncertainty analysis has been made for this source. The few studies made in this field give a relatively high uncertainty for this source.

6.6.3.5 Completeness

The information about this emission source is poor, and it is likely that there are more particle sources from the agricultural sector than included here.

6.6.3.6 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

7 LAND USE AND LAND-USE CHANGE (NFR sector 5)

There is no long-range transboundary air pollution reported for Norway from the Land use and land-use change sector.

8 WASTE (NFR sector 6)

NFR 1A1a

8.1 Overview

This sector includes small-scale waste incineration (6C). Emissions from waste incineration included here are emissions from flaring, except flaring from energy sectors, emissions from cremation and hospital waste (until 2005), The main emissions from Waste Incineration are included in the energy sector (1A) since all incineration of municipal, industrial and medical waste in Norway now is done with energy recovery The source sector 6.D. Waste Other covers emissions from municipal sewage sludge applied to parks etc. emissions from accidental car fires, building fires, and emissions from recovering processes in the waste trade.

Figure 8.1. Trends for the emissions for most of the long-range transboundary air pollutants from waste, relative to 1990.

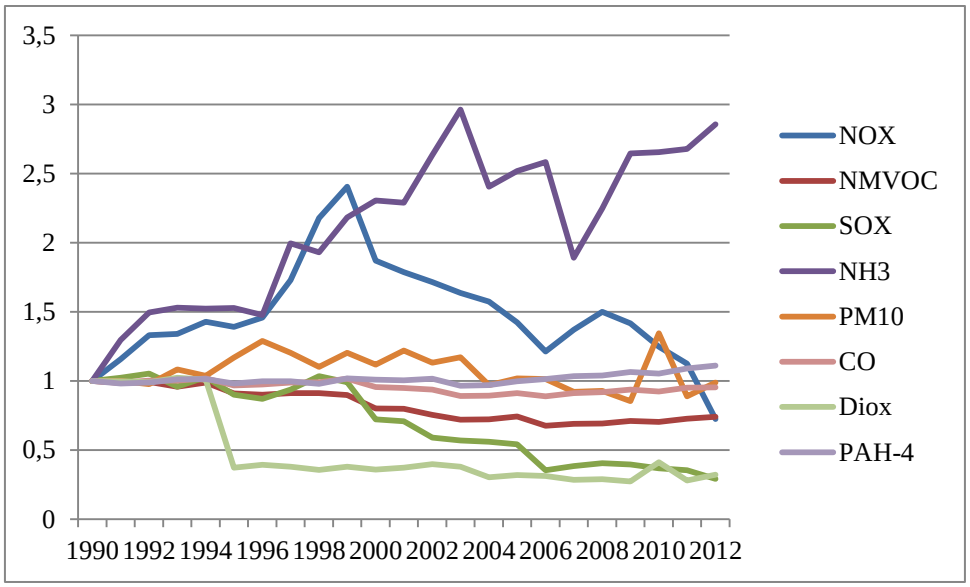


Figure 8.1 shows the trends for the emissions for most of the long-range transboundary air pollutants from waste, relative to 1990. With the exception of NH3 and PAH-4, the emissions of all pollutants have decreased since 1990.

8.2 Waste incineration

NFR 1A1a, 1A2d and 6C
Last update: 30.01.13

8.2.1 Description

Emissions from waste incineration in district heating plants are reported under energy (IPCC 1A1a), as the energy is utilised, and therefore described in section 3.2.2. In 2012, there were 12 waste incineration plants where household waste was incinerated. In addition, some incineration plants burn waste other than household waste, mainly wooden waste, paper, pasteboard and cardboard. These emissions are reported and described under energy. Waste, other than household waste, is also used as energy source in some manufacturing industries. These emissions are reported and described in the relevant subsectors under 1A2. Flaring off-shore and in refineries is included under sector 1B2c, Flaring in chemical industry is included under sector 2B5. In this chapter, the focus will be on waste from flaring, except flaring from energy sectors, and emissions from cremation and hospital waste until 2005.

8.2.2 Method

Emissions from flaring of landfill gas are estimated. The emissions are estimated by multiplying the amount of gas flared with the emission factors shown in table 8.1.

Emissions from cremation and hospital waste are estimated by emission factors multiplied with activity data. For hospital waste, the emissions of lead, cadmium and mercury used in the model are reported to the Norwegian Environment Agency. Emissions of arsenic, chromium and copper are only reported by two hospitals to the Norwegian Environment Agency for the year 1999. A country specific emission factor is made for each component. This factor is based on the ratio between reported emission figures for 1999 and the quantities of waste burned in 1999. This factor is then multiplied with the amount of waste burned at other hospitals for the years 1995 - 2005. Around 1995 more control device systems were installed at waste incineration plants as a result of stricter emission requirements. It is assumed that this also applied to incineration of hospital waste. For the years before 1995 is it assumed that the emissions were higher. The emission standards for particulate matter from waste incineration changed from 100 to 30 mg/Nm3. It was assumed that emissions of lead, cadmium copper and chromium follow the same pattern as particulate matter. It is believed however, that arsenic is more like properties of mercury and we assume that emissions of arsenic have been reduced in the same way as mercury. Emissions of mercury were regulated from 0.1 to 0.05 mg/Nm3 mg/Nm3 from 1994/1995. It is therefore assumed that emissions of arsenic before 1995 were twice as large as after 1995. Emissions of particulate matter are reported for all hospitals for the period 1990-1999. Since 2000, emissions from some of the hospitals are estimated based on EF and the amount of waste incinerated. Since 2006 all hospital waste is incinerated at waste incineration plants.

8.2.3 Activity data

Landfill gas

The total amount of landfill gas extracted each year is reported by landfill owners to the Norwegian Environment Agency. Statistics Norway subtracts the amount utilized for district heating and thermal power, which is given by the energy statistics in Statistics Norway. Information on the amount flared is given by the Norwegian Environment Agency. Emissions from landfill gas flared is included in 6C. Emissions from landfill gas used for district heating and used in other sectors are reported in the relevant subsectors under 1A1 and 1A4.

Natural gas

The amount of natural gas flared by the production of methanol is reported under 2B5.

Hospital waste

The amount of hospital waste was reported to Statistics Norway for the years 1998 and 1999. For the period 1990-1997 the average for 1998 and 1999 has been used. After 1999 there has been no collection of hospital waste data. Due to the lack of better information, the waste amount for 1999 has been used to calculate the emissions for subsequent years. The hospital incinerators have gradually been closed down, mainly due to new emission limits. Since 2006, no hospital incinerators have been in operation. Today hospital waste is incinerated in incinerators for municipal waste and emissions are included under 1A1a.

Cremation

The incineration of human bodies is a common practice that is performed on
an increasing part of the annually amount of deceased.The number of cremated bodies is gathered by the Ministry of Culture and published in Statistics Norway's Statistical Yearbook.

The average body weight is assumed to be 60 kg.

8.2.4 Emission factors

Table 8.1. Emission factors for flare of landfill gas, cremation and hospital waste incineration

Component	Flare landfill gas kg/tonnes	Cremation Tonnes/body	Hospital waste Tonnes/tonnes
SO_2	0.02	0.00001813	0.0014
CO_2	0	0	0.3
CO	0.04	0.000735	0.0028
NO_x	0.17	0.0000441	0.0014
Particles PM_{10}	0.14	2.54E-08	0.0005
TSP			0.0005
$PM_{2.5}$			0.0005
NMVOC	0	0.0000637	0.0007
CH_4	0.37	0.00001176	0.00023
N_2O	0.0015	0.0000147	0.000035
		kg/body	mg/tonne
Pb	NA	1.86E-08	Plant-specific emission factors
Cd	NA	3.11E-09	Plant-specific emission factors
Hg	NA	0.005	Reported
Cu	NA	7.70E-09	2594.6*
Cr	NA	8.44E-09	1272,4*
As	NA	1.10E-08	4705.6
Dioxins	NA	9.99E-09	0.29685
PAH	NA	0.0343	2.5
PAH-4	NA	0.01127	0.04
PAH-Ospar	NA	0.00049	0.9

NA=Not Applicable.

* Country specific emission factor used for the years after 1995. Emission factors for the years 1990 to 1994 can be given on request.

8.2.5 Uncertainties

Uncertainty estimates for long-range transboundary air pollutants are given in Appendix C.

8.2.5.1 Activity data

No new data on amounts of hospital waste have been reported since 1999. The amount of hospital waste the subsequent years may vary from the data reported in 1998 and 1999. Since 2006, no hospital incinerators have been in operation.

8.2.5.2 Emission factors

If the composition of the hospital waste is different to the waste the emission factors are based on, the calculated emissions will be incorrect. Combustion engineering and processes also influence the emissions. These uncertainties have not been calculated.

8.2.6 Source specific QA/QC

There is no source specific QA/QC procedure for this sector. See section 1.6 for the description of the general QA/QC procedure.

8.3 Other emission sources from the waste sector

NFR 6D

Last update: 21.09.12

8.3.1 Description

This category is a catch all for the waste sector. Emissions in this category could stem from accidental fires, sludge spreading, compost production and biogas production. In the Norwegian inventory emissions from sewage sludge applied on fileds other than agricultural soils accidential car fires, house fires, emissions from recovering processes in the waste trade and emissions from

combustion of hazardous waste are included in this category.

8.3.2 Method

8.3.2.1 Sewage sludge applied on fields

NH_3

Emissions of NH_3 are calculated for sewage sludge applied on fileds other than agricultural soils. To calculate NH_3 emissions from sewage sludge, the fraction of N in manure lost as NH_3 is used (fracgasm). The loss equals to total N in sewage sludge multiplied by fracgasm. See 6.4.2.5.

8.3.2.2 Car and house fires

Particles, heavy metals and POPs

Emissions of particles and dioxins are calculated for car fires and house fires. In addition, heavy metals are calculated for house fires. Emissions are calculated by multiplying the annual number of car and house fires with emission factors. Four types of buildings are separated with different emission factors: detached houses, undetached houses, apartment buildings and industrial buildings.

8.3.2.3 Waste trade

NH_3, particles, heavy metals and POPs

Emissions from recovering processes in the waste trade include emissions of NH_3, particles, heavy metals and PAH. The emission figures are reported annually by the actual plants to the Norwegian Environment Agency.

8.3.3 Activity data

8.3.3.1 Sewage sludge applied on fields

Statistics Norway's waste water statistics annually gives values for the amount of sewage sludge and the fraction of the sewage sludge that is applied on fields

8.3.3.2 Car and house fires

Data on the number of car and house fires are provided annually by the Directorate for Civil Protection and Emergency Planning. These figures only include fires reported to the fire service.

8.3.4 Emission factors

8.3.4.1 Sewage sludge applied on fields

The N-content in the sludge is given in Statistics Norway (2001), and the same value of 2.82 per cent is used for all years.

8.3.4.2 Car fires

The emission factor for particles is given by EPA (2002). EPA recommends the factor of 0.9 kg/car for combustion of wrecked cars without car tyres, and a factor for combustion of car tyres of 1.4 kg/car. This results in an overall emission factor of 2.3 kg/car. The emission factor for emission of dioxins from car fires is found in Hansen (2000).

8.3.4.3 House fires

It is difficult to estimate the amount of material burned in a house fire. In Finstad *et al*. (2002b) a calculation was made that has been used to scale the chosen emission factors, to reflect how much of the building that is lost in a fire. This scaling calculation is based on the amount of damage estimated in monetary value, and value on how much of the building and the furniture that is burned. The emission factors used for particles in the inventory are given by scaling the emission factors used for combustion of fuelwood in the households (Haakonsen and Kvingedal 2001). The emission factors for heavy metals are given by scaling the emission factors for combustion of wood waste in the industry (EPA 2002). For dioxins, OSPAR (Norwegian pollution control authority 2001) gives the emission factor of 170 µg I-TEQ per tonne burned material. The scaled emission factors used for the different building types are given in table 8.2.

Table 8.2. Emission factors used for car fires and house fires, unit/fire

	Car	Detached house	Undetached house	Apartment building	Industrial building
TSP (kg)	0.0023	0.14382	0.06162	0.04378	0.02723
PM_{10} (kg)	0.0023	0.14382	0.06162	0.04378	0.02723
$PM_{2.5}$ (kg)	0.0023	0.14382	0.06162	0.04378	0.02723
Pb (g)		0.00042	0.00018	0.00013	8E-05
Cd (g)		0.00085	0.00036	0.00026	0.00016
Hg (g)		0.00085	0.00036	0.00026	0.00016
As (g)		0.00135	0.00058	0.00041	0.00025
Cr (g)		0.00129	0.00055	0.00039	0.00024
Cu (g)		0.00299	0.00128	0.00091	0.00057
Dioxins (µg)	0.047	1.43817	0.61621	0.43779	0.27234

9 Other and Natural emissions

There is no long-range transboundary air pollution reported for Norway as Other or Natural emissions.

10 Recalculations and Improvements

10.1 Recalculations

10.1.1 Overall description of the recalculations for the long-range transboundary air pollutants

As part of the continual process of improving the emission estimates, the Norwegian emission inventory has been recalculated. The process involves correcting discovered errors and utilising new or improved information where this has become available. The entire time series, at present 1990-2011, are recalculated when the method for a certain source category is revised. The figures in the inventory are therefore, as far as possible, consistent through the whole time series.

The most important recalculations in the 2014 submission are:

1. In the most recent emission inventory, emissions from NMVOC and particles from handling of coal at Spitsbergen are included for the first time. The emission of NMVOC has increased by 0.3- 0.6 per cent for period due to these inclusion, and the emission of TSP has increased by 0.1- 0.6 per cent for period.
2. A new analysis of NO_x emissions from diesel motorson offshore oil and gas installations has led to a significant reduction in estimated emissions for all years. The national total (?) emission of NO_x has decreased by 0.7- 1.5 per cent for period due to these recalculations
3. In 2010 measurements were done to measure unintentional formation of dioxins, at plants producing ferrosilicon and silicon products. The measurements showed that there was no formation of dioxins in these processes. All historical figures of dioxins from these plants have been removed for the period 1990 to 2011. The emission of dioxins has decreased by 0.5-3.9 per cent for period due to this recalculation.
4. Emissions of HCB have been included in the submission for all years since 1990

In combination with some minor changes from other sources, the recalculations have caused several changes in the emission figures, see tables 8.4-8.6.

10.1.2 Specific description of the recalculations

10.1.2.1 Energy

Energy figures for the last year in the previous submission (2011) have been extensively revised, because the energy figures for 2011 used in the previous submission were preliminary. There will always be some changes in the energy figures for the last year, e.g. some figures on energy use in manufacturing industries will be adjusted, which will lead to adjustments in other sectors, as total use of oil products in the energy accounts sum up to national sales of petroleum products. Now the final figures for energy use are available and are used in the emission calculations. Changes in emission figures caused by such revisions will not be commented on specifically under each NFR code.

1A 1a Public electricity and heat production

- Consistency. For two district heating plants, reported 2006 figures for particulate matter were previously used also for 2007 –now the average of the figures reported for 2006 and 2008 have been used. For another district heating plant, reported 2005 figures for particulate matter were previously used also for 2006 –now the average of the figures reported for 2005 and 2007 have been used. Causes minor increase in emissions of TSP, PM10 and PM2.5 for all plants.
- Improved consistency. One plant has not reported emission figures for dioxins for the period 2006- 2011. Since 2006 emissions have not been included. In this year submission the reported figures for 2005 have been used for all years since 2005. This has led to increased emissions.
- Updated reported figures. For one district heating plant, reported 2010 figures were previously used also for 2011 – this has now been corrected. Causes increase in emissions of dioxins. Another plant reported 2009 figures were previously used for 2010 and 2011 – this has now been corrected. Causes increase in emissions of dioxins.
- Revised data. Figures on combustion of waste at one district heating plant have been revised for 2006, and another for 2008, causing higher emissions of NMVOC in both years.

1A 1c Manufacture of Solid Fuels and Other Energy Industries

- Revised data: Slight increase in reported NMVOC emissions in 2010 for one plant.
- Reallocation. Minor reported figures on emissions of SO_2 from one plant in 2007-2011 have been reallocated from 1B2ai to 1A1c.
- Completeness. The inclusion of previously not included combustion of natural gas for energy purposes in 2010-2011 at one plant causes somewhat higher emissions of all components except SO_2.
- Revised emission factors. A new analysis of NO_x emissions from diesel motors (?)on offshore oil and gas installations has led to a significant reduction in estimated emissions. Emissions from drilling activities and at fixed installations are reported under 1A1c, while emissions from other fuel consumption are reported in 1A3d.

1A 2 a Iron and steel

- Revised activity data. Change in data source for consumption of CO-rich gas at some plants 2008-2011. Affects only PM, PAH and some heavy metals.
- Correction of error. Corrected consumption of CO-rich gas at one plant 2011. Affects most emissions.

1A 2 b Non-ferrous metals

- Revised data. The reported NO_x figure for 2011 for one plant has been adjusted slightly downwards.
- Correction of error. Minor reduction in NO_x from one plant in 2011, due to the replacement of a previously reported 2010 figure with a reported 2011 figure.
- Reallocation. One industrial firm with both aluminium and anode producing plants, previously registered all energy use at the aluminium plant. From 2011, energy use at the anode plant has been specified, and this causes a transfer of some emissions from 1A2b to 1A2f in 2011.

1A 2 c Chemicals

- New data. Previously use of reported figures on SO_2 emissions from one plant for 2009-2011 has been replaced by factor estimations.
- Correction of error. A previous double counting of SO_2 and NO_x from one plant in 2010 and 2011 has been removed.
- Completeness. The inclusion of previously not included combustion of waste for enegy purposes in 2005-2009 at one plant causes somewhat higher emissions of all components.

1A 2 e Food processing, beverages and tobacco

- Completeness. The inclusion of previously not included combustion of waste for energy purposes at one plant in 2005 causes somewhat higher emissions of all components.

1A 2 f Other manufacturing

- Reallocation. One industrial firm with both aluminium and anode producing plants, previously registered all energy use at the aluminium plant. From 2011, energy use at the anode plant has been specified, and this causes a transfer of some emissions from 1A2b to 1A2f in 2011.
- Completeness. The inclusion of previously not included combustion of waste for energy purpose at one plant in 2005, 2006 and 2009 causes somewhat higher emissions of all components.

1A 3a Civil aviation

- Correction of error. Several misinterpretations of fuel consumption reports from companies have been corrected. Particularly for 2005-2006, but also minor changes for 2008-2011.
- Correction of error. The inclusion of consumption figures in 2010 for one airline company, that previously was left out, has caused a rise in all domestic emissions from civil aviation.
- Correction of error. There has been a shift in the distribution between airplanes and helicopters 2009-2011. This has caused changes in the emissions of NO_x, NMVOC and CO.

1A 3c Railways

- Completeness: NH_3 emissions from railways are now included, using default emission factor from the EMEP/EEA Guidbook.

1A 3d National navigation

- Revised emission factors. Revised sales figures for 2011 on the distribution between heavy fuel oils with different sulphur content have caused lower emission factors for SO_2.
- Revised emission factors. Revised data from the NO_x fund on NO_x mitigation acitivities has led to reduced emissions for 2007-2011.
- Revised emission factors. A new analysis of NO_x emissions from diesel motors (?)on offshore oil and gas installations has led to a significant reduction in estimated emissions. Emissions from drilling activities and at fixed installations are reported under 1A1c, while emissions from other fuel consumption are reported in 1A3d.

1 A 4 ai Commercial / Institutional: Stationary

- Correction of error. Emissions of particulate matter from one plant have been corrected.

Minor increase in emissions.

- Improved consistency. One plant has reported emission figures for Cd, As, Cr and Cu for the period 2005- 2009. Since 2009 emissions have not been included. In this year submission the reported figures for 2009 have been used for all years since 2009. This has led to increased emissions.

1 B 1 a Fugitive emission from solid fuels: Coal mining and handling

- Completeness. In the most recent emission inventory, emissions from NMVOC and particles from handling of coal at Spitsbergen are included for the first time.

1 B 2 a i Oil exploration, production, transport

- Revised data. Reported figure on emissions of NMVOC from loading of oil at one field in 2011 has been reduced by 600 tonnes.
- Reallocation. Minor reported figures on emissions of SO_2 from one plant in 2007-2011 have been reallocated from 1B2ai to 1A1c.
- Revised data. The reported emission figure for NMVOC from one plant in 2011 has been adjusted somewhat downwards.
- New data. Minor emission figures for NMVOC from one plant in 2010 and 2011 have been included.

1B 2a v Distribution of oil products

- Revised data. Emission figures for NMVOC 2006-2011 have been revised.

1B 2c Venting and flaring

* Revised data: Reported NMVOC emissions in 2010 for one plant have been somewhat increased.

10.1.2.2 Industrial processes

2A 7 Other mineral products

- Updated reported figures. For one plant, reported 2005 figures were previously used also for 2006 to 2011. In 2013 the plant has reported figures for the years after 2009. The emissions of chromium have decreased by 0.9, 0.9 and 1.0 per cent respectively for 2009, 2010 and 2011 due to this recalculation.

2B4 Silicon carbide production

- Updated reported figures. For one plant, reported 2004 figures were previously used also for 2006 and 2007 – this has now been changed. Reported figures for 2006 are now used for both years. This causes decrease in emissions of particulate matter.
- Revised data. Revised figures on use of reducing agents at one plant in 2011 have caused somewhat lower figures on emissions of CO.

2 B 5a Other chemical production

- Revised time series. The time series for NO_x from one plant has been revised for all years 1987-2011. Minor increases for most years, but reduction in 2003 and 2011.

2C 2 Ferroalloys production

- Correction of error. In 2010, measurements were done to measure unintentional formation of dioxins, HCB and PCB at plants producing ferrosilicon and silicon products. The measurements showed that there was no formation of dioxins in these processes. All historical figures of dioxins from these plants have been removed for the period 1990 to 2011. The emission of dioxins has decreased by 0.5-3.9 per cent for this period due to these recalculations.
- Correction of error. Emissions of NMVOC and dioxin, based on use of reducing agents, have increased somewhat in the period 2004-2011, due to the inclusion of coal in the activity data.

2 C 3 Aluminium production

- Changes in reported figures. One plant has reported emissions of chromium for 2008. This figure has replaced earlier used figure. The emissions of chromium have decreased by 0.2 per cent for 2008 due to this recalculation.

2 C 5 e Other Metal Production

- Correction of error. Minor reduction in SO_2 and NO_x in 2011, due to the elimination of a double counting.

2D 2 Food and drink

- Changes in activity data. Revised figures on production of beer and bread in 2011 have caused a minor change in NMVOC emissions.

10.1.2.3 Solvent and other product use

3 C Chemical products

- Correction of error resulted in an increase in NMVOC emissions of 5, 5, 6, 5, 3, 3 and 4 tonnes in 2005, 2006, 2007, 2008, 2009, 2010 and 2011 respectively. The correction consisted of a change in industry code and product code for some use of styrene. The net effect of the correction was however a reduction, since the amount was assigned an industry and product code that is given a small emission factor. See 3 D 3.

3 D 2 Domestic solvent use

- Revised sales figures for cosmetics give a decrease in NMVOC emissions of 4 tonnes in 2009 and an increase of 8 tonnes in 2011.

3 D 3 Other product use

- Correction of error resulted in a decrease in NMVOC emissions of 1319, 1292, 1386, 1366 tonnes in 2005, 2006, 2007 and 2008 respectively. The correction consisted of a change in industry code and product code for some use of styrene, mentioned above.
- Correction of error resulted in a decrease in NMVOC emissions of 1019 and 840 tonnes in 2009 and 2010 respectively. The correction consisted of i) a change in industry code and product code for some use of styrene, and ii) a change in product code resulting in a lower emission factor.
- Correction of error resulted in a decrease in NMVOC emissions of 3166 tonnes in 2011. The correction consisted of. i) a change in industry code and product code for some use of styrene, ii) a change in product code resulting in a lower emission factor, iii) a reduction

in the emission factor for one product type (construction materials), and iv) a revision of some activity data mainly for construction materials and process regulating agents.

10.1.2.4 Agriculture

4B11_Liquid systems, 4B12_Solid storage and dry lot and 4D2.2 Pasture range and paddock

- The time series 1990-2011 for the number of animals are changed for three categories of animals: heifers for replacement, horses and fur animals. The update of the data on heifers and horses is due to new information from the data sources (Cow Recording System at TINE BA and the Norwegian Agricultural Economics Research Institute (NILF) respectively). The update of fur animals is due to a revision of the factors for estimating male animals (the statistical source provides data only for female animals).

  The number of heifers is adjusted upwards between 4 and 15 per cent through the time series. Heifers represented 7.6 per cent of ammonia emissions from agriculture in 2011.

  The number of horses is adjusted upwards between 0 and 15 per cent through the time series, and around 14-15 per cent for the later years. Horses represented 4.1 per cent of ammonia emissions from agriculture in 2011.

  The number of fur animals is adjusted down between 9 and 10 per cent through the time series. Fur animals represented 1.5 per cent of ammonia emissions from agriculture in 2011.

4D1.2_ Animal Manure Applied to Soils

- Changes in estimated amounts applied due to changes in activity data (no. of animals), see 4.B11 above

4D1.6_Sewage sludge

- Ammonia emissions are 6-10 per cent lower through the time series compared to the previous submission due to a correction of the fracgasm factor. The fracgasm factor that was previously used was correspondingly higher. This source constituted slightly over 2 per cent of the ammonia emissions from agriculture in 2011.

4D2.2_Pasture range and paddock

- Changes in estimated amounts applied due to changes in activity data (no. of animals) of heifers and horses, see 4.B11 above

4G1_Treatment of straw

- Ammonia emissions are 6 per cent lower in 2009 and 20 per cent higher in 2010 and in 2011 compared to the previous submission, due to a revision of the acitivity data (amounts of ammonium used for straw treatment). This source constituted slightly less than 2 per cent of the ammonia emissions from agriculture in 2011.

10.1.2.5 Waste

6 D Other Waste

- Completeness. In the most recent emission inventory, emissions of N_2O and NH_3 from use of sewage sludge applied on parks and green spaces, cover on landfills, used as fertilizer and other use have been included for the first time for all years since 1990. Emissions of N_2O have increase by 0.1 to 0.3 per cent while emissions of NH_3 have increase by 0.5 to 1.4 per cent.

10.1.3 Implications of the recalculations for long-range transboundary air pollutants

10.1.3.1 Implications for emissions levels

Table 10.1 shows the effects of recalculations on the emission figures for the main pollutants 1990-2011, table 10.2 the effect on the PM emissions and table 10.3 the effects on the POP and heavy metal emission figures.

Table 10.1. Recalculations in 2014 submission compared to the 2013 submission. Main pollutants.

	SO_2	NO_X	NMVOC	CO	NH_3
	tonnes	tonnes	Tonnes	tonnes	tonnes
1990	0	-3733	1113	0	188
1991	0	-3801	1185	0	241
1992	0	-4222	980	0	266
1993	0	-5216	1092	0	262
1994	0	-4767	1088	0	255
1995	0	-4865	1071	0	258
1996	0	-5216	1097	0	251
1997	0	-6036	953	0	323
1998	0	-6174	997	0	335
1999	0	-6930	1281	0	343
2000	0	-6623	1395	0	347
2001	0	-5148	1238	0	384
2002	0	-4396	1131	0	442
2003	0	-4077	1744	0	509
2004	0	-4108	1101	0	350
2005	67	-3534	-481	116	386
2006	66	-3883	-428	103	391
2007	33	-3990	-49	66	305
2008	30	-3246	-376	141	366
2009	38	-3179	-247	101	597
2010	1	-4895	-288	-639	469
2011	-417	-5513	-2612	-1632	493

Table 10.2. Recalculations in 2014 submission compared to the 2013 submission. Particulate matter

	TSP	PM_{10}	$PM_{2.5}$
	tonnes	tonnes	Tonnes
1990	79	37	4
1991	82	39	5
1992	81	38	5
1993	75	35	4
1994	74	35	4
1995	74	35	4
1996	68	32	4
1997	84	40	5
1998	68	32	4
1999	84	40	5
2000	104	49	6
2001	187	88	11
2002	215	101	12
2003	293	138	16
2004	282	133	16
2005	153	73	11
2006	226	108	15
2007	386	185	27
2008	318	150	19
2009	250	119	17
2010	-6	-102	-169
2011	55	-33	-90

Table 10.3. Recalculations in 2014 submission compared to the 2013 submission. POPs and heavy metals

	Lead	Cadmium	Mercury	Arsenic	Chromium	Copper	PAH-4 (CLRTAP)	Dioxins
	Kg	Kg	Kg	Kg	Kg	Kg	Kg	mg
1990	0	0	0	0	0	0	0	-1292
1991	0	0	0	0	0	0	0	-1291
1992	0	0	0	0	0	0	0	-1207
1993	0	0	0	0	0	0	0	-1158
1994	0	0	0	0	0	0	0	-1405
1995	0	0	0	0	0	0	0	-1304
1996	0	0	0	0	0	0	0	-1438
1997	0	0	0	0	0	0	0	-1529
1998	0	0	0	0	0	0	0	-1214
1999	0	0	0	0	0	0	0	-1105
2000	0	0	0	0	0	0	0	-1071
2001	0	0	0	0	0	0	0	-924
2002	0	0	0	0	0	0	0	-648
2003	0	0	0	0	0	0	0	-591
2004	0	0	0	0	0	0	0	-887
2005	0	0	0	1	0	0	1	-576
2006	0	0	0	1	0	0	1	84
2007	0	0	0	1	0	0	1	-15
2008	0	0	0	1	-8	0	1	-196
2009	7	0	0	1	-11	12	1	78
2010	2	0	2	-2	-13	-70	-4	-48
2011	26	4	4	6	38	-31	-15	375

10.1.3.2 Implications for emission trends

As a result of the different recalculations for 1990-2011 there have been some changes in the trends. The differences are shown in the tables below.

Table 10.4. Trends in emissions 1990-2011. This submission vs. previous submission. Main Pollutants. Per cent change 1990-2011

	SO_2	NO_X	NMVOC	CO	NH_3
2014 submissio	-64.8	-9.5	-54.0	-58.7	9.5
2013 submissio	-64.0	-8.4	-52.9	-58.5	8.3

Table 10.5. Trends in emissions 1990-2011. This submission vs. previous submission. Particulate Matter. Per cent change 1990-2011

	TSP	PM_{10}	$PM_{2.5}$
2014 submissio	-11.5	-14.1	-11.6
2013 submissio	-11.5	-13.9	-11.4

Table 10.6. Trends in emissions 1990-2011. This submission vs previous submission. POPs and heavy metals. Per cent change 1990-2011

	Lead	Cadmium	Mercury	Arsenic	Chromium	Copper	PAH-4 (CLRTAP)	Dioxins
2014 submissio	-97.2	-50.6	-71.2	-50.1	-78.6	12.0	-75.8	-81.9
2013 submissio	-97.2	-50.9	-71.5	-50.3	-78.9	12.1	-75.7	-82.4

10.2 Planned improvements

10.2.1 Overview

There are several areas where improvement actions are needed to improve the Norwegian emission inventory system. In this chapter the main issues are listed.

10.2.2 General

- Many of the emission factors used in the inventory are relatively old, some over 10 years, and they need to be analysed. Some of them also lack good documentation and source references. Work has begun to go through all emission factors, register digitally those that have sufficiently documentation and flag those that do not for future revision. This work need to be continued.

10.2.3 Energy

- The energy statistics used as input to the Norwegian emission inventory is being improved continuously.
  - A project was started in 2011 to explain the large statistical differences between production and consumption of energy in the the Energy balance. Due to high production compared to low consumption the statistical differences are expected to continue to be high compared to national consumption, but errors have been found and corrected, and the knowledge of the statistical difference has increased. The project has continued in 2012 and 2013.
  - The technical system to the energy balance is being substituted to a more robust and reliable solution.

- The inventory for motorized equipment is being updated. A project that started in 2012 is planned to be finalized in 2014. The results is planned to be included in the 2015 submission.

10.2.4 Industrial processes

- No improvements are considered necessary at this time.

10.2.5 Solvent and other product use

- No improvements are considered necessary at this time.

10.2.6 Agriculture

- The national Norwegian NH_3 model needs to be better documented.
- Activity data on manure storage and management need to be updated.

10.2.7 Waste

- Fossil carbon content in incinerated waste is estimated based on old standard factors. As waste composition varies among nations and over time, updated factors based on national composition data would pose an improvement. An estimation of such updated factors is projected, based on local waste characterization studies.

11 Projections

11.1 Introduction

This chapter describes in more detail the projections for greenhouse gas emissions and long-range transboundary air pollutants in Norway up to 2030. In line with international reporting guidelines under the Framework Convention on Climate Change these projections are based on an extension of current measures and policies implemented when the projections were made, the 4th quarter of 2012 and the base year for the projections was 2010. Since the projections were produced the methodology for calculating historical emissions has been changed and hence the emissions have changed. Emissions in Table 11.1 for 1990, 2010-2012 reflects the effect of changed methodology. The two major changes performed is the method for calculating NH_3 emissions from agriculture and the NO_X emission factor for diesel motors off shore. The first mentioned change has increased the NH_3 emissions and latter has decreased the NO_X emission level. See decription of recalculation in IIR 2013 and this IIR. The projections in Table 11.1 do not include the effect of recalculations. This implies that the projection for NH_3 is too low and NO_X is too high.

11.2 The baseline scenario

In the baseline scenario, the development of NO_X emissions is highly dependent on emissions from oil and gas production, which constitute a large share of total Norwegian emissions. Strong economic growth has in general increased economic activity but in contrast to CO_2 emissions have emissions of NO_X, NMVOC and SO_2 in larger extent been counteracted by implementation of abatement technology. The escalation in the extraction of oil and gas, during the 1990s, account for most of the increase in historic NO_X emissions. In the projections, oil and gas production is anticipated to increase until 2015, and is then stabilised on that level up to 2020 and thereafter decrease to 2030. Emissions of NO_X from transport are estimated to continue to be reduced.

Table 11.1 shows projected emissions of NO_X, nmVOCs, NH_3 and SO_2. The estimates are based on the same assumptions as for the greenhouse gases. Included in the NO_X projections are the effect of the first agreement of NO_X reduction between the Ministry of Environment and the industry but not the second agreement for the period 2011-2017. According to both the first and second agreement the NO_X emissions will decrease by 16 kilotons.

Table 11.1 Anthropogenic emissions of NO, nmVOCs SO_2 and NH_3 . Thousand tonnes

	1990	2010[1]	2011	2012[1]	2020	2030
NO_X	191.7	182.0 (156)	174.2	166.2 (154)	161	138.6
SO_2[2]	52.2	19.5 (22)	18.4	16.7 (21)	20.4	20.2
NMVOC	293.7	142.5 (195)	135.9	137.3 (132)	120.6	116.3
NH_3	24.3	27.1 (23)	26.6	26.9 (25)	22.7	23.3

1 The Norwegian commitment according to the Gothenburg Protocol in brackets.
2 The estimated effect of the agreement between the authorities and industries on NO_X reductions for the second commitment period (2011-2017) is not included in the projections.

11.3 Methodology and key assumptions

The emission projections for Norway presented in this report uses various sources and methodologies. For energy-related emissions, the projections are largely based on macroeconomic model simulations supplemented by available micro studies.

The baseline scenario is based on measures adopted and implemented by 2010. The projections are based on information up to September 2012.

11.3.1 Macroeconomic assumptions and CO_2 emissions from the mainland economy

In the projections current policies are assumed to be continued. Accordingly, CO_2-taxes are maintained at today's level in real terms. Also the carbon price for industries included in the emission trading scheme is assumed to stay at the current level in real terms.

In the projections, total factor productivity is on average assumed to grow annually by almost 1.6 pct. in the mainland economy. As a result, emissions per unit produced in each sector will continue to fall over time. Moreover, for some emission sources it is assumed stronger than average growth in emission technology. Consequently, the amount of emissions in these sectors will not increase proportionally to the production or the use of factor input.

The model based projections of emissions from road transport have been adjusted, taking on board calculations from Statistics Norway's road model. Road transport is anticipated to grow per person but growth is slowing down. Use of bio fuels for road transportation is assumed to be about 5-6 pct. of fuel sales by 2020 and 2030. All in all, the projections imply somewhat lower growth in the emissions from road transport than experienced in the period 1990-2010.

Emissions in 2020 and 2030 will depend on structural developments, particularly in the energy-intensive industries. Production and emissions from energy intensive manufacturing are strongly correlated with electricity consumption in this sector. In the long run, as a technical assumption, demand for electricity from energy intensive manufacturing is anticipated to stay relatively stable at the same level as before the financial crisis hit.

Norway is the sixth largest hydro power producer in the world. Emissions from electricity production are small in Norway, as about 95 per cent (2011) of the supply of electricity originates from hydro power. In the projections, the production of renewables (e.g. hydro and wind power) is exogenously determined.

Table 11.2 lists key macroeconomic assumptions underpinning the Norwegian emission projections. In the baseline scenario average annual GDP growth is estimated at 2.9 per cent in 2011-2020 and at 1.8 per cent in 2020-2030. Growth in the mainland economy, i.e. total GDP excluding petroleum activities and ocean transport, is estimated at 3.4 per cent in 2010-2020 and 2.4 per cent in 2020-2030.

Table 11.2 Key macroeconomic assumptions

		2011	2020	2030
	Billion NOK		Annual average growth rate	
Gross domestic product		2 750	2.9	1.8
- Petroleum activities and ocean transport		660	0.4	-1.9
- Mainland Norway		2 090	3.4	2.4
Manufacturing		195	3.5	3.1
Consumption		1 723	4.0	2.9
Gross fixed capital formation		537	2.3	0.2
- Petroleum activities and ocean transport		154	1.5	-4.0
- Mainland Norway		383	2.6	1.5
Population in 1000		4 986	1.2	0.9
Number of persons employed in 1000		2 625	1.2	0.4
			Level	
Oil price (2011-NOK)		621	505	505
EU-ETS price (2011-NOK)		100	100	150
Electricity price (NOK/KWh 2011-NOK)		0.36	0.40	0.46
Net domestic energy use			Annual average growth rate	
- Petroleum products (Mtonnes)		9 843[1]	0.1	0.4
- Electricity (TWh)		114	1.3	0.4

[1] Including energy-sectors and excluding sea transport in international waters. Figure for 2009, as the classification in MSG may differ from energy accounts.
Sources: Statistics Norway and Ministry of Finance.

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Appendix A

Tier 1 Key Category Analysis- Norway – 2014 submission

Methodology

The submission includes tier 1 key category analysis for the years 1990 and 2012 for the components SO_2, NO_X, NH_3, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Pb, Hg, Cd, dioxins, PAH and HCB.

The same procedure has been performed for 1990 and 2012. The emissions are analysed using the NFR09 sources (from the 30.09.2009 reporting template) for both years. For each component the sources have been sorted according to their share of emissions, and the percentage of emissions of the component has been calculated. Sources are assigned as key until 95% of total emissions are covered.

For convenience, the analysis was performed with a few exceptions from the NFR09:

- Gasoline evaporation (1 A 3 b v) is included in 1 A 3 b i-ii

These exceptions do not change the ranking of the other categories, but they may affect which categories are included at the margin.

The result tables A1-A14 are sorted by share of total emissions in 2012 for each component separately. Key categories in 1990 which were not key in 2012 are placed at the bottom of each table.

When a source has become key in 2012, this may either mean that the emissions from this source have increased, or that it has decreased less than other sources. The key category analysis does not give information about the magnitude of emissions from each source, and can thus not be used to evaluate trends in emission levels for any given source.

Results

78 per cent of the 77 sources with emissions in 2012 were key to at least one component. This means that 17 sources have emissions, but are not key category for any component. This is especially prominent within the solvents and waste categories.

Some sources are key category to a wide range of components. This is the case in particular for public electricity and heat production (1 A 1 a), manufacture of solid fuels and other energy industries (1 A 1 c), stationary combustion in manufacturing industries (1 A 2 f i), road traffic (1 A 3 B i-iii), national navigation (1 A 3 d ii), residential plants (1 A 4 b i), ferroalloys production (2 C 2), aluminium production (2 C 3) and field burning of agricultural waste (4 F). The latter is not key to any primary gases, except CO, but key to particulates and a range of heavy metals and POPs.

Some sources are key category only to POPs and heavy metals. This is the case for chemicals (1 A 2 C), iron and steel production (2 C 1) and cremation (6 C d). The other sources in Table 1 are key category to the primary gases and in some cases also for POPs and heavy metals.

Looking at the three most dominant sources of emissions for each component in 2012, it becomes clear that there are some sources that are responsible for a large proportion of emissions. This is the case for emissions from passenger cars, national navigation, residential plants, ferroalloys

production and aluminium production. Some distinctive characteristics of the Norwegian society can explain why some sources are dominant key categories for emissions from many components. For instance, long and cold winters lead to high demand for heating of houses, and wood-burning is common. The wood-burning leads to high emissions of CO, particulate matter, cadmium and POPs from residential plants. Due to a history of cheap electricity (hydroelectric power), Norway has a high share of energy-demanding industry. Thus, industries such as ferroalloys and aluminium production dominate the emissions for SO_2, heavy metals and PAH.

Key categories for SO_2:

The dominant sources for emissions of SO_2 in 2012 were ferroalloy production and national navigation (Table A1). These sources were dominant in 1990 as well. SO_2 emissions from carbide production, especially silicon carbide, have become particularly less dominant since 1990. These emissions were reduced by more than three fourths from 1990 to 2012. Petroleum refining was not key in 1990, but has now become a key category for SO_2 emissions in Norway. This is due to the fact that although there has been only a slight increase in emissions from petroleum refining, total emissions have decreased by two thirds since 1990. By contrast, road traffic and chemical industry were key categories in 1990, but are no longer responsible for dominant SO_2 emissions. The decreased importance of road traffic as a source of SO_2 emissions is largely due to lower sulphur content in petrol and auto diesel.

Table A1 Key categories for SO_2 emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	52.232	16.657
2 C 2 Ferroalloys Production	***23.0 %***	***34.2 %***
1 A 3 d ii National Navigation	***8.0 %***	***9.2 %***
2 C 3 Aluminum Production	***8.3 %***	***7.9 %***
1 A 1 a Public Electricity and Heat Production	***2.1 %***	***7.8 %***
1 B 2 a iv Refining / Storage	***6.9 %***	***4.1 %***
1A 4 c iii National Fishing	***3.6 %***	***4.1 %***
2 B 4 Carbide Production	***8.5 %***	***4.0 %***
2 A 1 Cement Production	***1.1 %***	***3.8 %***
2 C 5 e Other metal production	***1.9 %***	***3.5 %***
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	***0.9 %***	***3.3 %***
1 A 2 d Pulp, Paper and Print	***2.3 %***	***2.5 %***
1 A 4 b i Residential plants	***2.5 %***	***2.3 %***
2 D 1 Pulp and Paper	***3.6 %***	***2.3 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	***4.8 %***	***2.3 %***
1 A 1 b Petroleum refining	0.7 %	***2.2 %***
1 A 4 a i Commercial / Institutional: Stationary	***1.9 %***	***1.8 %***
1 A 3 b iii R.T., Heavy duty vehicles	***3.4 %***	0.1 %
2 B 5 a Other chemical industry	***3.4 %***	0.0 %
1 A 2 e Food Processing, Beverages and Tobacco	***2.5 %***	0.8 %
1 A 3 b i R.T., Passenger cars	***2.2 %***	0.1 %
1 A 2 c Chemicals	***1.6 %***	1.1 %
1 A 2 f ii Mobile Combustion in Manufacturing Industries and Construction:	***0.9 %***	0.0 %
1 A 4 c ii Off-road Vehicles and Other Machinery	***0.9 %***	0.0 %
2 A 7 a Quarrying and mining of minerals other than coal	***1.1 %***	**.**

Key categories for NO_X:

Manufacture of solid fuels and other energy industries, national navigation and national fishing were dominant key categories for NO_X emissions both in 2012 and 1990 (Table A2). Emissions

from road traffic have become less dominant since 1990, especially for passenger cars. An increased share of cars with catalysts partly explains this decrease. Some new sources have become key categories since 1990. This is the case for commercial/institutional mobile combustion, civil aviation (domestic and international) and refining/storage.

Table A2 Key categories for NO_X emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	191.67	166.23
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	***12.9 %***	***28.6 %***
1A 4 c iii National Fishing	***11.8 %***	***12.7 %***
1 A 3 d ii National Navigation	***15.9 %***	***11.5 %***
1 A 3 b iii R.T., Heavy duty vehicles	***12.7 %***	***10.5 %***
1 A 3 b i R.T., Passenger cars	***18.6 %***	***8.1 %***
2 C 2 Ferroalloys Production	***4.9 %***	***4.9 %***
1 A 2 f ii Mobile Combustion in Manufacturing Industries and Construction:	***3.2 %***	***4.0 %***
1 A 3 b ii R.T., Light duty vehicles	***2.6 %***	***3.4 %***
1 A 4 a ii Commercial / Institutional: Mobile	0.4 %	***1.8 %***
1 A 4 c ii Off-road Vehicles and Other Machinery	***2.5 %***	***1.7 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	***2.3 %***	***1.7 %***
1 A 5 b Other, Mobile (Including military)	***1.5 %***	***1.3 %***
1 A 1 a Public Electricity and Heat Production	***0.7 %***	***1.0 %***
1 A 4 b i Residential plants	***1.1 %***	***1.0 %***
1 A 3 a ii (i) Civil Aviation (Domestic, LTO)	0.3 %	***0.8 %***
1 A 4 b ii Household and gardening (mobile)	***0.6 %***	***0.7 %***
2 B 2 Nitric Acid Production	***1.3 %***	***0.7 %***
1 A 3 a i (i) International Aviation (LTO)	0.2 %	***0.7 %***
1 B 2 a iv Refining / Storage	0.6 %	***0.6 %***
1 A 1 b Petroleum refining	***0.9 %***	0.4 %
1 A 2 c Chemicals	***0.8 %***	0.5 %
1 A 3 c Railways	***0.8 %***	0.4 %
1 A 2 d Pulp, Paper and Print	***0.7 %***	0.6 %

Key categories for NH_3:

There has been little change in the key categories for NH_3 from 1990 to 2012 (Table A3). Agricultural sources are dominant. Field Burning of Agricultural Wastes, however, which was a key category in 1990, no longer was so in 2012. For passenger cars, there has been an opposite development – this was an important key category only in 2012. Manure (other) also was key only in 2012.

Table A3 Key categories for NH_3 emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	24.337	26.933
4 B 1 a Dairy	***28.4 %***	***23.2 %***
4 B 1 b Non-Dairy	***16.4 %***	***19.5 %***
4 B 8 Swine	***10.5 %***	***12.1 %***
4 B 3 Sheep	***10.4 %***	***9.9 %***
4 D 1 a Synthetic N-fertilizers	***5.2 %***	***6.0 %***
4 D 2 c N-excretion on pasture range and paddock Unspesified	***5.0 %***	***5.3 %***
1 A 3 b i R.T., Passenger cars	0.7 %	***4.3 %***
4 B 9 a Laying Hens	***3.2 %***	***4.0 %***
4 B 6 Horses	***1.7 %***	***3.7 %***
4 B 9 b Broilers	***1.9 %***	***2.6 %***
4 G Other	***7.2 %***	***1.9 %***
2 B 2 Nitric Acid Production	***1.9 %***	***1.7 %***
4 B 13 Other	1.1 %	***1.6 %***
4 F Field Burning of Agricultural Wastes	***4.0 %***	0.3 %

Key categories for NMVOC:

NMVOC emissions are spread on a wide range of sources, Offshore loading of petroleum has been the most dominant emission source (Table A4). Due to efforts to reduce such emissions, this source has become less dominant than in 1990, and by 2012 it was surpassed by emissions from solvents (see below). NMVOC emissions from passenger cars was the second largest emission source in 1990, but this source's share of total emissions was reduced by two thirds in 2012.The NMVOC emissions from use of solvents were in the same order of magnitude in 1990 and 2012, but due to decreases in emissions from other sources, it has become the dominant key category. Variations in key categories between 1990 and 2012 within NFR code 3 A-D (Solvent and other product use) are partly due to the fact that the emissions in 1990 are reported solely within one subgroup within A, B and D, while all subgroups are used for 2012.

Table A4 Key categories for NMVOC emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	293.72	137.33
3 D 3 Other product use	***11.4 %***	***17.0 %***
1 B 2 a i Exploration Production, Transport	***39.8 %***	***16.2 %***
3 D 2 Domestic solvent use including fungicides	.	***9.7 %***
1 A 4 b ii Household and gardening (mobile)	***3.7 %***	***8.3 %***
1 B 2 a iv Refining / Storage	***3.2 %***	***7.0 %***
1 A 4 b i Residential plants	***2.5 %***	***6.9 %***
1 A 3 b i R.T., Passenger cars	***19.3 %***	***5.5 %***
1 B 2 c Venting and flaring	***1.2 %***	***5.0 %***
3 A 1 Decorative coating application	.	***4.1 %***
1 B 2 a v Distribution of oil products	***3.5 %***	***3.2 %***
1 B 2 b Natural gas	0.4 %	***2.1 %***
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	0.4 %	***1.9 %***
1 A 3 b iv R.T., Mopeds & Motorcycles	***0.7 %***	***1.3 %***
3 A 2 Industrial coating application	.	***1.1 %***
1 A 3 d ii National Navigation	***0.6 %***	***1.1 %***
1 A 2 f ii Mobile Combustion in Manufacturing Industries and Construction:	0.2 %	***1.1 %***
1 A 1 a Public Electricity and Heat Production	0.1 %	***0.9 %***
2 C 2 Ferroalloys Production	0.5 %	***0.9 %***
1 A 4 c ii Off-road Vehicles and Other Machinery	***0.8 %***	***0.8 %***
2 D 2 Food and Drink	0.4 %	***0.8 %***
1 A 4 a ii Commercial / Institutional: Mobile	0.0 %	***0.6 %***
3 A 3 Other coating application	***4.4 %***	0.0 %
1 A 3 b ii R.T., Light duty vehicles	***1.8 %***	0.5 %
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	***1.0 %***	0.3 %
4 F Field Burning of Agricultural Wastes	***0.9 %***	0.2 %
1 A 3 b iii R.T., Heavy duty vehicles	***0.7 %***	0.5 %

Key categories for CO:

Wood burning in residential plants was responsible for nearly half of the CO emissions in 2012, while the same was the case for passenger cars in 1990 (Table A5). CO emissions from residential plants have decreased slightly from 1990 to 2012, but as emissions from passenger cars have been reduced by 85 per cent in the same period, residential plants have become the major emission source. Another result of the reduced emissions from passenger cars, is that several minor sources have become key categories in 2012, even though their emissions may have been reduced.

Table A5 Key categories for CO emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	747.23	300.64
1 A 4 b i Residential plants	***20.5 %***	***44.3 %***
1 A 3 b i R.T., Passenger cars	***50.0 %***	***16.2 %***
1 A 4 b ii Household and gardening (mobile)	***5.4 %***	***13.6 %***
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	0.6 %	***3.2 %***
2 B 4 Carbide Production	***5.4 %***	***2.5 %***
1 A 3 b iv R.T., Mopeds & Motorcycles	***0.9 %***	***2.5 %***
1 A 4 c ii Off-road Vehicles and Other Machinery	***1.1 %***	***2.1 %***
1 A 1 a Public Electricity and Heat Production	0.1 %	***2.0 %***
1 A 3 b ii R.T., Light duty vehicles	***6.5 %***	***1.8 %***
1 A 3 b iii R.T., Heavy duty vehicles	0.8 %	***1.8 %***
1 A 2 f ii Mobile Combustion in Manufacturing Industries and Construction:	0.3 %	***1.6 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	0.6 %	***1.3 %***
1A 4 c iii National Fishing	0.5 %	***1.3 %***
1 A 2 d Pulp, Paper and Print	0.2 %	***1.1 %***
4 F Field Burning of Agricultural Wastes	***3.2 %***	0.7 %
2 C 5 e Other metal production	***2.7 %***	**.**

Key categories for particulates:

The by far most dominant emission source for particulates of all sizes both in 1990 and 2012 is burning of fuel wood in small stoves in households (Table A6, A7 and A8). Other important sources are other mineral products, ferroalloys production, construction and demolition and automobile road abrasion, tyre and brake wear.

Table A6 Key categories for TSP emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	69.949	68.403
1 A 4 b i Residential plants	***31.9 %***	***34.2 %***
2 A 7 d Other Mineral products	***9.6 %***	***17.6 %***
2 A 7 b Construction and demolition	***9.4 %***	***11.7 %***
1 A 3 b vii R.T., Automobile road abrasion	***10.8 %***	***6.8 %***
1 A 3 b vi R.T., Automobile tyre and brake wear	***4.2 %***	***6.5 %***
2 C 2 Ferroalloys Production	***5.6 %***	***3.5 %***
1 A 2 f ii Mobile Combustion in Manufacturing Industries and Construction:	***1.0 %***	***2.0 %***
1 A 3 d ii National Navigation	***1.9 %***	***1.9 %***
1 A 1 a Public Electricity and Heat Production	***0.7 %***	***1.6 %***
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	***0.7 %***	***1.6 %***
2 C 3 Aluminum Production	***3.5 %***	***1.5 %***
1A 4 c iii National Fishing	***1.1 %***	***1.4 %***
1 A 4 c ii Off-road Vehicles and Other Machinery	***1.4 %***	***1.3 %***
1 B 2 c Venting and flaring	***1.6 %***	***1.0 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	***1.7 %***	***0.9 %***
1 A 4 a ii Commercial / Institutional: Mobile	0.1 %	***0.8 %***
1 A 3 b i R.T., Passenger cars	0.4 %	***0.6 %***
1 A 3 b ii R.T., Light duty vehicles	***0.7 %***	***0.6 %***
4 F Field Burning of Agricultural Wastes	***3.3 %***	0.3 %
2 B 2 Nitric Acid Production	***1.8 %***	0.6 %
2 B 4 Carbide Production	***1.5 %***	0.1 %
1 A 3 b iii R.T., Heavy duty vehicles	***1.5 %***	0.4 %
2 A 7 a Quarrying and mining of minerals other than coal	***1.0 %***	0.1 %
2 D 1 Pulp and Paper	***0.6 %***	0.3 %

Table A7 Key categories for PM_{10} emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	50.594	45.924
1 A 4 b i Residential plants	***43.1 %***	***49.9 %***
2 A 7 d Other Mineral products	***5.2 %***	***9.9 %***
2 C 2 Ferroalloys Production	***7.7 %***	***5.3 %***
1 A 3 b vii R.T., Automobile road abrasion	***4.5 %***	***3.0 %***
1 A 2 f ii Mobile Combustion in Manufacturing Industries and Construction:	***1.4 %***	***3.0 %***
1 A 3 d ii National Navigation	***2.6 %***	***2.8 %***
2 A 7 b Construction and demolition	***2.0 %***	***2.7 %***
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	***0.9 %***	***2.3 %***
2 C 3 Aluminum Production	***4.7 %***	***2.2 %***
1 A 1 a Public Electricity and Heat Production	***0.7 %***	***2.1 %***
1A 4 c iii National Fishing	***1.5 %***	***2.0 %***
1 A 4 c ii Off-road Vehicles and Other Machinery	***2.0 %***	***1.9 %***
1 B 2 c Venting and flaring	***2.0 %***	***1.4 %***
1 A 3 b vi R.T., Automobile tyre and brake wear	***0.7 %***	***1.2 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	***2.1 %***	***1.2 %***
1 A 4 a ii Commercial / Institutional: Mobile	0.2 %	***1.1 %***
1 A 3 b i R.T., Passenger cars	0.5 %	***0.9 %***
1 A 3 b ii R.T., Light duty vehicles	***1.0 %***	***0.9 %***
1 A 4 b ii Household and gardening (mobile)	***0.7 %***	***0.8 %***
2 B 2 Nitric Acid Production	***2.0 %***	***0.7 %***
4 F Field Burning of Agricultural Wastes	***4.6 %***	0.4 %
2 B 4 Carbide Production	***2.1 %***	0.1 %
1 A 3 b iii R.T., Heavy duty vehicles	***2.0 %***	0.6 %
2 D 1 Pulp and Paper	***0.8 %***	0.4 %
2 A 7 a Quarrying and mining of minerals other than coal	***0.7 %***	0.0 %

Table A8 Key categories for $PM_{2.5}$ emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	41.439	37.195
1 A 4 b i Residential plants	***51.0 %***	***59.8 %***
2 C 2 Ferroalloys Production	***9.4 %***	***6.5 %***
1 A 2 f ii Mobile Combustion in Manufacturing Industries and Construction:	***1.7 %***	***3.5 %***
1 A 3 d ii National Navigation	***3.0 %***	***3.3 %***
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	***1.1 %***	***2.8 %***
1A 4 c iii National Fishing	***1.7 %***	***2.4 %***
1 A 1 a Public Electricity and Heat Production	0.4 %	***2.4 %***
1 A 4 c ii Off-road Vehicles and Other Machinery	***2.3 %***	***2.3 %***
1 B 2 c Venting and flaring	***2.0 %***	***1.5 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	***2.5 %***	***1.4 %***
1 A 4 a ii Commercial / Institutional: Mobile	0.2 %	***1.3 %***
2 C 3 Aluminum Production	***2.5 %***	***1.2 %***
2 A 7 b Construction and demolition	***0.8 %***	***1.2 %***
1 A 3 b i R.T., Passenger cars	***0.6 %***	***1.1 %***
1 A 3 b ii R.T., Light duty vehicles	***1.2 %***	***1.1 %***
1 A 3 b vi R.T., Automobile tyre and brake wear	***0.6 %***	***1.1 %***
1 A 4 b ii Household and gardening (mobile)	***0.9 %***	***0.9 %***
1 A 3 b iii R.T., Heavy duty vehicles	***2.4 %***	***0.7 %***
1 A 3 b vii R.T., Automobile road abrasion	***0.9 %***	***0.6 %***
2 B 2 Nitric Acid Production	***1.8 %***	***0.6 %***
4 F Field Burning of Agricultural Wastes	***5.3 %***	0.5 %
2 B 4 Carbide Production	***2.6 %***	0.1 %
3 D 3 Other product use	***0.6 %***	0.3 %
2 D 1 Pulp and Paper	***0.5 %***	0.4 %

Key categories for lead (Pb):

There has been a dramatic change in dominant sources for emissions of lead from 1990 to 2012 (Table A9). In 1990, road traffic was responsible for almost 90 per cent of lead emissions, due to high lead content in petrol. In 2012, petrol no longer contained significant amounts of lead, and other sources became dominant. The most significant emission sources in 2012 was automobile tyre and brake wear, while some manufacturing industries also were important.

Table A9 Key categories for Pb emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	188.74	5.5697
1 A 3 b vi R.T., Automobile tyre and brake wear	0.6 %	***36.5 %***
2 C 1 Iron and Steel Production	***1.3 %***	***12.6 %***
1 A 2 d Pulp, Paper and Print	0.1 %	***6.6 %***
2 C 2 Ferroalloys Production	0.7 %	***5.4 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	0.2 %	***5.1 %***
2 C 3 Aluminum Production	0.3 %	***4.8 %***
1 A 3 a ii (i) Civil Aviation (Domestic, LTO)	0.3 %	***4.7 %***
2 C 5 e Other metal production	0.2 %	***4.1 %***
1 A 3 b i R.T., Passenger cars	***82.1 %***	***2.5 %***
1 A 3 b iii R.T., Heavy duty vehicles	0.6 %	***2.0 %***
1 A 3 d ii National Navigation	0.1 %	***2.0 %***
1 A 4 b i Residential plants	0.1 %	***1.7 %***
2 B 5 a Other chemical industry	0.1 %	***1.6 %***
1 A 1 a Public Electricity and Heat Production	***1.1 %***	***1.5 %***
1A 4 c iii National Fishing	0.0 %	***1.1 %***
1 A 3 b ii R.T., Light duty vehicles	***6.1 %***	***1.0 %***
1 A 2 c Chemicals	0.0 %	***1.0 %***
1 A 4 a i Commercial / Institutional: Stationary	0.0 %	***0.9 %***
1 A 4 b ii Household and gardening (mobile)	***3.0 %***	0.1 %
1 A 3 b iv R.T., Mopeds & Motorcycles	***0.9 %***	0.0 %
2 A 7 d Other Mineral products	***0.8 %***	0.1 %

Key categories for mercury (Hg):

Mercury emissions stem from a wide variety of sources (Table A10), and in 2012 cremation was the most important source (19 per cent). By contrast, the largest sources in 1990 were ferroalloys production and other product use, with 35 and 20 per cent of the total respectively. In 2012, these emissions' share of total emissions was reduced to 8 and 6 per cent. Other product use comprises emissions from thermometers, fluorescent tubes and other instruments.

Table A10 Key categories for Hg emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	1.4234	0.396
6 C d Cremation	***4.9 %***	***19.8 %***
1 A 3 d ii National Navigation	***2.8 %***	***8.6 %***
3 D 3 Other product use	***20.0 %***	***7.0 %***
2 C 2 Ferroalloys Production	***35.2 %***	***7.0 %***
1A 4 c iii National Fishing	***1.7 %***	***6.2 %***
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	0.7 %	***6.2 %***
1 A 1 a Public Electricity and Heat Production	***6.9 %***	***5.5 %***
1 A 4 b i Residential plants	***2.2 %***	***5.4 %***
1 A 2 d Pulp, Paper and Print	***1.7 %***	***4.9 %***
1 A 4 a i Commercial / Institutional: Stationary	***1.0 %***	***3.5 %***
2 C 5 e Other metal production	***1.0 %***	***3.4 %***
2 A 1 Cement Production	***1.8 %***	***3.4 %***

1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	***2.2 %***	***3.3 %***
2 C 1 Iron and Steel Production	***7.1 %***	***2.5 %***
1 A 3 b i R.T., Passenger cars	***0.9 %***	***2.5 %***
2 B 5 a Other chemical industry	***5.2 %***	***1.4 %***
2 A 7 d Other Mineral products	0.5 %	***1.2 %***
1 A 3 a ii (i) Civil Aviation (Domestic, LTO)	0.2 %	***1.0 %***
1 A 2 c Chemicals	0.8 %	***1.0 %***
1 A 3 b vi R.T., Automobile tyre and brake wear	0.2 %	***0.9 %***
1 A 3 a i (i) International Aviation (LTO)	0.1 %	***0.8 %***
1 A 2 e Food Processing, Beverages and Tobacco	***1.1 %***	0.7 %

Key categories for cadmium (Cd):

From 1990 to 2012 cadmium emissions have been spread on a wider variety of sources (Table A11). Residential plants and pulp, paper and print were each responsible for one fourth of the emissions in 2012, compared to only 9-10 per cent in 1990, whereas ferroalloys production and other metal production were the largest emission sources in 1990.

Table A11 Key categories for Cd emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	1.1741	0.4771
1 A 4 b i Residential plants	***9.0 %***	***28.7 %***
1 A 2 d Pulp, Paper and Print	***10.3 %***	***17.8 %***
1 A 1 a Public Electricity and Heat Production	***8.1 %***	***8.9 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	***4.9 %***	***6.7 %***
1 A 3 b vii R.T., Automobile road abrasion	***4.3 %***	***6.6 %***
2 C 3 Aluminum Production	***7.8 %***	***4.3 %***
1 A 3 b i R.T., Passenger cars	***1.4 %***	***3.8 %***
2 C 2 Ferroalloys Production	***21.6 %***	***3.0 %***
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	0.5 %	***2.4 %***
1 A 3 b iii R.T., Heavy duty vehicles	0.5 %	***2.0 %***
1 A 3 d ii National Navigation	***1.1 %***	***2.0 %***
2 C 5 e Other metal production	***13.1 %***	***1.7 %***
1 A 2 c Chemicals	0.6 %	***1.6 %***
2 C 1 Iron and Steel Production	***4.0 %***	***1.5 %***
1 A 4 a i Commercial / Institutional: Stationary	0.4 %	***1.4 %***
1 A 3 b ii R.T., Light duty vehicles	0.2 %	***1.1 %***
1A 4 c iii National Fishing	0.5 %	***1.1 %***
2 B 4 Carbide Production	***8.0 %***	***0.9 %***
4 F Field Burning of Agricultural Wastes	***1.7 %***	0.4 %

Key categories for dioxins:

In 1990, quarrying and mining of minerals other than coal and production of metals other than iron, steel, ferroalloys and aluminium were the largest sources of dioxin emissions (Table A12). These sources were not key categories in 2012. These sources no longer emit dioxins, and thus other sources have become dominant. In 2012, residential plants were the largest source of dioxin emissions in Norway, followed by other waste and national navigation.

Table A12 Key categories for dioxin emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	126.42	21.918
1 A 4 b i Residential plants	***4.8 %***	***36.2 %***
6 D OTHER WASTE (f)	***1.7 %***	***10.0 %***
1 A 3 d ii National Navigation	***1.7 %***	***9.9 %***
1A 4 c iii National Fishing	***1.4 %***	***8.8 %***
1 A 1 c Manufacture of Solid Fuels and Other Energy Industries	0.5 %	***8.2 %***

2 C 3 Aluminum Production	0.6 %	***4.0 %***
1 A 2 d Pulp, Paper and Print	0.9 %	***4.0 %***
1 A 1 a Public Electricity and Heat Production	***10.0 %***	***3.8 %***
4 F Field Burning of Agricultural Wastes	***5.4 %***	***2.7 %***
2 A 1 Cement Production	0.2 %	***2.4 %***
2 C 2 Ferroalloys Production	***1.0 %***	***2.1 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	0.3 %	***1.7 %***
2 C 1 Iron and Steel Production	0.9 %	***1.0 %***
1 A 3 b i R.T., Passenger cars	***1.7 %***	***0.8 %***
6 C a Clinical Waste Incineration (d)	***4.0 %***	0.0 %
2 A 7 a Quarrying and mining of minerals other than coal	***40.4 %***	**.**
2 C 5 e Other metal production	***23.7 %***	**.**

Key categories for PAH:

There have been only slight changes in the key categories for PAH emissions from 1990 to 2012 (Table A13). Aluminium production and residential plants were the two most important sources for both years, although there has been a significant reduction in the share from aluminium production and an increase in the share from residential plants. Road traffic was a more important source for PAH emissions in 2012 than in 1990.

Table A13 Key categories for PAH emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	36.507	7.6414
2 C 3 Aluminum Production	***83.6 %***	***50.2 %***
1 A 4 b i Residential plants	***7.5 %***	***24.1 %***
1 A 3 b i R.T., Passenger cars	1.1 %	***6.9 %***
1 A 3 b iii R.T., Heavy duty vehicles	0.9 %	***5.3 %***
1 A 3 b vi R.T., Automobile tyre and brake wear	0.4 %	***3.3 %***
1 A 3 b ii R.T., Light duty vehicles	0.2 %	***2.9 %***
2 C 2 Ferroalloys Production	0.4 %	***2.0 %***
4 F Field Burning of Agricultural Wastes	***3.3 %***	***1.4 %***
2 C 5 e Other metal production	***1.3 %***	1.1 %

Key categories for HCB:

In 1990, other metal production was by far the largest sources of HCB emissions (Table A14). This source was not key in 2012. HCB emissions are now negligible, and thus other sources have become dominant. In 2012, road traffic was the largest source of HCB emissions in Norway, followed by aluminium production and electricity/heat production (waste incineration).

Table A14 Key categories for HCB emissions, 1990 and 2012. Key categories are given in bold italic.

Source	1990	2012
National total for the entire territory	124.55	1.2593
1 A 3 b i R.T., Passenger cars	0.0 %	***33.6 %***
2 C 3 Aluminum Production	0.1 %	***15.8 %***
1 A 3 b ii R.T., Light duty vehicles	0.0 %	***12.8 %***
1 A 4 b i Residential plants	0.1 %	***9.0 %***
1 A 1 a Public Electricity and Heat Production	0.6 %	***6.3 %***
1 A 3 b iii R.T., Heavy duty vehicles	0.0 %	***5.4 %***
1 A 3 d ii National Navigation	0.0 %	***4.0 %***
1A 4 c iii National Fishing	0.0 %	***3.3 %***
1 A 2 f i Stationary Combustion in Manufacturing Industries and Construction: Other	0.1 %	***2.2 %***
2 B 5 a Other chemical industry	0.0 %	***1.7 %***
2 C 1 Iron and Steel Production	0.0 %	***1.6 %***
2 C 5 e Other metal production	***98.8 %***	0.0 %

Appendix B

Emission factors

In the calculations the numbers are used with the highest available accuracy. In this tables though, they are only shown rounded off, which in some cases can lead to the result that the exceptions looks the same as the general factors. The tables include the emission factors used for estimating the acidifying pollutants, heavy metals and persistent organic pollutants. Due to practical reasons also the emission factors used for the Norwegian greenhouse gas inventory are included in the tables.

For road traffic this general view of the emission factors only includes last year's factors and not all time series.

In the tables for stationary combustion, dotted cells indicate combinations of fuel and source without consumption.

A description of the sector codes used in the tables is given in Appendix D.

CO_2, SO_2 and heavy metals - Stationary and mobile combustion

Table B1. General emission factors for CO_2, SO_2 and heavy metals

	CO_2	SO_2[1]	Pb	Cd	Hg	As	Cr	Cu
	tonne/tonne[2]	kg/tonne[2]	g/tonne[2]	g/tonne[2]	g/tonne[2]	g/tonne[2]	g/tonne[2]	g/tonne[2]
Coal	2.52	*16*[3]	*0.2*[3]	*0.003*[3]	*0.05*[3]	*0.089*[3]	*0.065*[3]	*0.087*[3]
Coke	3.19	18	*0.2*[3]	*0.003*[3]	*0.05*[3]	*0.089*[3]	*0.065*[3]	*0.087*[3]
Petrol coke	3.59	18	*0.2*	*0.003*	*0.05*	*0.089*	*0.065*	*0.087*
Motor gasoline	3.13	**0.01**	**0.03**[4]	0.01	0,0084	0.05	0.05	1.7
Aviation gasoline	3.13	0.4	675.7	0.01	0	0.05	0.05	1.7
Kerosene (heating)	3.15	**0.326**	0.07	0.01	0.03	0.05	0.04	0.05
Jet kerosene	3.15	**0.294**	0.07	0.01	0.03	0.05	0.05	0.05
Auto diesel	3.17[5]	**0.015**[6]	0.1	0.01	0,0023	0.05	0.05	1.7
Marine gas oil/diesel	3.17	**1.038**	0.1	0.01	0.05	0.05	0.04	0.05
Light fuel oils	3.17	**0.658**	0.1	0.01	0.05	0.05	0.04	0.05
Heavy distillate	3.17	**4.295**	0.1	0.01	0.05	0.05	0.04	0.05
Heavy fuel oil	3.2	**17.5**[7]	1	0.1	0.2	0.057	1.35	0.53
Natural gas (1000 Sm^3)	1.99**/2.34**[8]	0	0.00025	0.002	0.001	0.004	0.021	0.016
LPG	3	0	0	0	0	0.004	0.021	0.016
Refinery gas	2.8	0	0	0	0	0.004	0.021	0.016
Blast furnace gas	1.571	0	0	0	0	0.004	0.021	0.016
Fuel gas	2.5	0	0	0	0	0.004	0.021	0.016
Landfill gas	0	0.019	0	0	0	0.004	0.021	0.016
Biogas	0	0	0.000294	0.001998	0.001175	0.004466	0.024679	0.018803
Fuel wood	0	0.2	0.05	0.1	0.010244	0.159	0.152	0.354
Wood waste	0	0.37	0.05	0.1	0.010244	0.159	0.152	0.354
Black liquor	0	0.37	0.05	0.1	0.010244	0.159	0.152	0.354
Municipal waste	**0.5417**[9]	1.4	**0.00304**	**0.00015**	**0.00016**	0.022	0.001	0.000985
Special waste	3.2	9.2	14	0.6	0.2	1	31	25

[1] Applies to 2012 for petroleum products; the factors change yearly, in accordance with changes in the sulphur content in the products.
[2] For natural gas: 1000 Sm^3.
[3] Exceptions: Direct-fired furnaces in cement production = 9.1 and small stoves in households = 20.
[4] From 1997 - considerably higher earlier years. Earlier used factors are not shown in this Appendix.
[5] From 2006 the emission factor has been corrected for use of bio diesel, which not causes emissions of CO_2: 2006: 3.159, 2007: 3.114, 2008: 3.029, 2009: 3.007, 2010: 2.992, 2011: 3.006, 2012: 2.989.
[6] Applies to road traffic.Weighted average of duty-free and dutiable auto diesel.
[7] Stationary combustion.
[8] Respectively dry gas (domestic use) and rich gas (continental shelf).
[9] From 1996. For earlier years: 0.251.
Numbers in italics have exceptions for some sectors, see table B2 and B5. Bold numbers are different for different years, see table B3, B4 and B5.
Source: Norwegian Petroleum Industry Association, Rosland (1987), SFT (Norwegian pollution control authority 1990), SFT (Sandgren *et al.* 1996), Finstad *et al*. (2001) and Finstad *et al*. (2003) .

Table B2. Exceptions from the general emission factors for heavy metals: Solid fuels in small stoves (households)

	Pb	Cd	Hg	As	Cr	Cu
	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne
Coal	2.5	0.15	0.3	1.2	0.9	1.2
Coke	2.5	0.15	0.3	1.2	0.9	1.2

Table B3. Time series for variable emission factors for SO_2 (kg/tonne)

Years	V11 Motor gasoline	V13 Kerosene (heating)	V14 Jet kerosene	V15 Auto diesel				V17 Marine gas oil/diesel	V18 Light fuel oils	V19 Heavy distillate	V20 Heavy fuel oil (LS-oil)	V20 Heavy fuel oil (NS-oil)
	General	General	General	General	M.1A3B.1 Passenger cars	M.1A3B.2 Light duty vehicles	M.1A3B.3 Heavy duty vehicles	General	General	General	General	General
1980	1	0.2	0.2	6.6	.	.	.	6.6	6.6	15	19	46
1987	0.7	0.4	0.4	4.4	.	.	.	4.4	4.4	9	19	44
1989	0.6	0.4	0.4	3.4	.	.	.	3.4	3.4	7.6	18.2	40
1990	0.6	0.3	0.3	3.2	.	.	.	3.2	3.2	6	17	39.4
1991	0.6	0.38	0.38	2.8	.	.	.	2.8	2.8	4.6	16.8	43.6
1992	0.6	0.32	0.32	2.6	.	.	.	2.6	2.6	4.4	16.4	42.6
1993	0.6	0.42	0.42	2.2	.	.	.	2.2	2.2	4.4	16.2	45.8
1994	0.6	0.36	0.36	1.4	.	.	.	1.4	1.4	4.2	14.2	44.8
1995	0.24	0.46	0.46	1.4	.	.	.	1.4	1.4	4.6	11.8	43.4
1996	0.22	0.46	0.5	1.2	.	.	.	1.2	1.2	3.8	12.6	46.6
1997	0.16	0.46	0.46	1.2	.	.	.	1.2	1.2	3.8	12.6	47.2
1998	0.16	0.42	0.42	0.8	.	.	.	1.8	1.8	4.2	12.4	42.8
1999	0.22	0.32	0.32	0.6	.	.	.	1.6	1.6	4.4	12.8	39
2000	0.18	0.36	0.36	1.4	0.1174	0.1174	0.1174	1.8	1.8	4.6	14.4	31
2001	0.18	0.46	0.46	0.8	0.0885	0.0885	0.0885	1.8	1.8	4.8	13.2	44.4
2002	0.2	0.32	0.32	0.6	0.0708	0.0708	0.0708	1.6	1.2	4.8	12	43.8
2003	0.1	0.3	0.3	0.8	0.0748	0.0748	0.0748	2	0.8	4.6	14	44.2
2004	0.06	0.3	0.3	0.8	0.0748	0.0748	0.0748	1.8	0.8	5	14.2	44.2
2005	0.01	0.28	0.28	0.8	0.0278	0.0278	0.0278	1.8	0.8	4.6	13.6	39.2
2006	0.01	0.27	0.27	1.38	0.0393	0.0393	0.0393	2	1.38	4.44	10.4	26.2
2007	0.01	0.296	0.296	0.73	0.0244	0.0244	0.0244	1.53	0.73	4.17	17.8	20
2008	0.01	0.286	0.286	0.786	0.0285	0.0285	0.0285	1.562	0.986	3.098	17.5	28.5
2009	0.01	0.302	0.371	0.016	0.016	0.016	0.016	1.069	0.949	4.31	17.4	27.8
2010	0.01	0.324	0.294	0.015	0.015	0.015	0.015	1.184	0.978	4.31	17.5	28
2011	0.01	0.334	0.296	0.015	0.015	0.015	0.015	1.196	0.984	4.32	17.8	28.4
2012	0.01	0.326	0.294	0.015	0.015	0.015	0.015	1.038	0.658	4.295	17.5	27.4

Table B4. Time series for variable emission factors for heavy metals, stationary combustion. g/tonne

			1990-1991			1992-		
Sector	Source	Fuel	Pb	Cd	Hg	Pb	Cd	Hg
General	S.03	V51	0.0085	0.00047	0.00035	0.00304	0.00015	0.00016

Table B5. Exceptions with time series for variable emission factors for natural gas combusted by oil exploration, tonne CO_2/1000 Sm^3 natural gas

Sector	Source	Fuel	Component	1990-1994	1995	1996	1997	1998	1999	2000	2001	2002*
230600.1	S.02	V31	CO_2	2.34	2.29	2.3	2.3	2.31	2.5	2.48	2.47	2.45
230600.1	S.1B2C	V31	CO_2	2.34	2.42	2.34	2.34	2.34	2.48	2.52	2.42	2.47

*For the years after 2002 reported emissions are used

Aviation - CH4, N2O, NOX, NMVOC, CO, particles and PAH

Table B6. General emission factors for aviation

Source	Fuel	CH_4 kg/ tonne	N_2O kg/ tonne	NO_X kg/ tonne	NMVOC kg/ tonne	CO kg /tonne	NH_3 kg/ tonne	TSP, PM_{10}, $PM_{2.5}$ kg/tonne	PAH g/ tonne	PAH-OSPAR g/tonne	PAH-4 g/tonne	Dioxins ug/ tonne
M.1A3A.111 Jet/turboprop 0-100 m	V14 Jet kerosene	***0.185***	0.1	*6.854*	*1.668*	*18.764*	0	0.025	*0.54*	0.02	0.005	0.06
M.1A3A.112 Jet/turboprop 100-1000 m	V14 Jet kerosene	***0.030***	0.1	*13.208*	*0.273*	*2.036*	0	0.025	*0.32*	*0.02*	*0.005*	0.06
M.1A3A.12 Jet/turboprop cruise	V14 Jet kerosene	0	0.1	*12.106*	*0.569*	*3.080*	0	0.007	*0.29*	*0.02*	*0.005*	0.06
M.1A3A.211 Helicopter 0-100 m	V14 Jet kerosene	*3.2*	0.1	6.67	*28.8*	*36.6*	0	0.025	*0.54*	0.02	*0.005*	0.06
M.1A3A.212 Helikopter 100-1000 m	V14 Jet kerosene	*3.2*	0.1	6.67	*28.8*	*36.6*	0	0.025	*0.32*	*0.02*	*0.005*	0.06
M.1A3A.22 Helicopter cruise	V14 Jet kerosene	0	0.1	6.67	*32*	*36.6*	0	0.007	*0.29*	*0.02*	*0.005*	0.06
M.1A3A.311 Small aircrafts 0-100 m	V12 Aviation gasoline	3.61	0.1	0	32.5	898.7	0	0.025	*0.54*	0.02	*0.005*	2
M.1A3A.312 Small aircrafts 100-1000 m	V12 Aviation gasoline	1.55	0.1	3.617	13.95	932.5	0	0.025	*0.32*	*0.02*	*0.005*	2
M.1A3A.32 Small aircrafts cruise	V12 Aviation gasoline	0	0.1	2.92	19.48	926	0	0.007	*0.29*	*0.02*	*0.005*	2

Numbers in italics have exceptions for some sectors, see table B7, and bold numbers are different for different years, see table B8.
Source: IPCC (2000), Finstad *et al*. (2001) and Finstad *et al*. (2002a).

Table B7. Exceptions from the general factors for aviation

Component	Emission factor	Fuel		Source	Sectors
CH_4	0.35	V14	Jet kerosene	M.1A3A.111-112, M1A3A.211-212	248422
NO_X	13.51	V14	Jet kerosene	M.1A3A.111, M1A3A.211	248422
NO_X	13.29	V14	Jet kerosene	M.1A3A.112, M1A3A.212	248422
NO_X	11.7	V14	Jet kerosene	M.1A3A.12, M.1A3A.22	248422
NMVOC	7.43	V14	Jet kerosene	M.1A3A.111, M1A3A.211	248422
NMVOC	7.36	V14	Jet kerosene	M.1A3A.112, M1A3A.212	248422
NMVOC	4.3	V14	Jet kerosene	M.1A3A.12, M.1A3A.22	248422
CO	23.67	V14	Jet kerosene	M.1A3A.111, M1A3A.211	248422
CO	23.15	V14	Jet kerosene	M.1A3A.112, M1A3A.212	248422
CO	20.9	V14	Jet kerosene	M.1A3A.12, M.1A3A.22	248422
PAH	0.18	V12, 14	Aviation gasoline, jet kerosene	M.1A3A.111, M1A3A.211, M1A3A.311	235100.2N
PAH	0.05	V12, 14	Aviation gasoline, jet kerosene	M.1A3A.112, M1A3A.212, M1A3A.312	235100.2N
PAH	0.1	V12, 14	Aviation gasoline, jet kerosene	M.1A3A.12, M.1A3A.22, M.1A3A.32	235100.2N
PAH-OSPAR, PAH-4	0	V12, 14	Aviation gasoline, jet kerosene	M.1A3A.112, M.1A3A.12, M1A3A.212, M.1A3A.22, M1A3A.312, M.1A3A.32	235100.2N

Table B8. Time series for variable emission factors for aviation. Factors for 1989, 1995, and 2000 are calculated as given in the table. Factors for 1990-1994 and 1996-1999 are calculated by linear interpolation. Factors before 1989 and after 2000 are kept constant

			CH_4			NO_X			NMVOC			CO		
Sector	Source	Fuel	1989	1995	2000	1989	1995	2000	1989	1995	2000	1989	1995	2000
General	M.1A3A.111	V14	0.156	0.201	0.185	6.026	7.2	6.854	1.402	1.8	1.668	11.105	17.5	18.764
	M.1A3A.112	V14	0.026	0.033	0.030	11.611	13.904	13.208	0.230	0.297	0.273	1.205	1.895	2.036
	M.1A3A.12	V14	0	0	0	10.663	12.061	12.106	1.022	0.660	0.569	3.450	3.268	3.080
235100.2N	M.1A3A.111	V14	0.157	0.336	0.393	6.725	8.118	7.689	1.410	3.025	3.534	11.557	17.213	18.954
	M.1A3A.112	V14	0.026	0.055	0.067	12.960	15.643	15.619	0.231	0.495	0.605	1.254	1.868	2.978
	M.1A3A.12	V14	0	0	0	10.663	11.572	11.333	1.022	3.505	0.502	3.450	6.293	1.701
665100.2	M.1A3A.111	V14	0.157	0.336	0.393	6.725	8.118	7.689	1.410	3.025	3.534	11.557	17.213	18.954
	M.1A3A.112	V14	0.026	0.055	0.067	12.960	15.643	15.619	0.231	0.495	0.605	1.254	1.868	2.978
	M.1A3A.12	V14	0	0	0	10.663	11.572	11.333	1.022	3.505	0.502	3.450	6.293	1.701

Road traffic - CH4, N2O, NOX, NMVOC, CO, NH3, particles and PAH

Table B9. General emission factors for road traffic

Source	Fuel	CH_4 kg/tonne	N_2O kg/tonne	NO_X kg/tonne	NMVOC kg/tonne	CO kg/tonne	NH_3 kg/tonne	TSP, PM_{10} kg/tonne	$PM_{2.5}$ kg/tonne	PAH g/tonne	PAH-OSPAR g/tonne	PAH-4 g/tonne	Dioxins ug/tonne
M.1A3B.1 Passenger car	V11 Motor gasoline	**0.454**	**0.056**	**5.485**	**7.767**	**50.630**	**1.277**	**0.051**	**0.051**	**1.000**	**0.446**	**0.126**	**0.1**
	V15 Auto diesel	**0.017**	**0.086**	**9.093**	**0.692**	**3.762**	**0.020**	**0.414**	**0.393**	4.367	2.383	0.447	0.1
	V31 Natural gas	0.261	0.0255	0.871	0.0653	1.69	0	0.122	0.122	0.015	0.00085	0	0.05
	V32 LPG	0	**0.047**	**1.926**	0	**11.599**	0	**0.037**	**0.037**	0	0	0	0.06
M.1A3B.2 Other light duty cars	V11 Motor gasoline	**0.667**	**0.116**	**7.637**	**11.613**	**120.312**	**0.997**	**0.096**	**0.096**	**1.000**	**0.446**	**0.126**	**0.1**
	V15 Auto diesel	**0.016**	**0.062**	**11.257**	**0.645**	**4.060**	**0.014**	**0.860**	**0.817**	4.367	2.383	0.447	0.1
M.1A3B.3 Heavy duty vehicles	V11 Motor gasoline	**0.583**	**0.044**	**28.311**	**16.982**	**22.539**	**0.019**	0	0	1.995	0.997	0.21	**0.1**
	V15 Auto diesel	**0.013**	**0.065**	**17.509**	**0.519**	**5.254**	**0.009**	**0.300**	**0.285**	**3.563**	**1.782**	**0.428**	**0.1**
	V31 Natural gas												
	V37 Bio gas	0	0	**34.003**	0	**5.884**	**0.008**	**0.140**	**0.140**	0.015	0.00085	0	0.05
M.1A3B.41 Moped	V11 Motor gasoline	**20.856**	**0.053**	**3.192**	**119.340**	**206.822**	**0.053**	0	0	2	0.53	0.08	**0.1**
M.1A3B.42 Motorcycle	V11 Motor gasoline	**1.245**	**0.059**	**4.491**	**21.532**	**218.435**	**0.059**	0	0	2	0.53	0.08	**0.1**

Bold numbers are different for different years, but only the 2010 data are shown in this Appendix, except for CH_4 (table B10) and N_2O (table B11).
Source: Results from Statistiics Norway's use of HBEFA (INFRAS 2009) and Finstad *et al*. (2001).

Table B10. Average CH_4 emission factors for road traffic including cold start emissions and evaporation, g CH_4/ kg fuel

	V11 Motor gasoline					V15 Auto diesel		
	Passenger car	Other light duty cars	Heavy duty vehicles	Moped	Motorcycle	Passenger car	Other light duty cars	Heavy duty vehicles
1980	2.024	2.282	0.587	13.285	3.815	0.119	0.109	0.116
1987	2.021	2.273	0.592	13.417	3.853	0.109	0.099	0.100
1989	1.961	2.239	0.584	13.234	3.622	0.118	0.108	0.108
1990	1.863	2.178	0.570	12.901	3.360	0.111	0.101	0.083
1991	1.821	2.184	0.574	12.988	3.106	0.107	0.099	0.082
1992	1.772	2.150	0.575	13.015	2.870	0.098	0.093	0.078
1993	1.721	2.080	0.577	13.055	2.615	0.078	0.077	0.068
1994	1.660	1.996	0.578	13.092	2.412	0.086	0.089	0.074
1995	1.592	1.888	0.581	13.153	2.253	0.083	0.085	0.071
1996	1.450	1.730	0.572	12.949	2.016	0.079	0.080	0.066
1997	1.392	1.674	0.588	13.303	1.952	0.081	0.082	0.066
1998	1.264	1.512	0.571	12.929	1.684	0.077	0.074	0.056
1999	1.164	1.410	0.568	12.871	1.594	0.074	0.070	0.052
2000	1.106	1.347	0.583	13.209	1.542	0.070	0.067	0.049
2001	0.976	1.176	0.559	12.682	1.428	0.060	0.058	0.043
2002	0.890	1.077	0.558	12.662	1.398	0.053	0.053	0.040
2003	0.804	0.996	0.552	13.142	1.408	0.048	0.049	0.038
2004	0.719	0.917	0.544	14.292	1.426	0.042	0.044	0.035
2005	0.682	0.896	0.568	16.233	1.522	0.038	0.041	0.034
2006	0.628	0.844	0.574	17.502	1.505	0.033	0.036	0.032
2007	0.601	0.814	0.590	18.939	1.475	0.029	0.032	0.029
2008	0.564	0.768	0.591	19.745	1.370	0.025	0.027	0.026
2009	0.532	0.730	0.588	20.220	1.324	0.022	0.023	0.022
2010	0.497	0.690	0.578	20.289	1.270	0.019	0.020	0.017
2011	0.480	0.686	0.585	20.895	1.265	0.018	0.018	0.015
2012	0.454	0.667	0.583	20.856	1.245	0.017	0.016	0.013

Source: Results from Statistics Norway's use of HBEFA (INFRAS 2009)

Table B11. Average N_2O emission factors for road traffic including cold start emissions and evaporation, g N_2O/ kg fuel

	V11 Motor gasoline					V15 Auto diesel		Heavy duty vehicles
	Passenger car	Other light duty cars	Heavy duty vehicles	Moped	Motorcycle	Passenger car	Other light duty cars	
1980	0.086	0.116	0.045	0.053	0.058	0	0	0.032
1987	0.095	0.114	0.045	0.054	0.059	0	0	0.029
1989	0.098	0.112	0.045	0.053	0.058	0	0	0.031
1990	0.099	0.109	0.043	0.052	0.057	0	0	0.029
1991	0.105	0.109	0.044	0.052	0.057	0	0	0.028
1992	0.110	0.111	0.044	0.052	0.058	0	0	0.026
1993	0.117	0.117	0.044	0.052	0.058	0	0	0.022
1994	0.125	0.123	0.044	0.053	0.058	0	0	0.025
1995	0.135	0.134	0.044	0.053	0.058	0.003	0.005	0.026
1996	0.146	0.143	0.044	0.052	0.057	0.009	0.012	0.026
1997	0.155	0.158	0.045	0.053	0.059	0.018	0.020	0.029
1998	0.153	0.161	0.044	0.052	0.057	0.027	0.026	0.028
1999	0.154	0.168	0.043	0.052	0.057	0.036	0.034	0.028
2000	0.160	0.180	0.045	0.053	0.059	0.045	0.041	0.029
2001	0.156	0.188	0.043	0.051	0.057	0.049	0.043	0.027
2002	0.156	0.204	0.043	0.051	0.057	0.056	0.046	0.026

2003	0.152	0.179	0.042	0.050	0.056	0.061	0.049	0.025
2004	0.147	0.178	0.042	0.050	0.056	0.065	0.052	0.024
2005	0.087	0.168	0.043	0.052	0.058	0.072	0.057	0.024
2006	0.083	0.165	0.044	0.052	0.059	0.076	0.060	0.023
2007	0.081	0.164	0.045	0.054	0.060	0.082	0.064	0.025
2008	0.077	0.155	0.045	0.054	0.060	0.086	0.065	0.028
2009	0.073	0.146	0.045	0.053	0.060	0.086	0.064	0.033
2010	0.067	0.132	0.044	0.052	0.059	0.082	0.061	0.042
2011	0.062	0.126	0.045	0.053	0.059	0.084	0.061	0.056
2012	0.056	0.116	0.044	0.053	0.059	0.086	0.062	0.065

Source: Results from Statistics Norway's use of HBEFA (INFRAS 2009)

Navigation - CH4, N2O, NOX, NMVOC, CO, particles and POPs

Table B12. General emission factors for navigation

	CH_4 kg/ tonne	N_2O kg/ tonne	NO_X kg/ tonne	NMVOC kg /tonne	CO kg/ tonne	NH_3 kg/ tonne	TSP, PM_{10} kg/ tonne	$PM_{2.5}$ kg/ tonne	PAH g/ tonne	PAH-OSPAR g /tonne	PAH-4 g/ tonne	Dioxins ug/ tonne
V17 Marine gas oil/diesel, V18 Light fuel oils	*0.23*	*0.08*	***33.31***	*2.4*	*2.9*	0	1.6	1.5	1.6	0.26	0.04	4
V19 Heavy distillate, V20 Heavy fuel oil	*0.23*	*0.08*	***33.31***	*2.4*	*2.9*	0	5.4	5.1	1.6	0.26	0.04	4
V31 Natural gas (1000 Sm^3)	**46.83**	0	4.0	0.814	2.143	0	0.032	0.032	0.015	0.00085	0	0.05

Numbers in italics have exceptions for some sectors, see table B13, and bold numbers are different for different years, see table B14-B16.
Source: Flugsrud and Rypdal (1996), Tornsjø (2001), Finstad *et al.* (2001), Finstad *et al*. (2002b), Finstad *et al.* (2003), Bremnes Nielsen and Stenersen (2010).

Table B13. Exceptions from the general factors for navigation

Component	Emission factor (kg/tonne)	Fuel		Sector
CH_4	0.8	V17	Marine gas oil/diesel	230600.1 -230600.3
CH_4	1.9	V20	Heavy fuel oil	230600.1 -230600.3
N_2O	0.02	V17	Marine gas oil/diesel	230600.1 -230600.3
NO_X	**43.16**	V17, 19, 20	Marine gas oil/diesel, light fuel oils, heavy distillate, heavy fuel oil	230310.N
NO_X	70	V17, 20	Marine gas oil/diesel, light fuel oils, heavy distillate, Heavy fuel oil	230600.1 -230600.3
NO_X	**47.23**	V17, 19, 20	Marine gas oil/diesel, light fuel oils, heavy distillate, heavy fuel oil	248422
NMVOC	**1.4**	V17, 18, 19, 20	Marine gas oil/diesel, light fuel oils, heavy distillate, heavy fuel oil	230310.N
NMVOC	**2.3**	V17, 19, 20	Marine gas oil/diesel, light fuel oils, heavy distillate, heavy fuel oil	248422
NMVOC	5	V17	Marine gas oil/diesel, light fuel oils	230600.1 -230600.3
NMVOC	**5**	V19, 20	Heavy distillate, heavy fuel oil	230600.1 -230600.3
CO	7.9	V17, 18, 19, 20	Marine gas oil/diesel, light fuel oils, heavy distillate, heavy fuel oil	230310.N
CO	**1.6**	V17, 18, 19, 20	Marine gas oil/diesel, light fuel oils, heavy distillate, heavy fuel oil	230600.1
CO	7	V17, 19, 20	Marine gas oil/diesel, light fuel oils, heavy distillate, heavy fuel oil	230600.1 -230600.3
CO	2.3	V17, 19, 20	Marine gas oil/diesel, light fuel oils, heavy distillate, heavy fuel oil	248422

Table B14. Time series for variable emission factors for navigation. NO_X

Sector	Fuel	1980-1999	1980-1986	1987	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
General	V17-20		57.33	56.99	56.90	56.85	56.80	56.89	56.77	56.82	56.68	57.23	57.47	57.41	56.82

			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
General	V17-20		57.82	57.96	57.18	56.80	56.51	55.90	55.55	54.61	51.52	48.03	44.00	38.90	33.31
230310.N	V17, 19, 20	52.11	52.12	52.01	51.90	51.80	51.69	51.58	51.48	50.93	49.90	47.41	45.17	43.64	43.16
248422	V17, 19, 20	50.17	49.82	49.60	49.39	49.17	48.95	48.74	48.52	48.31	48.09	47.88	47.66	47.44	47.23

Source: (Flugsrud *et al.* 2010)

Table B15. Time series for variable emission factors for navigation. CH_4

Sector	Fuel	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
General	V31	31.43	31.43	31.43	49.99	52.71	54.55	54.43	36.81	38.83	41.65	42.73	40.50	46.83

Table B16. Time series for variable emission factors for navigation. NMVOC and CO

Sector	Fuel	NMVOC						CO	
		1980-1990	1980-1997	1980-1998	1991-	1998-	1999-	1980-1997	1998-
General	V17-20							3.1	2.9
230310.N	V17-20			1.5			1.4		
230600.1	V17-20							2	1.6
230600.1,230910	V19,20	6.4			5				
230600.1,230910	V 20								
248422	V17-20		2.2			2.3			

Other mobile sources including railways - CH4, N2O, NOX, NMVOC, CO, NH3, particles and POPs

Table B17. General emission factors for other mobile sources

		CH_4 kg/ tonne	N_2O kg/ tonne	NO_X kg/ tonne	NMVOC kg/ tonne	CO kg/ tonne	NH_3 kg/ Tonne	TSP, PM_{10} kg/ tonne	$PM_{2.5}$ kg/ tonne	PAH g/ tonne	PAH-OSPAR g/tonne	PAH-4 g/ tonne	Dioxins ug/ tonne
M.1A3C Railway	V01 Coal	0.28	0.04	3	1.1	3	0	1.6/1.14	0.82	0.46	0.16	0.024	1.6
	V15 Auto diesel	0.18	1.2	47	4	11	0.007	3.8	3.8	3.3	0.53	0.08	0.1
M.1A3E.21 Small boats 2 stroke	V11 Motor gasoline	5.1	0.02	6	240	415	0	8	8	2	0.53	0.08	**0.1**
M.1A3E.22 Small boats 4 stroke	V11 Motor gasoline	1.7	0.08	12	40	1 000	0	1	1	2	0.53	0.08	**0.1**
	V15 Auto diesel	0.18	0.03	54	27	25	0	4	4	3.3	0.53	0.08	0.1
M.1A3E.31 Motorized equipment 2 stroke	V11 Motor gasoline	6	0.02	**2**[1]	500	700	0	8	8	2	0.53	0.08	**0.1**
M.1A3E.32 Motorized equipment 4t	V11 Motor gasoline	*2.2*	*0.07*	10	110	1 200	0	1	1	2	0.53	0.08	**0.1**
	V15 Auto diesel	0.*17*	1.3	**21.9**	*6*	*15*	0.005	*4*	3.8	3.3	0.53	0.08	0.1
	V18 Light fuel oils	0.17	1.3	*50*	*6*	*15*	0.005	*7.1*	6.*75*	3.3	0.53	0.08	0.1

M.1A3E.1 Snow scooter has the same emission factors as M.1A3B.41 Moped, see table B9.

Bold numbers are different for different years. [1]Before 1995 the emission factor was 1.3.

Numbers in italics have exceptions for some sectors, see table B18–B19.

Sources: Bang (1993), SFT (Bang *et al.* 1999), Finstad *et al*. (2001), Finstad *et al*. (2002b), Finstad *et al*. (2003), Winther and Nielsen (2006), EEA /2013).

Table B18. Exceptions from the general factors for greenhouse gases and precursors for other mobile sources

Component	Emission factor (kg/tonne)	Fuel		Source	Sectors
CH_4	6.2	V11	Motor gasoline	M.1A3E.31 Motorized equipment 2 stroke	230100
CH_4	3.7	V11	Motor gasoline	M.1A3E.32 Motorized equipment 4 stroke	230100
CH_4	7.7	V11	Motor gasoline	M.1A3E.31 Motorized equipment 2 stroke	230210
CH_4	8.1	V11	Motor gasoline	M.1A3E.31 Motorized equipment 2 stroke	330000
CH_4	5.5	V11	Motor gasoline	M.1A3E.32 Motorized equipment 4 stroke	330000
CH_4	0.18	V15	Auto diesel	M.1A3E.32 Motorized equipment 4 stroke	330000
N_2O	0.08	V11	Motor gasoline	M.1A3E.32 Motorized equipment 4 stroke	230500-233320
NO_X	**23.4**	V15	Auto diesel	M.1A3E.32 Motorized equipment 4 stroke	230100
NO_X	**15.0**	V15	Auto diesel	M.1A3E.32 Motorized equipment 4 stroke	230210
NO_X	54	V18	Light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230100
NO_X	52	V18	Light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230210
NO_X	47	V18	Light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230710-230892, 234910
NO_X	48	V18	Light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	232360, 248422
NO_X	46	V18	Light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	234110-234120
NMVOC	7.2	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230100
NMVOC	5.7	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230210
NMVOC	4	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230710-230892,234910
NMVOC	4.8	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	232360, 248422
NMVOC	3.8	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	234110-234120
CO	25	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230100
CO	20	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230210
CO	11	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230710-230892, 234910
CO	17	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	234110-234120
CO	18	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	248422

Bold numbers are different for different years, see table B20.

Table B19. Exceptions from the general factors for other pollutants for other mobile sources

Component	Emission factor (kg/tonne)	Fuel		Source	Sectors
TSP, PM_{10}	7.1	V15	Auto diesel	M.1A3E.32 Motorized equipment 4 stroke	230100-230210
TSP, PM_{10}	3.8	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230710-230892, 234910
TSP, PM_{10}	4.2	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	232360
TSP, PM_{10}	5.3	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	234110-234120
TSP, $PM1_0$	5.4	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	248422
$PM_{2.5}$	6.75	V15	Auto diesel	M.1A3E.32 Motorized equipment 4 stroke	230100-230210
$PM_{2.5}$	3.61	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	230710-230892, 234910
$PM_{2.5}$	3.99	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	232360
$PM_{2.5}$	5.04	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	234110-234120
$PM_{2.5}$	5.13	V15, 18	Auto diesel, light fuel oils	M.1A3E.32 Motorized equipment 4 stroke	248422

Table B20. Time series for NO_X emission factors for use of auto diesel in motorized equipment 4t

Sector	1980	1987	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
General	38.8	39.4	39.9	40.2	41.0	41.7	42.3	42.9	43.4	43.9	44.3	44.5	43.6	42.6	41.2
230100	30.1	31.2	32.2	32.7	33.6	34.2	34.9	35.6	36.6	38.3	39.3	40.0	40.7	41.3	41.8
230210	31.2	34.0	36.2	37.2	38.4	40.1	41.3	42.5	43.7	44.5	45.4	46.0	45.7	45.4	44.8

Sector	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
General	39.7	37.7	35.7	34.0	32.2	29.9	27.6	26.1	24.6	23.3	21.9
230100	40.8	39.3	37.9	36.3	34.4	32.3	30.3	28.4	26.8	25.0	23.4
230210	42.3	38.7	35.5	32.0	28.1	24.4	22.0	19.5	17.7	16.2	15.0

Source: Winther and Nielsen (2006). Data for 2005 and later are extrapolations.

Table B21. Time series for variable emission factors for other mobile sources

Fuel	Component	1980-1990	1991	1992	1993	1994	1995	1996	1997-
V11 Gasoline	Dioxins	1.32	1.11	0.95	0.69	0.25	0.23	0.11	0.1

CH4 - Stationary combustion

Table B22. General emission factors, kg CH_4/tonne fuel

Source	V01 Coal	V02 Coke	V03 Petrol coke	V41 Fuel wood	V42 Wood waste	V43 Black liquor	V44 Wood pellets	V45 Wood briquettes	V04 Char-coal	V31 Natural gas (1000 Sm^3)	V33 Re-finery gas	V34 Blast fur-nace gas	V36 Land-fill gas	V35 Fuel gas	V32 LPG	V13 Kero-sene (heating)	V17 Marine gas oil/ diesel	V18 Light fuel oils	V19 Heavy dis-tillate	V20 Heavy fuel oil	V51 Muni-cipal waste	V52 Special waste
S.01 Direct-fired furnaces	0.028	0	0	.	.	.	.	.	.	*0.05*	0.054	0.054	.	*0.05*	.	.	0.016	.	0.04	0.04	.	0.04
S.02 Gas turbines	.	.	.	.	.	.	.	.	.	0.91	.	.	0.24	.	.	.	0	.	.	.	.	.
S.03 Boilers	*0.28*	0.28	0.28	.	0.25	0.25	0.25	0.25	.	*0.2*	0.24	*0.24*	0.24	0.24	0.17	0.17	*0.4*	*0.4*	*0.4*	*0.4*	0.23	*0.4*
S.04 Small stoves	8.4	8.4	.	5.3	.	.	5.3	.	8.4	.	.	.	.	.	0.24	0.3	.	0.4	0.4	.	.	.
S.1B2C Flares	.	.	.	.	.	.	.	.	.	0.24	0.28	.	0.37	.	.	.	.	.	.	.	.	.

Numbers in italics have exceptions for some sectors, see table B23.
Source: IPCC (1997a), SFT (Sandgren *et al.* 1996), SINTEF (Karlsvik 1995) and OLF (The Norwegian oil industry association 1994).

Table B23. Exceptions from the general factors for CH_4, stationary combustion (kg CH_4/tonne fuel)

Emission factor	Fuel		Source	Sectors
0	V31, 35	Natural gas (1000 Sm^3), fuel gas	S.01 Direct fired furnaces	232350-232360
0.085	V31	Natural gas (1000 Sm^3)	S.01 Direct fired furnaces	232014
0.03	V01	Coal	S.03 Boilers	230500, 230600.1, 230600.3, 231922, 233510-233530
0.1	V17, 18, 19, 20, 52	Fuel oils incl. spezial waste	S.03 Boilers	230500-233530 (Industry incl. power supply)
0.0425	V31	Natural gas (1000 Sm^3)	S.03 Boilers	230500, 230600.1, 230600.3, 231922, 233510-233530
0	V34	Blast furnace gas	S.03 Boilers	231922
1	V33	Refinery gas	S.02 Gas turbines	233511

N2O - Stationary combustion

Table B24. General emission factors. kg N_2O/tonne fuel

Source	V01 Coal	V02 Coke	V03 Petrol coke	V41 Fuel wood	V42 Wood waste	V43 Black liquor	V44 Wood pellets	V45 Wood bri-quettes	V04 Char-coal	V31 Natural gas (1000 Sm^3)	V33 Re-finery gas	V34 Blast furn-ace gas	V36 Land-fill gas	V35 Fuel gas	V32 LPG	V13 Kero-sene (heating)	V17 Marine gas oil/ diesel	V18 Light fuel oils	V19 Heavy dis-tillate	V20 Heavy fuel oil	V51 Munici-pal waste	V52 Special waste
S.01 Direct-fired furnaces	0	0	0	.	.	.	.	.	.	*0.02*	0.024	0.024	0.024	0.024	.	.	0.03	.	0.03	0.03	.	0.03
S.02 Gas turbines	.	.	.	.	.	.	.	.	.	0.019	.	.	0.005	.	.	.	0.024	.	.	.	.	.
S.03 Boilers	0.04	0.04	0.04	.	0,07	0,07	0.07	0.07	.	0.004	0.005	0.005	0.005	0.005	0.03	0.03	0.03	0.03	0.03	0.03	0.035	0.03
S.04 Small stoves	0.04	0.04	.	0.032	.	.	0.032	.	0.04	.	.	.	.	.	0.03	0.03	.	0.03	0.03	.	.	.
S.1B2C Flares	.	.	.	.	.	.	.	.	.	0.02	0.024	.	0.002	.	.	.	.	.	.	.	.	.

Numbers in italics have exceptions for some sectors, see table B25.
Source: IPCC (1997a), SFT (Sandgren *et al.* 1996) and OLF (The Norwegian oil industry association 1994).

Table B25. Exceptions from the general factors for N_2O. Stationary combustion (kg N_2O/1000 Sm^3 natural gas)

Emission factor	Fuel		Source	Sectors
0.017	V31	Natural gas	S.01 Direct-fired furnaces	232014
0.023	V33	Refinery gas	S.02 Gas turbines	233511

NOX - Stationary combustion

Table B26. General emission factors. kg NO_X/tonne fuel

Source	V01 Coal	V02 Coke	V03 Petrol coke	V41 Fuel wood	V42 Wood waste	V43 Black liquor	V44 Wood pellets	V45 Wood bri-quettes	V04 Char-coal	V31 Natural gas (1000 Sm^3)	V33 Re-finery gas	V34 Blast furn-ace gas	V36 Land-fill gas	V35 Fuel gas	V32 LPG	V13 Kero-sene (heating)	V17 Marine gas oil/ diesel	V18 Light fuel oils	V19 Heavy dis-tillate	V20 Heavy fuel oil	V51 Munici-pal waste	V52 Special waste
S.01 Direct-fired furnaces	16	20	20	.	.	.	.	.	.	*5.95*	5.4	5.4	.	5.4	.	.	70	.	*5*	*5*	.	5
S.02 Gas turbines	.	.	.	.	.	.	.	.	.	*6.27*	.	.	.	.	.	.	16	.	.	.	.	.
S.03 Boilers	*3*	*3*	3.4	.	0.9	0.9	1.3	1.3	.	2.55	*3*	*3*	0.01	*3*	2.3	3	*2.5*	*2.5*	*2.5*	*4.2*	1.365	*4.2*
S.04 Small stoves	*3*	*3*	.	**0.985**	.	.	1.1	.	1.4	.	.	.	.	.	2.3	2.5	.	2.5	2.5	.	.	.
S.1B2C Flares	.	.	.	.	.	.	.	.	.	12	7	.	0.17	.	.	.	.	.	.	.	.	.

Numbers in italics have exceptions for some sectors, see table B27, and bold numbers are different for different years, see table B28.
Source: Rosland (1987). Fuel wood factor based on data from annual surveys on use of fuel wood in households.

Table B27. Exceptions from the general factors for NO_X. Stationary combustion. kg NO_X /tonne fuel

Emission factor	Fuel		Source	Sectors
24	V19, 20, 52	Heavy distillate, heavy fuel oil, special waste	S.01 Direct-fired furnaces	231910.2, 232350
6.13	V31	Natural gas (1000 Sm^3)	S.01 Direct-fired furnaces	232014
9.5	V19, 20	Heavy distillate, heavy fuel oil	S.01 Direct-fired furnaces	232360
8.681	V31	Natural gas (1000 Sm^3)	S.02 Gas turbines	230600.1
1,4	V31	Natural gas (1000 Sm^3)	S.1B2C Flares	230600.1
3	V17, 18, 19	Fuel oils	S.03 Boilers	230500-233320
4.5	V01	Coal	S.03 Boilers	230500-233320
3.4	V02	Coke	S.03 Boilers	230500-233320
5	V20, 52	Heavy fuel oil, special waste	S.03 Boilers	230500-233320
2.9	V35	Fuel gas	S.03 Boilers	232011-232050, 232411-232442
0.01	V34	Blast furnace gas	S.03 Boilers	233510-233530
6.27	V33	Refinery gas	S.02 Gas turbines	233511
1.4	V01, 02	Coal, coke	S.04 Small stoves	330000

Table B28. Time series for variable emission factors for NO_X. Stationary combustion. kg NO_X /tonne fuel

Sector	Source	Fuel	1980-1990	1991	1992-1994	1995	1996-1998	1999-2004	2005	2006	2007	2008	2009	2010	2011
General	S.04	V41	0.982	0.981	0.982	0.981	0.982	0.981	0.985	0.984	0.987	0.988	0.987	0.988	0.986

Sector	Source	Fuel	1980-1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000-
230600.1	S.02	V31	8.223	8.172	8.234	8.444	8.617	8.874	9.128	9.185	9.528	9.087	8.681

NMVOC - Stationary combustion

Table B29. General emission factors. kg NMVOC/tonne fuel

Source	V01 Coal	V02 Coke	V03 Petrol coke	V41 Fuel wood	V42 Wood waste	V43 Black liquor	V44 Wood pellets	V45 Wood bri-quettes	V04 Char-coal	V31 Natural gas (1000 Sm^3)	V33 Re-finery gas	V34 Blast furnace gas	V36 Land-fill gas	V35 Fuel gas	V32 LPG	V13 Kero-sene (heating)	V17 Marine gas oil/ diesel	V18 Light fuel oils	V19 Heavy dis-tillate	V20 Heavy fuel oil	V51 Munici-pal waste	V52 Special waste
S.01 Direct-fired furnaces	0	0	0	.	.	.	.	.	.	*0*	0.1	*0.*		*0.*	.	5	.		*0.3*	*0.3*	.	*0.3*
S.02 Gas turbines	.	.	.	.	.	.	.	.	.	0.24	.	.	.	.	.	.	0.03	.	.	.	.	.
S.03 Boilers	*1.1*	0.6	0.6.		*1.30*		1.3	1.3	.	0.085	0.1	*0.10*		*0.1*	*0.1*	0.4	*0.4*	*0.4*	*0.4*	0.3	0.7	0.3
S.04 Small stoves	*1.1*	0.6	.	7.0	.	.	6.501	.	10.		..		.	.	0.1	*0.4.*		0.4	0.4	.	.	
S.1B2C Flares	.	.	.	.	.	.	.	.	.	0.06	13.5.		0	.	.	.	.	.	.	.	.	.

Numbers in italics have exceptions for some sectors, see table B30.
Source: Rosland (1987) and SFT (Sandgren *et al.* 1996).

Table B30. Exceptions from the general factors for NMVOC. Stationary combustion. kg NMVOC/tonne fuel

Emission factor	Fuel		Source	Sectors
0	V 19, 20, 52	Heavy distillate, heavy fuel oil, special waste	S.01 Direct-fired furnaces	231910.2, 232350
0.1	V34	Blast furnace gas	S.01 Direct-fired furnaces	231910.2
0.085034	V31	Natural gas (1000 Sm^3)	S.01 Direct-fired furnaces	232014
0.9	V19, 20	Heavy distillate, heavy fuel oil	S.01 Direct-fired furnaces	232360
0.8	V01	Coal	S.03 Boilers	230500-233320
0	V32, 34, 35, 42	LPG, blast furnace gas, fuel gas, wood waste	S.03 Boilers	230500-233320, 231711, 232011-232050, 233510-233530
0.6	V17, 18, 19	Fuel oils	S.03 Boilers	330000
10	V01	Coal	S.04 Small stoves	330000
0.6	V13	Kerosene (heating)	S.04 Small stoves	330000

CO - Stationary combustion

Table B31. General emission factors. kg CO/tonne fuel

Source	V01 Coal	V02 Coke	V03 Petrol coke	V41 Fuel wood	V42 Wood waste	V43 Black liquor	V44 Wood pellets	V45 Wood bri-quettes	V04 Char-coal	V31 Natural gas (1000 Sm^3)	V33 Re-finery gas	V34 Blast furn-ace gas	V36 Land-fill gas	V35 Fuel gas	V32 LPG	V13 Kero-sene (heating)	V17 Marine gas oil/ diesel	V18 Light fuel oils	V19 Heavy dis-tillate	V20 Heavy fuel oil	V51 Munici-pal waste	V52 Special waste
S.01 Direct-fired furnaces	0	0	0	.	.	.	.	.	.	0	0	*0*	.	*0*	.	.	5	.	*0.2*	*0.2*	.	*0.2*
S.02 Gas turbines	.	.	.	.	.	.	.	.	.	1.7	.	.	.	.	.	.	0.7	.	.	.	.	.
S.03 Boilers	3	3	3	.	*15*	0	15	15	.	0	0	0	0	0	*0.5*	2	*2*	2	2	*0.4*	2.8	*0.4*
S.04 Small stoves	3	3	.	**99.2**	.	.	2.6	.	100	.	.	.	.	.	0.5	*2*	.	2	2	.	.	.
S.1B2C Flares	.	.	.	.	.	.	.	.	.	*1.5*	*0*	.	0.04	.	.	.	.	.	.	.	.	.

Numbers in italics have exceptions for some sectors, see table B32, and bold numbers are different for different years, see table B33.

Table B32. Exceptions from the general factors for CO. Stationary combustion. kg CO/tonne fuel

Emission factor	Fuel		Source	Sectors
0	V 19, 20, 52	Heavy distillate, heavy fuel oil, special waste	S.01 Direct-fired furnaces	231910.2, 232350, 232360
0.01	V34	Blast furnace gas	S.01 Direct-fired furnaces	231910.2
0.2	V20. 52	Heavy fuel oil, special waste	S.03 Boilers	230500-233320
0	V32, 42	LPG, wood waste	S.03 Boilers	230500-233320, 231711
6.5	V17, 18, 19	Fuel oils	S.03 Boilers	330000
100	V01, 02	Coal, coke	S.04 Small stoves	330000
6.5	V13	Kerosene (heating)	S.04 Small stoves	330000
1.7	V31	Natural gas (1000 Sm^3)	S.1B2C Flares	231922

Table B33. Time series for variable emission factors for CO. Stationary combustion. kg CO/tonne fuel

Sector	Source	Fuel	1980-1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
General	S.04	V41	149.1	148.4	146.3	142.6	137.6	131.0	122.2	111.5	115.5	111.9	110.6	107.9	105.0

Sector	Source	Fuel	2010	2011	2012
General	S.04	V41	103.3	101.2	99.2

NH3 - Stationary combustion

Table B34. General emission factors. kg NH_3/tonne fuel

Source	V01 Coal	V02 Coke	V03 Petrol coke	V41 Fuel wood	V42 Wood waste	V43 Black liquor	V44 Wood pellets	V45 Wood bri-quettes	V04 Char-coal	V31 Natural gas (1000 Sm^3)	V33 Re-finery gas	V34 Blast furn-ace gas	V36 Land-fill gas	V35 Fuel gas	V32 LPG	V13 Kero-sene (heating)	V17 Marine gas oil/ diesel	V18 Light fuel oils	V19 Heavy dis-tillate	V20 Heavy fuel oil	V51 Munici-pal waste	V52 Special waste
S.04 Small stoves	.	.	.	0.066	.	.	0.066	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
All other sources	0	0	0	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Particulate matter - Stationary combustion

Table B35. General emission factors. kg particle component/tonne fuel

Com-po-nent	Source	V01 Coal	V02 Coke	V03 Petrol coke	V41 Fuel wood	V42 Wood waste	V43 Black liquor	V44 Wood pellets	V45 Wood bri-quettes	V04 Char coal	V31 Natural gas (1000 Sm^3)	V33 Re-finery gas	V34 Blast furn-ace gas	V36 Landfill gas	V35 Fuel gas	V32 LPG	V13 Kero-sene (heat-ing)	V17 Marine gas oil/ diesel	V18 Light fuel oils	V19 Heavy dis-tillate	V20 Heavy fuel oil	V51 Municipal waste	V52 Special waste
TSP	S.01 Direct-fired furnaces	*1.6*	1.6	1.6	.	.	.	.	.	.	0.122	0.144	0.144	.	0.144	.	.	0.286	.	*	*	.	*5.68*
TSP	S.02 Gas turbines	.	.	.	.	.	.	.	.	.	0.122	.	.	.	.	.	.	0.286	.	.	.	.	.
TSP	S.03 Boilers	*1.6*	1.6	1.6	.	2,69	0	2,69	2,69	.	0.122	0.144	0.144	0.144	0.144	0.136	0.296	0.286	0.286	*	*	*0.05*	*5.68*
TSP	S.04 Small stoves	4.2	2.85	3.5	**17.65**	.	.	1.1	.	2.4	.	.	.	.	.	0.136	*0.3*	.	0.3	.	.	.	.
TSP	S.1B2C Flares	.	.	.	.	.	.	.	.	.	0.002	0.144	.	0.144	.	.	.	.	.	.	.	.	.
PM_{10}	S.01 Direct-fired furnaces	*1.14*	1.14	1.14	.	.	.	.	.	.	0.122	0.144	0.144	.	0.144	.	.	0.143	.	*	*	.	*4.87*
PM_{10}	S.02 Gas turbines	.	.	.	.	.	.	.	.	.	0.122	.	.	.	.	.	.	0.143	.	.	.	.	.
PM_{10}	S.03 Boilers	*1.14*	1.14	1.14	.	2,52	0	2,52	2,52	.	0.122	0.144	0.144	0.144	0.144	0.136	0.148	0.143	*0.15*	*	*	*0.05*	*4.87*
PM_{10}	S.04 Small stoves	2.8	1.71	2.1	**17.29**	.	.	1.1	.	2.4	.	.	.	.	.	0.136	0.16	.	0.155	.	.	.	.
PM_{10}	S.1B2C Flares	.	.	.	.	.	.	.	.	.	0.002	0.144	.	0.144	.	.	.	.	.	.	.	.	.
$PM_{2.5}$	S.01 Direct-fired furnaces	*0.82*	0.82	0.82	.	.	.	.	.	.	0.122	0.144	0.144	.	0.144	.	.	0.036	.	*	*	.	*3.2*
$PM_{2.5}$	S.02 Gas turbines	.	.	.	.	.	.	.	.	.	0.122	.	.	.	.	.	.	0.036	.	.	.	.	.
$PM_{2.5}$	S.03 Boilers	*0.82*	0.82	0.82	.	*2,52*	0	2,52	2,52	.	0.122	0.144	0.144	0.144	0.144	0.136	0.037	*0.12*	*0.12*	*	*	*0.05*	*3.2*
$PM_{2.5}$	S.04 Small stoves	0.86	0.86	1.05	**16.77**	.	.	1.1	.	2.4	.	.	.	.	.	0.136	*0.12*	.	0.119	.	.	.	.
$PM_{2.5}$	S.1B2C Flares	.	.	.	.	.	.	.	.	.	0.002	0.144	.	0.144	.	.	.	.	.	.	.	.	.

Numbers in italics have exceptions for some sectors, see table B37, and bold numbers are different for different years, see table B38.

* General emission factors for all sources for heavy distillate and heavy fuel oil are given in table B36 for all years.

Source: Finstad *et al*. (2003). Fuel wood factor based on data from annual surveys on use of fuel wood in households

Table B36. General particle emission factors for heavy distillate and heavy fuel oil for all sources. Factors dependent on sulphur content. kg particle component /tonne fuel

Fuel	Com-ponent	1990	1991	1992	1993	1994	1995	1996-1997	1998	1999	2000-
V19	TSP	0.803	0.714	0.701	0.701	0.688	0.714	0.663	0.688	0.701	0.714
	PM_{10}	0.690	0.614	0.603	0.603	0.592	0.614	0.570	0.592	0.603	0.614
	$PM_{2.5}$	0.450	0.400	0.393	0.393	0.385	0.400	0.371	0.385	0.393	0.400
V20	TSP	1.350	1.339	1.316	1.304	1.190	1.053	1.098	1.087	1.110	1.201
	PM_{10}	1.161	1.151	1.131	1.121	1.023	0.905	0.944	0.934	0.954	1.033
	$PM_{2.5}$	0.761	0.754	0.741	0.735	0.671	0.593	0.619	0.613	0.625	0.677

Source: Finstad *et al*. (2003).

Table B37. Exceptions from the general factors for particles. Stationary combustion

Emission factor (kg TSP/tonne)	Emission factor (kg PM_{10}/tonne)	Emission factor (kg $PM_{2.5}$/tonne)	Fuel		Source	Sectors
4.06	2.4	1.4	V52	Special waste	S.01 Direct-fired furnaces	230500-233320
5.45	3.54	1.45	V01	Coal	S.01 Direct-fired furnaces	233530
4.2	2.8	0.86	V01	Coal	S.03 Boilers	230100
.	0.143 (V18)	0.036 (V17, 18)	V17, 18	Light fuel oils	S.03 Boilers	230500-233320
4.06	2.4	1.4	V52	Special waste	S.03 Boilers	230500-233320
5.45	3.54	1.45	V01	Coal	S.03 Boilers	233530
0.5	0.5	0.5	V51	Municipal waste	S.03 Boilers	253800
0.3	0.155	0.119	V13	Kerosene (heating)	S.04 Small stoves	330000

Table B38. Time series for variable emission factors for particles. Stationary combustion. kg particle component /tonne fuel

Compo-nent	Source	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
TSP	S.04	V41	22.24	22.24	22.24	22.25	22.26	22.25	22.26	22.27	22.24	22.05	21.68	21.22
PM_{10}	S.04	V41	21.80	21.80	21.80	21.80	21.81	21.81	21.81	21.83	21.79	21.61	21.25	20.79
$PM_{2.5}$	S.04	V41	21.13	21.13	21.13	21.14	21.15	21.14	21.15	21.16	21.12	20.95	20.60	20.16

			2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
TSP	S.04	V41	20.62	19.82	18.85	19.10	18.80	18.66	18.41	18.16	17.96	17.78	17.65
PM_{10}	S.04	V41	20.21	19.42	18.47	18.72	18.42	18.29	18.04	17.79	17.60	17.43	17.29
$PM_{2.5}$	S.04	V41	19.59	18.83	17.91	18.15	17.86	17.73	17.49	17.25	17.06	16.89	16.77

POPs (Persistent Organic Pollutants) - Stationary combustion

Table B39.General emission factors for PAH

Component	Source	V01 Coal	V02 Coke	V03 Petrol coke	V41 Fuel wood	V42 Wood waste	V43 Black liquor	V44 Wood pellets	V45 Wood bri-quettes	V04 Char-coal	V31 Natural gas (1000 Sm^3)	V33 Re-finery gas	V34 Blast furn-ace gas	V36 Land-fill gas	V35 Fuel gas	V32 LPG	V13 Kero-sene (heat-ing)	V17 Marine gas oil/ diesel	V18 Light fuel oils	V19 Heavy dis-tillate	V20 Heavy fuel oil	V51 Munici-pal waste	V52 Special waste
PAH	S.01 Direct-fired furnaces	0.17	0.17	0.17	.	0.018	0.018	.	.	.	0.015	0.018	0.018	.	0.018	.	.	1.6	.	0.015	0.015	.	0.015
g/tonne																							
PAH	S.02 Gas turbines	.	.	.	.	.	.	.	.	.	0.015	.	.	.	.	.	.	1.6	.	.	.	.	.
g/tonne																							
PAH	S.03 Boilers	0.46	0.46	0.46	.	0.018	0.018	0.16	0.16	.	0.015	0.018	0	0.018	0.018	0.018	0.007	*0.01*	*0.01*	0.015	0.015	*2.5*	0.015
g/tonne	S.04 Small stoves	39.9	27.8	27.8	**24.48**	.	.38.8	.	39.9	.	.	.	.	.	.0.039	0.039	.	1.01	.	.	.	.	.
PAH	S.1B2C Flares	.	.	.	.	.	.	.	.	.	0.015	0.018	.	0.018	.	.	.	.	.	.	.	.	.
g/tonne																							
PAH	M.1A3C Railroad	0.46	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
g/tonne																							
PAH-OSPAR	S.01 Direct-fired furnaces	0.02	0.02	0.02	.	.	.	.	.	.	9E-04	0.001	0.001	.	0.001	.	.	0.26	.	0.004	0.004	.	0.004
g/tonne																							
PAH-OSPAR	S.02 Gas turbines	.	.	.	.	.	.	.	.	.	9E-04	.	.	.	.	.	.	0.26	.	.	.	.	.
g/tonne																							
PAH-OSPAR	S.03 Boilers	0.16	0.16	0.16	.	0.061	0.061	0.061	0.061	.	9E-04	0.001	0.001	0	0.001	0.001	8E-04	0	0	0.004	0.004	*0.7*	0.004
g/tonne																							
PAH-OSPAR	S.04 Small stoves	18	13.4	13.4	3.97	.	.	6.8	.	18	.	.	.	.	.0.007	0.007	.	0.57	.	.	.	.	.
g/tonne																							
PAH-OSPAR	S.1B2C Flares	.	.	.	.	.	.	.	.	.	9E-04	0.001	.	0	.	.	.	.	.	.	.	.	.
g/tonne																							
PAH-OSPAR	M.1A3C Railroad	0.16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
g/tonne																							
PAH-4	S.01 Direct-fired furnaces	0	0	0	.	.	.	.	.	.	0	0	0	.	0	.	.	0.04	.	4E-04	4E-04	.	4E-04
g/tonne																							
PAH-4	S.02 Gas turbines	.	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	0.04	.	.	.	.	.
g/tonne																							
PAH-4	S.03 Boilers	0.024	0.024	0.024	.	0.016	0.016	0.016	0.016	.	0	0	0	0	0	0	1E-04	1E-04	1E-04	4E-04	4E-04	0.03	4E-04
g/tonne																							
PAH-4	S.04 Small stoves	2.6	0.4	0.4	**1**.37	.	.	2.5	.	2.6	.	.	.	.	.	0	0	.	0.003	.	.	.	.
g/tonne																							
PAH-4	S.1B2C Flares	.	.	.	.	.	.	.	.	.	0	0	.	0	.	.	.	.	.	.	.	.	.
g/tonne																							
PAH-4	M.1A3C Railroad	0.024	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
g/tonne																							

Numbers in italics have exceptions for some sectors, see table B42, and bold numbers are different for different years, see tables B40 and B43.
Source: Finstad *et al*. (2001). Fuel wood factor based on data from annual surveys on use of fuel wood in households

Table B40. Time series for variable emission factors for PAH[1]. Stationary combustion (g component /tonne fuel)

Compo-nent	Source	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
PAH	S.04	V41	50.70	50.70	50.71	50.71	50.71	50.70	50.70	50.71	50.37	49.26	47.34	44.68	41.26	36.72	31.22	32.94
PAH-OSPAR	S.04	V41	8.03	8.03	8.03	8.03	8.03	8.02	8.03	8.03	7.97	7.80	7.50	7.09	6.56	5.84	4.97	5.29
PAH-4	S.04	V41	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.71	2.69	2.63	2.54	2.40	2.22	1.98	1.68	1.81

			2006	2007	2008	2009	2010	2011	2012
PAH	S.04	V41	31.13	30.28	28.78	27.35	26.37	25.41	24.48
PAH-OSPAR	S.04	V41	5.00	4.89	4.67	4.44	4.30	4.13	3.97
PAH-4	S.04	V41	1.71	1.68	1.61	1.53	1.49	1.42	1.37

Table B41. General emission factors for dioxins

Component	Source	V01 Coal	V02 Coke	V03 Petrol coke	V41 Fuel wood	V42 Wood waste	V43 Black liquor	V44 Wood pellets	V45 Wood briquettes	V04 Charcoal	V31 Natural gas (1000 Sm^3)	V33 Refinery gas	V34 Blast furnace gas	V36 Landfill gas	V35 Fuel gas	V32 LPG	V13 Kerosene (heating)	V17 Marine gas oil/ diesel	V18 Light fuel oils	V19 Heavy distillate	V20 Heavy fuel oil	V51 Municipal waste	V52 Special waste
Dioxins ug/tonne	S.01 Direct-fired furnaces	1.6	1.6	1.6	.	.	.	.	.	.	0.05	0	0	.	0	.	.	4	.	0.1	0.1	.	4
Dioxins ug/tonne	S.02 Gas turbines	.	.	.	.	.	.	.	.	.	0.05	.	.	.	.	.	.	4	.	.	.	.	.
Dioxins ug/tonne	S.03 Boilers	1.6	1.6	1.6	.	1	1	1	1	.	0.05	0	0	0	1	*0.06*	0.1	0.1	*0.1*	*0.1*	*0.1*	0.02	4
Dioxins ug/tonne	S.04 Small stoves	10	10	10	5.9	.	.	5.9	.	10	.	.	.	.	.	0.06	0.06	.	0.2	.	.	.	.
Dioxins ug/tonne	S.1B2 C Flares	.	.	.	.	.	.	.	.	.	0.05	0	.	0	.	.	.	.	.	.	.	.	.

Numbers in italics have exceptions for some sectors, see table B42.
Source: Finstad *et al*. (2002b).

Table B42. Exceptions from the general factors for POPs. Stationary combustion

Emission factor (g PAH/tonne)	Emission factor (g PAH-OSPAR/tonne)	Emission factor (g PAH-4/tonne)	Emission factor (ug dioxin/tonne)	Fuel		Source	Sectors
0.0008	0.0005	.	.	V17, 18	Fuel oils	S.03 Boilers	230500-233320
.	.	.	0.2	V18, 19	Heavy distillate, heavy fuel oil	S.03 Boilers	330000
0.75	**0.2**	**0.01**	.	V51	Municipal waste	S.03 Boilers	233530

Table B43. Time series for variable emission factors for PAH. Stationary combustion

			1980-1994			1995-		
Sector	Source	Fuel	Emission factor (g PAH/tonne)	Emission factor (g PAH-OSPAR/tonne)	Emission factor (g PAH-4/tonne)	Emission factor (g PAH/tonne)	Emission factor (g PAH-OSPAR/tonne)	Emission factor (g PAH-4/tonne)
General	S.03	V51	2.5	0.7	0.03	0.75	0.2	0.01

Source: NILU/NIVA (Norwegian institute for air research and Norwegian institute for water research 1995)/ Karlsson *et al*. (1992).

Appendix C

Uncertainty analysis

Long-range transboundary air pollutants

Source for the uncertainty estimates for long-range transboundary air pollutants is Rypdal and Zhang (2001).

Table C1. Summary of expert judgements of uncertainties in point sources

Production type	Number of plants	Pollutant	Emission determination method and uncertainty evaluation	Assessment (average)
Pulp and paper	6	SO_2	Continuous emission measurements and estimations from sulphur content of fuel. Diffuse emissions of sulphur compounds when producing sulphite pulp. The latter has a higher uncertainty than both the measured and estimated stack emissions.	± 4 %
Oil refineries	2 (3)	SO_2	Continuous emission measurements and estimations from sulphur content of fuel.	± 5 %
		NO_x	Based on measurements and calculations.	± 10 %
		NMVOC	Combination of point measurements and calculations. Emissions are variable with possibilities of systematic errors. Emissions from loading of products have lower uncertainty than the fugitive. Differences between the refineries due to different technology, products and operations.	± 45 %
Petrochemical industries and gas terminal	4	NO_x	Annual measurements and/or calculations	± 7 %
		NMVOC	Several emission points. Difficult to measure properly and high variability. Uncertainty is in any case lower than for the refineries as mostly gas is handled (high demand for security).	± 25 %
Cement	2	SO_2	Continuous measurements and annual measurements/calculations. High variability as cement plants incinerates special waste.	± 12 %
		NO_x	Continuous measurements and annual measurements/calculations. High variability as cement plants incinerates special waste.	± 12 %
Ammonia and fertiliser	2	NO_x	Continuous/weekly measurements.	± 7 %
		NH_3	Several emission points. Several measurements performed each year. Low variability.	± 10 %
Silicon carbide (SiC)	3	SO_2	Emissions are estimates based on consumption and sulphur content of coke. The sulphur content is measured independently for every delivery. There is, however, uncertainty connected to the end products and degree of oxidation and definition applied, so reporting can seem inconsistent.	± 20 %
Ferroalloys	16	SO_2	Emissions are estimates based on consumption and sulphur content of coke and the sulphur in products. The sulphur content is measured independently for every delivery. The sulphur content of products are measured regularly, but shows small variability.	± 2 %
		NO_x	Estimates using emission factors. Emission factors are based on measurements. Emission factors are, however, only available for some types of ferroalloys and emissions are not estimated for the others.	± 10-20 %*
Aluminium	8	SO_2	Monthly measurements (covering emissions from stack and ceiling)	± 7 %
		NO_x	Emissions are estimated based on emission factors (see table 4).	-
Waste incineration	8	SO_2	Annual representative measurements. Variable emissions due to the waste fraction incinerated.	± 7 %
		NO_x	Annual representative measurements.	± 10 %

* Additional uncertainty due to possible incomplete reporting.

Table C2. Summary of standard deviation and probability density of activity data

SNAP category	Pollutant source	Important for	Standard deviation (2σ). %	Density shape	Source/Comment
01, 02, 03	Gas combustion	NO_x	± 4	Normal	Directorate of oil and gas
01, 02, 03, 07, 08	Oil combustion (total)	SO_2, NO_x	± 3	Normal	Spread in data.
0102	Waste combustion - Energy industries	SO_2, NO_x, NMVOC	± 5	Normal	Expert judgement
0202	Coal and coke combustion - Residential	SO_2, NO_x, NMVOC	± 20	Normal	Expert judgement
090201	Waste combustion - Other sectors	SO_2, NO_x, NMVOC	± 30	Lognormal	Expert judgement
01, 02, 03	Wood combustion - All sectors	SO_2, NO_x, NMVOC	± 30	Lognormal	Expert judgement
01, 03	Coal and coke combustion-Industry	SO_2, NO_x, NMVOC	± 5	Normal	Spread in data
07, 08	Oil, road/off-road/catalytic/non-catalytic	SO_2, NO_x, NMVOC, NH_3	± 20	Normal	Comparisons of data
0805	Oil combustion - Aviation	SO_2, NO_x, NMVOC	± 20	Normal	Expert judgement
0804	Oil combustion - Shipping	SO_2, NO_x, NMVOC	± 10	Normal	Comparisons of data
0401	Refineries (throughput)	NMVOC	± 3	Normal	Expert judgement
040301	Aluminium production	NO_x	± 3	Normal	Expert judgement
040302	Ferroalloy production	NO_x	± 3	Normal	Expert judgement
040605	Bread production	NMVOC	± 30	Normal	Expert judgement
040607	Beer production	NMVOC	± 10	Normal	Expert judgement
050202	Loading of crude oil	NMVOC	± 3	Normal	Expert judgement
0505	Gasoline distribution	NMVOC	± 3	Normal	Expert judgement
0601	Solvent use	NMVOC			See emission factor
09	Waste combustion in small scale	SO_2, NO_x, NMVOC	± 50	Lognormal	Expert judgement
090201	Methane incineration (landfills)	NO_x, NMVOC	± 5	Normal	Expert judgement
090204	Flaring of natural gas	NO_x, NMVOC	± 4	Normal	As combustion of gas
090204	"Flaring" of crude oil	SO_2, NO_x, NMVOC	± 10	Normal	Expert judgement
090203/4	Other flaring	NO_x, NMVOC	± 5	Normal	Expert judgement
090207	Incineration of hospital waste	NO_x, NMVOC	± 20	Normal	Expert judgement
090901	Cremation	SO_2, NO_x, NMVOC	± 20	Normal	Expert judgement
10	Animal population	NH_3	± 5-10	Normal	Expert judgement
10	Agricultural soils - Treatment of straw	NH_3			See emission factor
1001	Agricultural soils - Fertiliser use	NH_3	± 5	Normal	Agriculture authorities
1009	Agricultural soils - Manure use	NH_3	± 20	Normal	Expert judgement

Table C3 Summary of standard deviation and probability density of emission factors

SNAP source category	Pollutant source	Standard deviation (2σ). %	Density shape	Source/Comment
01, 02, 03	SO_2 - Oil combustion, general	± 1	Normal	Expert judgement. Oil companies
01, 02, 03	SO_2 - Oil combustion, heavy fuel oil	-50 - +100	Normal	Expert judgement. Oil companies
01, 03	SO_2 - Coal combustion	-50 - +100	Lognormal	Spread in data
01, 03	SO_2 - Wood combustion	-50 - +100	Lognormal	Spread in data
0804	SO_2 - Oil combustion, domestic shipping	± 25	Normal	Expert judgement. Oil companies
01, 02 (+03)	NO_x - Combustion in area sources	± 40-50	Normal	Spread in data
0105	NO_x - Combustion off-shore	± 40	Lognormal	Expert judgement
040301	NO_x - Aluminium production	-50 - +100	Lognormal	Expert judgement
07	NO_x - Road traffic	± 25-30	Normal	Expert judgement, spread in data
0704/0705	NO_x - Motorcycles	± 40	Normal	Expert judgement, spread in data
0801-02, 0806-09	NO_x - Equipment and railways	± 40	Normal	Spread in data
0804	NO_x - Shipping	± 15	Normal	Spread in data
0805	NO_x - Aircraft	± 20	Normal	EEA (2000)
0902	NO_x - Flaring	± 40	Lognormal	Expert judgement
01, 02 (+03)	NMVOC - Combustion in area sources	± 40-50	Normal	Spread in data
0105	NMVOC - Combustion offshore	± 50	Lognormal	Expert judgement
040605/07	NMVOC- Beer and bread production	-50 - +100	Lognormal	EEA (2000)
050201	NMVOC- Oil loading onshore	± 30	Normal	Rypdal (1999), Expert judgement
050202	NMVOC- Oil loading offshore	± 40	Normal	Rypdal (1999), Expert judgement
0505	NMVOC - Gasoline distribution	± 50	Lognormal	EEA (2000)
0601	NMVOC - Solvent use	± 30	Normal	Rypdal (1995)
0701	NMVOC - Road traffic (gasoline vehicles)	± 40-50	Normal	Expert judgement, spread in data
0703	NMVOC - Road traffic (diesel vehicles)	± 20-30	Normal	Expert judgement, spread in data
0704/0705	NMVOC - Motorcycles	± 40	Normal	Expert judgement, spread in data
0801-02, 0806-09	NMVOC - Equipment and railways	± 40	Normal	Spread in data
0804	NMVOC - Shipping	± 50	Normal	Spread in data
0805	NMVOC - Aircraft	± 25	Normal	EEA (2000)
0902	NMVOC - Flaring	± 50	Lognormal	Expert judgement
07	NH_3 - Road traffic	Factor 3	Lognormal	Expert judgement, spread in data
1001	NH_3 -Agriculture, fertiliser	± 20	Normal	Expert judgement
1005	NH_3 -Agriculture, animal manure	± 30	Normal	Expert judgement
10	NH_3 -Agriculture, treatment of straw	± 5	Normal	Expert judgement

Table C4. Uncertainty in emission level of pollutants. 1990, 1998 and 2010

1990	μ (mean) ktonnes	Relative standard deviation (σ/μ)	Uncertainty 2σ (% of mean)	Uncertainty 2σ (ktonnes)
SO_2	52.7	0.02	4.0	2
NO_x	219.0	0.062	12	27
NMVOC	298.4	0.09	18	54
NH_3	22.9	0.104	21	5
1998	μ (mean) ktonnes	Relative standard deviation (σ/μ)	Uncertainty 2σ (% of mean)	Uncertainty 2σ (ktonnes)
SO_2	29.8	0.021	4.2	1
NO_x	224.0	0.062	12	27
NMVOC	344.5	0.105	21	72
NH_3	27.0	0.091	18	5
2010*	μ (mean) ktonnes	Relative standard deviation (σ/μ)	Uncertainty 2σ (% of mean)	Uncertainty 2σ (ktonnes)
SO_2	22.0	0.025	5.0	1
NO_x	156.0	0.062	12	19
NMVOC	194.0	0.074	15	29
NH_3	23.0	0.105	21	5

* Projected data with uncertainties as if they were historical.

Table C5. Uncertainties in emission trends 1990-1998 and 1990-2010

	Absolute change (μ_{2010}-μ_{1990})	% change ((μ_{2010}-μ_{1990})*100/μ_{1990})	Relative standard deviation ($\sigma/(\mu_{2010}$-$\mu_{1990})$)	Uncertainty 2σ (absolute change)	Uncertainty 2σ (%-point of change)
1990-1998					
SO_2	-23.0	-43	-0.04	1.7	3.2
NO_x	+4.8	+2	+3.00	28	13
NMVOC	+43.8	+15	+0.40	35	12
NH_3	+4.1	+18	+0.22	1.8	8.0
1990-2010					
SO_2	-30.7	-58	-0.03	1.8	3.4
NO_x	-62.8	-29	-0.21	26.9	12
NMVOC	-104.9	-35	-0.18	38	13
NH_3	+0.0	0	61.3	3.1	13

* Projected values with uncertainties as if they were historical.

Appendix D

Economic sectors in the Norwegian emission model

The classification is an aggregated version of the one used in the national accounts. To make the standard sectors more appropriate for emission calculations, a few changes have been made, e.g. "Private households" is defined as a sector. The classification is aggregated from the Norwegian *Standard Industrial Classification*, SIC2007 (Statistics Norway 2009). The SIC is identical to the European NACE (rev. 2) classification up to the four-digit level. A national level has been introduced at the five-digit level.

The sector numbers in the model have six or, in a few cases, eight digits. The first two digits refer to the main sectors of the economy: 23 = private sector, 24 = central government, 25 = local government, 33 = private households, and 66 = foreign activity. For clarity, the two first digits are only included for the first sector listed in each main sector in the table below.

The next four digits are approximate SIC codes. The first two of these in most cases correspond to SIC at the two-digit level, but some sector numbers, particularly those used for service industries, are aggregates of several SIC divisions. The detailed relationship is shown in the following table, where the sectors are listed with the corresponding SIC codes.

For emissions from solvents and paraffin wax, figures are available at a somewhat more disaggregated sector level, but since these sectors do not reflect the general detailing level in the emission calculations, they are not included in the table below.

Sector number	SIC code	Sector name
Agriculture and forestry		
230100	01.01-5, 01.7	Agriculture
0160	01.6	Services related to agriculture
0210	02	Forestry and logging
Fishing		
0310-N	03.1	Fishing
0320	03.2	Operation of fish farms
Energy sectors		
0500	05	Coal mining
0600.1	06 part, 49.5	Extraction of crude petroleum and natural gas, offshore: Permanent installations
0600.2	06 part	Extraction of crude petroleum and natural gas, offshore: Moveable installations
0600.3	06 part	Extraction of crude petroleum and natural gas: Plants on shore
1910.2	19.1 part	Coking plants
1922	19.2 part	Manufacture of refined petroleum products
3510	35.12, 35.13, 35.14	Transmission, distribution and trade of electricity
3511	35.11	Production of electricity
3520	35.2	Manufacture and distribution of gas
3530	35.3	Steam and hot water supply
Mining/manufacturing		
0710	07.1, 07.29	Mining of ores except uranium and thorium
0721	07.21	Mining of uranium and thorium ores
0810	08 except 08.92	Quarrying and mining except ores and extraction of peat
0892	08.92	Extraction and agglomeration of peat
0910	09.1, 52.215	Service activities incidental to oil and gas extraction
0990	09.9	Service activities incidental to mining
1010	10.1	Production, processing and preserving of meat and meat products
1020	10.2	Processing and preserving of fish and fish products
1030	10.3	Processing and preserving of fruit and vegetables
1040	10.4	Manufacture of vegetable and animal oils and fats
1050	10.5	Manufacture of dairy products
1060	10.6	Manufacture of grain mill products, starches and starch products
1080	10.7, 10.8	Manufacture of other food products
1090	10.9	Manufacture of prepared animal feeds
1100	11	Manufacture of beverages
1200	12	Manufacture of tobacco products
1300	13	Manufacture of textiles and textile products
1400	14	Manufacture of wearing apparel
1500	15	Manufacture of leather, leather products and footwear
1610	16.1	Sawmilling and planing of wood, impregnation of wood
1620	16.21, 16.22, 16.24, 16.29	Manufacture of products of wood, cork, straw and plaiting materials, except furniture
1630	16.23	Manufacture of builders' supplies
1711	17.11	Manufacture of pulp
1712	17.12	Manufacture of paper and paperboard
1720	17.2	Manufacture of articles of paper and paperboard
1800	18	Printing and service activities related to printing and reproduction of recorded media
1910.1	19.1 part	Manufacture of coke oven products
1921	19.2 part	Manufacture of refined petroleum products except oil refineries
2011	20.11, 20.12, 20.13	Manufacture of basic chemicals
2014	20.14	Manufacture of other organic basic chemicals
2015	20.15	Manufacture of fertilisers and nitrogen compounds

Sector number	SIC code	Sector name
2016	20.16, 20.17	Manufacture of plastics and synthetic rubber in primary forms
2020	20.2	Manufacture of pesticides and other agrochemical products
2030	20.3	Manufacture of paints and varnishes, printing ink and mastics
2040	20.4	Manufacture of soap and detergents and toilet preparations
2050	20.5, 20.6	Manufacture of other chemical products
2100	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
2200	22	Manufacture of rubber and plastic products
2310	23.1	Manufacture of glass and glass products
2320	23.2, 23.3, 23.4	Manufacture of refractory products, clay building materials and other porcelain and ceramic products
2350	23.5	Manufacture of cement, lime and plaster
2360	23,6, 23.7, 23.9	Manufacture of products of cement, lime and plaster and other non-metallic mineral products
2411	24.101, 24.2, 24.3	Manufacture of basic iron and steel
2412	24.102	Manufacture of ferroalloys
2440	24.4 except 24.42	Other non-ferrous metal production
2442	24.42	Aluminium production
2451	24.51, 24.52	Casting of iron and steel
2453	24.53, 24.54	Casting of light metals and other non-ferrous metals
2510	25.1, 25.2, 25.3	Manufacture of structural metal products, tanks, reservoirs and containers etc. of metal
2570	25.7	Manufacture of cutlery, tools and general hardware
2590	25.4, 25.5, 25.6, 25.9	Manufacture of other metal products
2610	26.1, 26.2	Manufacture of electronic components and computers
2630	26.3	Manufacture of communication equipment
2640	26.4	Manufacture of consumer electronics
2650	26.5, 26.6, 26.7, 26.8	Manufacture of other electronic and optical products
2750	27.5	Manufacture of domestic appliances
2790	27.1, 27.2, 27.3, 27.4, 27.9	Manufacture of other electrical apparatus and equipment
2810	28.1, 28.2	Manufacture of general-purpose machinery
2830	28.3, 28.4, 28.9	Manufacture of special-purpose machinery
2900	29	Manufacture of motor vehicles and parts and accessories for motor vehicles
3011	30.1 except 30.113 and 30.116	Building of ships and boats
3012	30.113, 30.116	Building of oil platforms
3020	30.2	Manufacture of railway and tramway locomotives and rolling stock
3030	30.3	Manufacture of aircraft and spacecraft
3090	30.4, 30.9	Manufacture of other transport equipment
3100	31	Manufacture of furniture
3210	32.1	Manufacture of jewellery, bijouterie and related articles
3290	32.2, 32.3, 32.4, 32.5, 32.9	Other manufacturing
3310	33.1	Repair of fabricated metal products, machinery and equipment
3320	33.2	Installation of industrial machinery and equipment
Water supply, sewerage, waste management and remediation activities		
3600	36	Water collection, treatment and supply
3800	37-39	Sewerage, waste collection, treatment and disposal activities; materials recovery
Construction		
4120	41.2, 42, 43	Construction

Sector number	SIC code	Sector name
Wholesale and retail trade		
4700	45, 46, 47	Wholesale and retail trade, repair of motor vehicles and personal and household goods
Transport etc.		
4910	49.1, 49.2	Transport via railways
4932	49.32	Taxi operation
4939	49.31, 49.39	Other land passenger transport
4940	49.4	Freight transport by road
5020.N	50.101, 50.201	Ocean transport
5030	50.102, 50.109, 50.202, 50.203, 50.204, 50.3, 50.4	Inland and coastal water transport
5100.1N	51 part	Domestic air transport
5100.2N	51 part	International air transport
5222	52 except 52.215, 79	Supporting and auxiliary transport activities
5300	53, 61	Post and telecommunications
Accommodation and food service activities		
5500	55, 56	Accommodation, food and beverage service activities
Business services		
5800	58	Publishing activities
6200	62, 63, 95	Information technology services
6600	64, 65, 66	Financial and insurance activities
6810	41.1, 68	Real estate activities
7100	69-71, 73-74, 78, 80-82	Other business activities
7200	72	Research and development
7700	77	Rental and leasing activities
8500	85	Education
8600	75, 86-88	Health and social work
9300	59-60, 90-93	Recreational, cultural and sporting activities
9400	94, 99	Activities of membership organisations
9600	96	Other service activities
Central government		
245222	52, 79	Supporting and auxiliary transport activities
7100	69-71, 73-74, 78, 80-82	Other business activities
7200	72	Research and development
8410	84.1, 84.21, 84.23, 84.24, 84.25, 84.3	Public administration
8422	84.22	Defence
8500	85	Education
8600	75, 86-88	Health and social work
9300	59-60, 90-93	Other service activities
Local government		
253700	37	Sewerage
3800	38	Waste collection, treatment and disposal activities; materials recovery
6000	59-60, 90-93	Other service activities
8410	84.1, 84.21, 84.23, 84.24, 84.25, 84.3	Public administration
8500	85	Education
8600	75, 86-88	Health and social work
9600	96	Other personal service activities
Private households		

Sector number	SIC code	Sector name
330000	n.a.	Private households
Foreign activities in Norway		
665020	n.a.	Foreign activities in Norway, ocean transport
665100.2	n.a.	Foreign activities in Norway, air transport

Appendix E

Source classifications used in the Norwegian emission inventory

Table E1. Source classifications used in the national emission inventory

Oil and gas extraction			
	Oil and gas extraction (stationary combustion)		
		Offshore	
			Natural gas in turbines etc., offshore
			Flaring, offshore
			Diesel fixed installations
			Diesel mobile installations, production
			Diesel mobile installations, exploration
			Well testing
		Onshore installations	
			Natural gas in turbines etc., onshore intallations
			Flaring, onshore installations
	Oil and gas extraction (process emissions)		
		Offshore	
			Cold flaring and leakage
			Oil loading at sea
		Onshore installations	
			Oil loading, land
			Gas terminals
Manufacturing industries and mining			
	Manufacturing industries and mining, stationary combustion		
		Wood processing	
		Oil refining	
		Chemical industries	
			Petrochemistry
			Fertiliser
			Other chemical industries
		Mineral industry	
			Cement, lime and plaster
			Other mineral industries
		Metal industry	
		Other industries and mining	
	Manufacturing industries and mining, processes		
		Wood processing	
		Oil refining	
		Chemical industries	
			Petrochemistry
			Fertiliser
			Carbides
			Other chemical industries

- Mineral industry
  - Cement
  - Other mineral industries
- Metal industry
  - Iron, steel and ferro-alloys
  - Aluminium
  - Other metals
  - Anodes
- Other manufacturing industries and mining
  - Coal mining
  - Other mining
  - Fermentation (bread and beer)
  - Asphalt production plants
  - Other industries

Energy supply

Heating in other industries and households

- Heating in other industries
  - Heating in primary industries
  - Heating in construction and building
  - Heating in other service industries
- Heating in households

Road traffic

- Passenger cars
  - Passenger cars - petrol
  - Passenger cars - diesel
- Light duty vehicles
  - Light duty vehicles- petrol
  - Light duty vehicles - diesel
- Heavy duty vehicles
  - Heavy duty vehicles - petrol
  - Heavy duty vehicles - diesel etc.
- Motorcycles and mopeds
  - Motorcycles
  - Mopeds

Aviation, navigation, fishing, motorized equipment etc.

- Railways
- Domestic aviation
  - Domestic aviation < 1000 m
  - Domestic aviation > 1000 m
- Coastal navigation
  - Navigation - Coastal traffic etc.
  - Navigation - Fishing
- Other mobile combustion
  - Small boats
  - Snowmobiles

		Tractors, constructions machines and other motorized equipment: diesel
		Tractors, constructions machines and other motorized equipment: petrol
Agriculture		
	Enteric fermentation and manure	
		Enteric fermentation
		Manure
	Fertiliser and agriculture, other	
		Fertilizer
		Agriculture, other
International transportation		
	International navigation	
	International aviation	
Other		
	Landfill gas	
	Road, tyre and brake wear	
		Road wear
		Tyre and brake wear
		Railway contact wire abrasion
	Products containing fluorinated gases, solvents etc.	
		Products containing fluorinated gases
		Other products, including solvents
	Other	
		Fires, cremations etc.
		Gas distribution
		Petrol distribution
		Whitening of industrial waste
		Waste water and waste water handling
		Sources not mentioned elsewhere

Table E2. UNFCCC/CRF[1] and EMEP/NFR source sector categories

CRF		NFR	
1A1a	Public Electricity and Heat Production	1A1a	Public electricity and heat production
1A1b	Petroleum refining	1A1b	Petroleum refining
1A1c	Manufacture of Solid Fuels and Other Energy Industries	1A1c	Manufacture of solid fuels and other energy industries
1A2a	Iron and Steel	1A2a	Iron and steel
1A2b	Non-Ferrous Metals	1A2b	Non-ferrous Metals
1A2c	Chemicals	1A2c	Chemicals
1A2d	Pulp, Paper and Print	1A2d	Pulp, paper and print
1A2e	Food Processing, Beverages and Tobacco	1A2e	Food processing, beverages and tobacco
1A2f	Other (oil drilling, construction, all other manufacturing industries)	1A2fi	Stationary combustion in manufacturing industries and construction: Other
1A3e	Other transportation/ Off-road vehicles and other machinery	1A2fii	Mobile Combustion in Manufacturing Industries and Construction
1C1a	International bunkers/ Aviation (1)	1A3ai(i)	International aviation (LTO)
		1A3ai(ii)	International aviation (Cruise) (1)
1A3a	Civil aviation (Domestic)	1A3aii(i)	Civil aviation (Domestic, LTO)
		1A3aii(ii)	Civil aviation (Domestic, Cruise) (1)
1A3b	Road transportation	1A3bi	Road transport: Passenger cars
		1A3bii	Road transport: Light duty vehicles
		1A3biii	Road transport: Heavy duty vehicles
		1A3biv	Road transport: Mopeds & motorcycles
		1A3bv	Road transport: Gasoline evaporation
		1A3bvi	Road transport: Automobile tyre and brake wear
		1A3bvii	Road transport: Automobile road abrasion
1A3c	Railways	1A3c	Railways
1C1b	International bunkers/ Marine (1)	1A3di(i)	International maritime navigation (1)
1A3d	Navigation	1A3dii	National navigation (Shipping)
1A3e	Other transportation/ Other non-specified	1A3e	Pipeline compressors
1A4a	Commercial/Institutional	1A4ai	Commercial / institutional: Stationary
1A3e	Other transportation/ Off-road vehicles and other machinery	1A4aii	Commercial / institutional: Mobile
1A4b	Residential	1A4bi	Residential: Stationary plants
1A3e	Other transportation/ Off-road vehicles and other machinery	1A4bii	Residential: Household and gardening (mobile)
1A4c	Agriculture/Forestry/Fishing	1A4ci	Agriculture/Forestry/Fishing: Stationary
		1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery
		1A4ciii	Agriculture/Forestry/Fishing: National fishing
1A5a	Other stationary (including military)	1A5a	Other stationary (including military)
1A5b	Other, Mobile (including military)	1A5b	Other, Mobile (including military, land based and recreational boats)
1B1a	Fugitive emissions from fuels/ Coal mining and handling	1B1a	Fugitive emission from solid fuels: Coal mining and handling
1B1b	Fugitive emissions from fuels/ Solid Fuel Transformation	1B1b	Fugitive emission from solid fuels: Solid fuel transformation
1B2aiii	Fugitive Emissions from Fuels/ Oil/ Transport	1B2aiii	Transport
1B2aiv	Fugitive Emissions from Fuels/ Oil/ Refining / storage	1B2aiv	Refining / storage
1B2av	Fugitive Emissions from Fuels/ Oil/ Distribution of oil products	1B2av	Distribution of oil products
1B2b	Fugitive Emissions from Fuels/ Natural gas	1B2b	Natural gas
1B2c	Fugitive Emissions from Fuels/ Oil and natural gas/ Venting and Flaring	1B2c	Venting and flaring
2A1	Cement Production	2A1	Cement production
2A2	Lime Production	2A2	Lime production
2A3	Limestone and Dolomite Use	2A3	Limestone and dolomite use
		2A7a	Quarrying and mining of minerals other than coal
		2A7b	Construction and demolition
		2A7d	Other Mineral products
2A7→	Leca Production		
2A7→	Ore		
2B1	Ammonia Production	2B1	Ammonia production
2B2	Nitric Acid Production	2B2	Nitric acid production
2B4.1	Silicon Carbide	2B4	Carbide production
2B4.2	Calcium Carbide		
2B5.5	Methanol	2B5a	Other chemical industry
2B5→	Plastic		

2B5→	Production of Explosives		
2B5→	Sulphuric acid production		
2B5→	Titanium Dioxide Production		
2C1	Iron and Steel Production	2C1	Iron and steel production
2C2	Ferroalloys Production	2C2	Ferroalloys production
2C3	Aluminium Production	2C3	Aluminum production
2C4	Aluminium and Magnesium Foundries		
2C5	Metal Production/ Other	2C5e	Other metal production
2D1	Pulp and Paper	2D1	Pulp and paper
2D2	Food and Drink	2D2	Food and drink
2F	Consumption of Halocarbons and SF6		
2G	Industrial processes/ Other (Paraffin wax)	2G	Other production, consumption, storage, transportation or handling of bulk products
3A	Paint Application	3A1	Decorative coating application
		3A2	Industrial coating application
		3A3	Other coating application
3B	Degreasing and Dry Cleaning	3B1	Degreasing
		3B2	Dry cleaning
3C	Chemical Products, Manufacture and Processing	3C	Chemical products
3D	Solvent and other product use/ Other	3D1	Printing
		3D2	Domestic solvent use including fungicides
		3D3	Other product use
4A1	Enteric fermentation/ Cattle/ Mature Dairy Cattle Mature Non-Dairy Cattle Young Cattle		
4A3	Enteric fermentation/ Sheep		
4A4	Enteric fermentation/ Goats		
4A6	Enteric fermentation/ Horses		
4A8	Enteric fermentation/ Swine		
4A9	Enteric fermentation/ Poultry		
4A10	Enteric fermentation/ Other		
4B1a	Manure management/ Cattle/ Mature Dairy Cattle Mature Non-Dairy Cattle Young Cattle	4B1a	Cattle dairy
4B3	Manure management/ Sheep	4B3	Sheep
4B4	Manure management/ Goats		
4B6	Manure management/ Horses		included in 4B13
4B8	Manure management/ Swine	4B8	Swine
4B9	Manure management/ Poultry	4B9b	Broilers
4B10	Manure managemen/ Other		included in 4B13
4B12	Manure managemen/ Liquid Systems		
4B13	Manure management/ Solid Storage and Dry Lot	4B13	Other
4D1	Agricultural soils/ Direct soil emission	4D1a	Synthetic N-fertilisers
4D2	Agricultural soils/ Pasture, Range and Paddock Manure	4D2c	N-excretion on pasture range and paddock unspecified
4D3	Agricultural soils/ Indirect emissions		
4D4	Agricultural soils/ Other		
4F1	Field burning of agricultural wastes/ Cereals	4F	Field burning of agricultural wastes
		4G	Agriculture other
5	Land Use, Land Use Change and Forestry (2)		
6A1	Managed waste disposal on land	6A	Solid waste disposal on land
6B1	Industrial Wastewater	6B	Waste-water handling
6B2	Domestic and Commercial Waste Water		
6Cb→	Waste Incineration/ Incineration of hospital wastes	6Ca	Clinical wasteincineration
6Ca	Waste Incineration/ Biogenic	6Cc	Municipal waste incineration
6Cb→	Waste Incineration/ Incineration of corpses	6Cd	Cremation
6D	Waste/ Other	6D	Other waste(e)

(1) Memo items

(2) Land Use, Land Use Change and Forestry is calculated and documented by *Skog og landskap*

[1] Reporting in the CRF is more detailed for some source categories than shown in the table. In particular, emissions from energy use in 1A are reported by fuel, and emissions from use of fluorinated compounds in 2F are reported by substance and usage.

Norwegian Environment Agency
Telephone: +47 73 58 05 00 | Fax: +47 73 58 05 01
E-mail: post@miljodir.no
Web: www.environmentagency.no
Postal address: Postboks 5672 Sluppen, N-7485 Trondheim
Visiting address Trondheim: Brattørkaia 15, 7010 Trondheim
Visiting address Oslo: Strømsveien 96, 0602 Oslo

The main tasks of the Norwegian Environment Agency are the reduction of greenhouse gas emissions, nature management and the prevention of pollution.

We are an agency under the Ministry of Climate and Environment with 700 employees in Trondheim and Oslo. The agency also includes the Norwegian Nature Inspectorate, which has more than sixty local offices

Our primary functions are to monitor the state of the environment, provide environment-related information, exercise regulatory authority, oversee and guide regional and municipal authorities, collaborate with the authorities of relevant government sectors, act as an expert adviser, and assist in international environmental measures.