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Informative Inventory Report (IIR) 2024. Norway

Air Pollutant Emissions 1990-2022

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Contents

Executive Summary 1

1. Introduction 2
1.1 National Inventory Background 2
1.2 Institutional arrangements 2
1.3 Inventory preparation process 2
1.3.1 Pollutants included, data collection and processing 2
1.3.2 Archiving 4
1.4 Methods and data sources 4
1.4.1 Structure of the general emission model 4
1.4.2 Pollutants, industries, fuels, and sources 5
1.5 Key Categories 8
1.6 QA/QC and Verification methods 8
1.6.1 QA Procedures 8
1.6.2 General QC procedures 9
1.6.3 Source category-specific QC procedures 12
1.6.4 Verification studies 13
1.7 General uncertainty evaluation 14
1.7.1 Acidifying substances and NMVOC 14
1.7.2 Heavy metals and persistent organic pollutants 14
1.8 General Assessment of Completeness 14

2. Explanation of key trends 21
2.1 Acidifying substances and NMVOC 21
2.1.1 Total emissions of acidifying gases 21
2.1.2 NO_X 21
2.1.3 SO_2 23
2.1.4 NH_3 25
2.1.5 NMVOC 27
2.2 CO 29
2.3 PM, POPs and heavy metals 30
2.3.1 PM_{10} 32
2.3.2 PM2.5 34
2.3.3 Black carbon (BC) 34
2.3.4 Dioxins 36
2.3.5 PAH-4 38
2.3.6 HCB 41

2.3.7 PCB 43
2.3.8 Lead 44
2.3.9 Cadmium 46
2.3.10 Mercury 47
2.3.11 Copper, chromium, and arsenic 49

3. ENERGY (NFR sector 1) 49
3.1 Overview 49
3.2 Energy combustion 50
3.2.1 Overview 50
3.2.2 Energy industries 61
3.2.3 Manufacturing industries and construction 67
3.2.4 Transport 69
3.2.5 Other sectors 100
3.2.6 International bunkers 103
3.3 Fugitive emissions from fuels 105
3.3.1 Overview 105
3.3.2 Coal mining and handling 106
3.3.3 Uncontrolled combustion and burning coal dumps 107
3.3.4 Oil and natural gas 108

4. INDUSTRIAL PROCESSES AND PRODUCT USE (NFR sector 2) 119
4.1 Overview 119
4.2 Mineral products 120
4.2.1 Cement production 120
4.2.2 Lime production 122
4.2.3 Glass and glass fibre production 123
4.2.4 Mining and extraction of stones and minerals 124
4.2.5 Construction and demolition 125
4.2.6 Ceramics 127
4.2.7 Non-metallurgical Magnesia Production 127
4.2.8 Sandpit and rock-crushing plant 129
4.2.9 Concrete pumice stone 129
4.2.10 Rock wool production 131
4.2.11 Production of mineral white (plaster) 133
4.2.12 Construction and repairing of vessels - Sandblasting 134
4.3 Chemical Industry 135
4.3.1 Ammonia Production 135
4.3.2 Production of nitric acid 136

4.3.3 Silicon carbide 137
4.3.4 Production of calcium carbide 140
4.3.5 Production of titanium dioxide 142
4.3.6 Production of methanol 144
4.3.7 Production of fertilizer 145
4.3.8 Production of sulphuric acid 145
4.3.9 Production of plastic 146
4.3.10 Production of explosives 147
4.3.11 Chloralkali production 148
4.3.12 Production of pigments 148
4.3.13 Production of soap 149
4.3.14 Paint and varnish production 150
4.4 Metal production 150
4.4.1 Production of iron and steel 150
4.4.2 Production of ferroalloys 152
4.4.3 Production of primary aluminium 158
4.4.4 Production of secondary aluminium 161
4.4.5 Production of magnesium 163
4.4.6 Production of zinc 165
4.4.7 Production of nickel 166
4.4.8 Manufacture of anodes 167
4.5 Solvents and product use 169
4.5.1 Solvent losses (NMVOC) 169
4.5.2 Road paving with asphalt 174
4.5.3 Leather preparing 175
4.5.4 Creosote-treated materials 176
4.5.5 Mercury-containing products 177
4.5.6 Tobacco 178
4.5.7 Use of fireworks 179
4.6 Other production 180
4.6.1 Pulp and paper 180
4.6.2 Food and beverages industry 182
4.6.3 Ore mines 183
4.7 Wood processing 184
4.7.1 Description 184
4.7.2 Method 184
4.7.3 Activity data 184
4.7.4 Emission factors 184

4.7.5 Uncertainties 184
4.7.6 Source specific QA/QC 184
4.8 Consumption of POPs and heavy metals - Hg, PCBs 184
4.8.1 Description 185

5. Agriculture 186
5.1 Overview..186
5.2 Livestock population characterization 189
5.2.1 Data sources...189
5.2.2 Method for estimating number of cattle 191
5.2.3 Method for estimating number of sheep...192
5.2.4 Deviations from FAO statistics 193
5.2.5 Uncertainties 193
5.2.6 Source specific QA/QC 193
5.3 Nitrogen in animal manure as basis for emission estimates 193
5.4 Emissions from manure management 196
5.4.1 Description 197
5.4.2 NH_3 emissions from manure management..197
5.4.3 NO_X emissions from manure management...204
5.4.4 NMVOC emissions from manure management 205
5.4.5 PM emissions from manure management 207
5.4.6 Source specific QA/QC 208
5.5 Crop production and agricultural soils 209
5.5.1 Description 209
5.5.2 NH_3 emissions from agricultural soils 209
5.5.3 NO_X emissions from agricultural soil 214
5.5.4 NMVOC emissions from cultivated crops...215
5.5.5 Particle emissions from farm-level agricultural operations 216
5.5.6 Use of pesticides...217
5.5.7 Uncertainties 217
5.5.8 Source specific QA/QC 218
5.6 Field burning of agricultural waste 219
5.6.1 Description 219
5.6.2 Method..219
5.6.3 Activity data 220
5.6.4 Emission factors...221
5.6.5 Uncertainties 221
5.6.6 Source specific QA/QC 222
5.7 Other agricultural emissions 222

5.7.1 Description 222
5.7.2 NH_3 emissions from treatment of straw 222

6. WASTE (NFR sector 5)....223
6.1 Overview....223
6.2 Solid waste disposal on land 224
6.2.1 Description 224
6.2.2 Method....224
6.2.3 Activity data 224
6.2.4 Uncertainties 225
6.2.5 Source specific QA/QC 225
6.3 Compost production....225
6.3.1 Description 225
6.3.2 Methodological issues....226
6.3.3 Activity data 226
6.3.4 Emission factors....226
6.3.5 Uncertainties 226
6.3.6 Source specific QA/QC 226
6.4 Waste incineration 227
6.4.1 Description 227
6.4.2 Method....227
6.4.3 Activity data 228
6.4.4 Emission factors....229
6.4.5 Uncertainties 230
6.4.6 Source specific QA/QC 230
6.5 Wastewater handling....230
6.5.1 Description 230
6.5.2 Method....230
6.5.3 Activity data 231
6.5.4 Uncertainties 231
6.5.5 Source specific QA/QC 231
6.6 Other emission sources from the waste sector....231
6.6.1 Description 231
6.6.2 Method....232
6.6.3 Activity data 232
6.6.4 Emission factors....232
6.6.5 Uncertainties 234
6.6.6 Source specific QA/QC 234

7. Other and Natural emissions 234

8. Recalculations and Improvements 235
8.1 Recalculations 235
8.1.1 Overall description of the recalculations for the long-range transboundary air pollutants 235
8.1.2 Specific description of the recalculations 235
8.1.3 Implications of the recalculations for long-range transboundary air pollutants ..240
8.2 Planned improvements 244
8.2.1 Implemented and planned improvements in response to the review process 244
8.2.2 Overview 262
8.2.3 General 262
8.2.4 Energy 262
8.2.5 Industrial processes and product use 262
8.2.6 Agriculture 263
8.2.7 Waste 263

9. Projections 264
9.1 Introduction 264
9.2 The baseline scenario 264
9.3 Methodology and key assumptions 265

10. Reporting on gridded emissions and LPS 267
10.1 Gridded emissions 267
10.1.1 EMEP grid squares 267
10.1.2 Scope 267
10.1.3 Recent improvements 267
10.1.4 Planned improvements 267
10.2 LPS 268

References 269

Appendix A 277

Appendix B 295

Appendix C 297

Appendix D 306

Appendix E 311

Appendix F 315

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 and Statistics Norway. This report has been prepared by the Norwegian Environment Agency in close collaboration with Statistics Norway's Division for Energy, Environment and Transport.
The most important recalculations in the 2024 submission are:

- 1A3bvii Automobile road abrasion - The model calculating road abrasion in Norway has been reviewed and is updated. This work will continue in 2024 and further changes are expected. The emissions are recalculated from 1990-2021 and resulting in increased emissions of particles, Cd and PAH.
- 1A1B, 1A1C, 1B2A, 1B2B and 1B2C - During 2023, there has been a recalculation of emissions of NMVOC from land-based companies associated with the oil industry. The emissions have been revised throughout the entire time series, back to 1990 resulting in reduced emissions of NMVOC.
- 3B and 3D – Revised method for calculating the animal population of pigs resulted in a decrease in emissions of NOx and NH3, in the period 1990 - 2021

Chapter 8.1 Recalculations gives a more thorough description of changes in the most recent emission calculations.

1. Introduction

1.1 National Inventory Background

Last update: 19.02.2024

The Norwegian national inventory for long-range transboundary air pollutants includes emission data for the years 1990-2022. The emissions covered in this report are those covered 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 emission reporting guidelines under the UNECE LRTAP Convention/EMEP.

1.2 Institutional arrangements

Last update: 31.01.22

The Norwegian emissions inventories have been produced for about three decades as collaboration between Statistics Norway (SSB) and the Norwegian Environment Agency (NEA). The roles and responsibilities of SN and NEA are specified in a signed agreement. Statistics Norway is responsible for the official statistics on emissions to air and contributes to the reporting to the UNECE. Their tasks include:

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

The Norwegian Environment Agency is responsible for:

- international reporting to the UNECE
- emission factors for all emission 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, e.g., the road traffic model

Activity data[1] 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 and the Norwegian Public Roads Administration. Emission figures are derived from models operated by Statistics Norway. In the modelling activities Statistics

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

Norway makes use of the data collected by the Norwegian Environment Agency on emission factors 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, and the Norwegian Environment Agency also participates in this quality control before reporting to the UNECE.

Continuous improvement of the inventory is secured through annual contracts between NEA and SN, providing additional financial resources for improvement projects. These contracts contain descriptions of improvement projects planned for the coming year. The process of identifying and prioritizing improvement projects is normally initiated in fall and considers:

- Findings from the latest review under the LRTAP convention
- Key category analysis and uncertainty analysis as reported in the most recent IIR
- Findings and needs identified by the inventory teams in the two institutions
- Budgets and available human resources in NEA and SN

The documentation and archiving systems are described in chapter 1.3.

1.3 Inventory preparation process

Last update: 31.01.22
The Norwegian emission inventory is based on a general emission model and a series of more detailed supplementary models, which cover specific emission sources and pollutants (e.g., road traffic, air traffic, solvents). These smaller models feed results into the general model. All 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 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 and processing

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

Table 1.1. Definition in the Norwegian emission inventory of pollutants which are covered 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-4	Emissions are calculated for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene.
	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 component's toxicity equivalency factor (I-TEF). TEQ = sum ($PCDD_i$ * TEF_i) + sum ($PCDD_j$ * TEF_j).
	Hexachlorobenzene	HCB	
	Polychlorinated biphenyl	PCB	
Particulates			
	Total suspended particulates	TSP	
	-	PM_{10}	Particulate matter with diameter less than 10µm
	-	$PM_{2.5}$ [2]	Particulate matter with diameter less than 2.5µm
	Black carbon	BC	
Other pollutants			
	Carbon monoxide	CO	
	Non-methane volatile organic compounds	NMVOC	

Source: Statistics Norway/Norwegian Environment Agency

The collected data are subjected to the Quality Assurance and Quality Control (QA/QC) routines described in chapter 1.6 as well as source specific routines as described under each source chapter (chapters 3-6). 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.

[2] If not otherwise specified, the $PM_{2.5}$ does not include the condensable component.

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 Archiving

The national emission 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 the general Norwegian emission model. This includes supplementary models such as road traffic and air traffic, as well as several 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 supplementary models there is an established archiving routine where all input data and results from every calculation cycle are stored.

Both Statistics Norway and the Norwegian Environment Agency 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 separate 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.

1.4 Methods and data sources

Last update: 18.02.22

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 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 supplementary models. Aggregated results from the supplementary models are used as input to the general model. The supplementary models are presented in the appropriate sections of chapters 3-6. 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 balance, the use of different forms of energy is allocated to industries (economic sectors). To calculate emissions to air, energy use must also be allocated to technical sources (e.g., equipment).

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

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 categories are based on EMEP/NFR categories, with further subdivisions where more detailed methods are available.

1.4.2 Pollutants, industries, fuels, and sources

The *pollutants* currently included in the Norwegian emission model are listed in Table 1.1. The model uses approximately 200 *industries* (economic sectors). The classification is common with the basic 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 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 Table 1.2, Table 1.3 and Table 1.4.

Table 1.2. Energy commodities in the Norwegian emission inventory

Energy commodity	Aggregate fuel category in 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.

Source: Statistics Norway/Norwegian Environment Agency

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

Source	NFR
Stationary combustion	
Direct fired furnaces	1A1, 1A2
Gas turbines	1A1c, 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 (0-1000m)	1A3a ii (i), 1A5b
Aviation jet/turboprop (cruise)	1A3a ii (ii), 1A5b
Aviation helicopter (0-1000m)	1A3a ii (i)
Aviation helicopter (cruise)	1A3a ii (ii)
Aviation small craft (0-1000m)	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	1A4b, c
Equipment 4 stroke, tractor	1A2g-vii, 1A4a, b, c,

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

Source: Statistics Norway/Norwegian Environment Agency

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	Snow scooter	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	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
CO 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	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

Source: Statistics Norway

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

1.5 Key Categories

Information about key categories is given in Appendix A.

1.6 QA/QC and Verification methods

Last update: 19.02.2024

This chapter focuses on general QA/QC procedures. Source specific QA/QC is described in detail in each source chapter (chapters 3-6). However, some information is also included in chapter 1.6.3.

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 plan, which covers the reporting of long-range transboundary air pollution as well as greenhouse gases. A detailed description of this is presented in Annex V in the National Inventory Report for Norway.

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 and the reporting of long-range transboundary air pollution to the UNECE. This includes coordination of the QA/QC procedures.

Statistics Norway is responsible for the quality control system regarding technical activities of the inventory preparation.

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.

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 source categories a person within the Norwegian Environment

Agency who has not been involved in the calculations and the quality controls will perform the QA for the particular source.

1.6.2 General QC procedures

The established QC procedures include the following:

- General inventory level QC procedures, as listed in table 6.1 in chapter 6 of the 2006 IPCC Guidelines (IPCC 2006), 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.

The Norwegian emission inventory is produced in several steps. Preliminary estimates are first produced by Statistics Norway 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.

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 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.

The checks performed for the Norwegian emission inventory are described below.

- *Check that assumptions and criteria for the selection of activity data, emissions factors, and other estimation parameters 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 official 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. Furthermore, all input data (reported emissions, emission factors and activity data) for the latest inventory year are routinely compared to those of the previous inventory year, using automated procedures. Large changes are automatically flagged for further, manual QC. In addition, implied emission factors (IEFs) are calculated for emissions from stationary combustion at point sources. The IEFs are subjected to the same comparison between the years t and t-1. The most thorough checks are made for the gases and categories with the largest contribution to total emissions.

- *Check that emissions are calculated correctly*

When possible, estimates based on different methodologies are compared. 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, occasional 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 categories*

Activity data and other parameters that are common to several source categories should be evaluated for consistency. An example is recovery of landfill gas. A fraction of this gas is flared, and emissions are reported in the Waste source category. Another fraction is recovered for energy purposes, and this gas is an input to the energy balance with emissions reported in the Energy source category. Consistency checks ensure that the amount landfill gas subtracted from source category 5A (Managed waste disposal on land), equals the amount added to source category 1A (Energy combustion) and source category 5C (Waste incineration) (the amount of gas flared).

- *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 and calculated correctly*

For long-range transboundary air pollutants, the last uncertainty analysis was undertaken in 2024. See further information about the uncertainty analysis in section 1.7 and Appendix C.

- *Check time series consistency*

The NEA is responsible for the methodologies used in the inventory and therefore for the consistency of the time series. SN and the NEA have established procedures to check the recalculated inventories. Every recalculation is explained (Cf. chapter 8.1) and the NEA check that it ensures consistency in the time-series.

- *Check completeness*

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 which are not covered. However, we are quite certain that emissions from potentially additional sources are very small or negligible. During comparisons with previous emission estimates, any emission calculations that have been erroneously omitted during the most recent production cycle will be identified and included.

- *Trend checks*

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 2016 Statistics Norway/the Norwegian Environment Agency calculated emission data for 2015 for the first time. These data were compared with the 2014 figures for detection of any considerable deviations. Some large deviations may be correct, caused for instance by the shutdown of large industrial plants or the launch of new ones.

- *Review of internal documentation and archiving*

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 reproducibility of emissions and uncertainty estimates. The 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.

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 to represent the best estimates for national circumstances, and a rationale for the choice of emission factor is provided. The emission factors are often compared with default factors from the most recent EMEP/EEA air pollutant inventory guidebook and emission factors from other literature. Furthermore, activity data have been closely examined and quality controlled, as have the uncertainty estimates.

The QC procedures regarding 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 good practice.

In the following is a more detailed description of QC of emission data reported from plants:

Plant emission data that are used in the European Emission trading system (EU-ETS) will undergo annual QC checks. Activity data and emission estimates from plants that are included in the EU-ETS undergoes annual third-party verification. The source-specific QC checks for other plants are performed as part of the controls of the reporting under the emission permits.

The plant specific data undergo further QC from the emission inventory team at the Norwegian Environment Agency before figures are sent to Statistics Norway for inclusion in the emission inventory. Statistics Norway is responsible for reporting the results of the key category analysis to the Norwegian Environment Agency, and the agency places special emphasis on plants that belong to key categories.

At some point since the inclusion in the inventory, each plant has been QC checked more thoroughly, including:

- An assessment and documentation of measurements and sampling
  - Measurement frequency
  - Sampling
  - Use of standards (e.g., ISO)
- 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 Statistics Norway (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 (in collaboration with Statistics Norway)
- 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.

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 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 are as (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 was finalised in 2010. This project focused on emission of particulate matter. The final report contains 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

In 2015, a Nordic project started, financed by the Nordic Council of Ministers, with the aim to improve the Nordic emission inventories on heavy metals and POP compounds. In the proposed programme the experts working with air pollutant inventories in Denmark, Finland, Iceland, Norway, and Sweden will have a yearly meeting for knowledge exchange. The focus is to compare emission factors and methodologies used, inform about national studies performed, and study and set up further plans to develop national air pollution inventories, especially for emission sources where studies and other Nordic information sources can be used in developing methodologies suitable for Nordic countries. This project is an on-going project. In 2021, it will focus on emissions from biogas production and pulp and paper, among other sectors.

In 2017, a Nordic project, financed by the Nordic Council of Ministers, went through the emission factors for SLCP emissions from residential wood combustion in the Nordic countries. The overall objective of this project was to improve the Nordic emission inventories of SLCPs (Kindbom et al. 2017). This project included comparisons of emission factors for elemental carbon (EC), organic carbon (OC), particulate matter (PM2.5), methane (CH4) and non-methane volatile organic compounds (NMVOC).

1.7 General uncertainty evaluation

Last update: 14.02.24

The results from the uncertainty analyses are part of the basis for prioritising improvement projects for the inventory. General information about the uncertainty analysis is given in Appendix C.

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:

- $SO_2 < NO_X < NH_3 \approx NMVOC$

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 of former project and the results of the 2024 analyses are given in Appendix C.

1.7.2 Heavy metals and persistent organic pollutants

The uncertainty is generally higher for heavy metals (HMs) and persistent organic pollutants (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 suitable the emission factors found in international literature are for Norwegian conditions. Emission factors for some HM and POP 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 HMs 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

Last update: 14.02.24

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 $PM_{2.5}$), CO and the POPs dioxins, Benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene (PAH-4), HCB and

PCB. Norway also voluntary reports the heavy metals As, Cr and Cu and BC. Emissions of Ni, Se and Zn are not estimated.

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 all pollutants are reported for all years from 1990. Regarding sectoral coverage, sources not covered in the inventory even if emissions can be expected, have been reported as Not Estimated (NE) in the NFR tables. The table below provides explanations and an overview of the sources and pollutants that are not estimated, even if emissions might be expected. In each sector chapter more details about completeness are given.

Table 1.5 Explanation to the Notation key NE

NFR category	Substance(s)	Further details
All	Ni, Se, Zn,	There is no reporting obligation for these substances. Norway does not estimate emissions of these substances.
1.A	NH3	According to the EMEP/EEA Guidebook, emission of ammonia (NH3) is not caused by combustion process, and hence in general not occurring in NFR category 1.A "Energy combustion". Emissions resulting from incomplete reaction of NH3 additive in denitrification processes will however occur in some combustion categories and is estimated where relevant in the Norwegian inventory. 'NA' ('not applicable') might be a more accurate notation key in NFR categories where no NH3 additive is applied, and this will be investigated
1.A.1.b	CO, PCB (from 2021)	Emissions were previously estimated from one refinery. This refinery closed down in 2021.
1A2gvii	benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene and PCB	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
1A3ai(i)	PCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1A3aii(i)	PCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1A3biv	benzo(k) fluoranthene, indeno (1,2,3-cd) pyrene	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
1A3bvi	benzo(a) pyrene, benzo(k) fluoranthene, indeno (1,2,3-cd) pyrene, HCB, PCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook

1A3bvii	As, Cr, Cu, Pb, Hg, Indeno (1,2,3-cd) pyrene, benzo(a) pyrene, benzo(k) fluoranthene, HCB, PCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1A3c	HCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1A3ei	PAH, PCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1A4aii	benzo(k) fluoranthene, indeno (1,2,3-cd) pyrene, HCB, PCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1A4bii	benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene, HCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1A4ci	HCB	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
1A4cii	benzo(k) fluoranthene, indeno (1,2,3-cd) pyrene, HCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1B1b	PAH, As, Cd, Hg, Pb, NMVOC, PM_{10}, $PM_{2.5}$, TSP, BC, PCB, NH3	The activity is considered insignificant.
1B1c	PAH, PCB, PCDD/ PCDF	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1B2ai	SOx	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1B2aiv	PAH, PCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1B2aiv	PCDD/ PCDF	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
1B2b	Sox	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1B2c	NH3	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1B2d	PAH, HCB, PCB, PCDD/ PCDF	No emission factor is provided in the 2023 EMEP/EEA Guidebook
1B2d	As, Hg, NH3	Emissions are not estimated because of lack of activity data. Will be considered in future submissions
2A2	CO	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2A3	CO, NMVOC, PCDD/ PCDF , PAH, HCB, SOx	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2A3	Cd, Cr, Cu Hg	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook for glass wool and glass fibre. Can be potentially estimated for glass production, but the plants are closed down.

2A5b	NMVOC	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2A6	PAH, CO, Cu, HCB, NMVOC, NOx, PCB, PCDD/ PCDF	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2A6	Cr and Cd for 2021	Emissions couldn't be measured by plants for 2021. It was under detection limits.
2B1	PM_{10}, PM2.5, SOx ,TSP	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2B1	NMVOC	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
2B2	PM_{10}, PM2.5, TSP	No emission factor is provided in the 2023 EMEP/EEA Guidebook
2B5	benzo(k) fluoranthene, HCB, NOx, PCB, PCDD/ PCDF	No emission factor is provided in the 2023 EMEP/EEA Guidebook
2B6	CO, NMVOC, NH_3	No emission factor is provided in the 2023 EMEP/EEA Guidebook for sulphate process.
2B6	PCB, PCDD/ PCDF (2010-2022)	Emissions are not estimated because of lack of activity data. Will be considered in future submissions.
2B6	PAH (2010-2014, 2018-2022)	Emissions for the periods 1990-2009 and 2015-2017 are reported by the plant included in this source category. For the rest of the times series, emissions are not estimated because of lack of activity data. Will be considered in future submissions.
2B10a	CO (1990-1996)	Emissions are not estimated because of lack of activity data. Will be considered in future submissions.
2B10a	SOx (2006-2021)	Emissions are estimated for production of sulphuric acid until 2005. From 2006 there is no production anymore and for other activities in NFR 2B10a, emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook for other activities occurring.
2B10b	NMVOC	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2C1	NH_3	No emission factor is provided in the 2023 EMEP/EEA Guidebook
2C1	CO, NMVOC, NOx, SOx	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
2C2	CO, NH_3	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2C3	NMVOC	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2C3	NH_3 (1990-1992, 2002-2022)	Emissions from secondary aluminium production have been estimated during the production period (1993-2001). Emissions from primary aluminium production are not estimated because there is no emission factor in the EMEP/EEA Guidebook.
2C6	BC, PAH, CO, HCB, NH_3, NMVOC, NOx	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook

2C6	PCDD/ PCDF (dioxins/ furans)	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
2C7b	As, BC, PAH, CO, Cr, HCB, PCDD/ PCDF (dioxins/ furans), NMVOC, PCB	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2C7b	Cd, Hg, Pb	Emissions are considered insignificant
2C7c	Cr, Cu, HCB, NH_3, PCB	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2C7d	PAH, Cr, Cu, HCB, NH_3, PCB,	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2D3c	BC, CO, NMVOC, TSP	This emission source has been assessed as insignificant.
2D3d, 2D3e, 2D3f, 2D3g	BC	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2D3g	As, PAH, Cd, CO, Cr, Cu, HCB, Hg, NOx, Pb, $PM_{2.5}$, SOx, PCB, PCDD/ PCDF	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2D3g	TSP, PM_{10} (2019)	Emissions are not estimated because of lack of activity data. Will be considered in future submissions
2D3g	NH_3 (from 2014)	NH3 emissions included for the period 1990-2013 comes from leather preparing activity. The plant has been closed down in 2013. There is no emission factor or methodology description in the EMEP/EEA Guidebook for other activities in 2D3g. NE is therefore used for emissions from 2014.
2G	HCB, PCB	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2H1	PAH, HCB, NH_3	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2H2	BC, PAH, HCB, PM_{10}, $PM_{2.5}$, TSP, PCB	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2H3	BC, PAH, HCB, PCB	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2I	As, PAH, Cu, HCB, PCB, PCDD/ PCDF	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2J	PAH, Cu, HCB, PCB	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2K	As, PAH, Cd, Cr, Cu, HCB, Hg, Pb, PCB	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
2L	PAH, HCB, PCB, PCDD/ PCDF	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
3B4f	All	Is considered insignificant.
3Da2c	NH3 (1990-1995)	Emissions are not estimated because of lack of activity data
3Da4	NH3	Emissions are not estimated because of lack of emission factor or in the 2019 EMEP/EEA Guidebook. Incorporation of emission factor provided

		in 2023 EMEP/EEA Guidebook will be considered in the future submission
3De	NH3	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
3Df (	PCBs 1990-2008)	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
5A	CO, NH_3	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
5A	Hg	No emission factor is provided in the 2023 EMEP/EEA Guidebook
5B1	BC, NMVOC, NOx, PM_{10}, $PM_{2.5}$, TSP, SOx	No emission factor is provided in the 2023 EMEP/EEA Guidebook
5B2	BC, PAH, Cd, CO, Cr, Hg, HCB, NMVOC, NOx, Pb, PCB, PCDD, PCDF, PM_{10}, $PM_{2.5}$, SOx	No emission factor is provided in the 2023 EMEP/EEA Guidebook
5B2	NH_3	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
5C1a	NH_3	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
5C1a	HCB, PCB (1990-1993)	Emissions are not estimated because of lack of activity data. Will be considered in future reporting.
5C1a	Cd, Hg, Pb, HCB and PCB (2007)	The only plant included in this sector was out of drift in 2007. The notation key will be change to NO for the next submission
5C1a	PAH (1990-1993, from 2002)	Emissions are not estimated because of lack of activity data. Will be considered in future reporting.
5C1a	NMVOC (2003-2022)	Emissions are not estimated because of lack of activity data
5C1bi, 5C1bii	PAH, Cd, HCB, Hg, NH_3, NMVOC, Pb, PCB, PCDD/PCDF	Incorporation of emission factor provided in 2023 EMEP/EEA Guidebook will be considered in the future submission
5C1biii	benzo(k) fluoranthene, Indeno (1,2,3-cd) pyrene, NH_3	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
5C1biii	PCB (2002-2005)	2002-2005: Emissions are not estimated because of lack of activity data. Will be considered in future submissions.
5C1biii	Cd, Hg , HCB NMVOC, Pb , PCDD/PCDF, benzo(a) pyrene, benzo(b) fluoranthene and PCB(2006-2021)	From 2006 are emissions reported under 5C1a. The notation key will be change to IE for the next submission
5C1biv	All	Emissions are not estimated because of lack of activity data
5C2	All	This activity is forbidden in Norway and is therefore assumed to be insignificant in Norway.

5D1	As, Cd, Cr, Cu, Hg, Pb, PM_{10}, $PM_{2.5}$, TSP	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
5D1	NH_3	Is considered insignificant in Norway
5D2	As, Cd, Cr, Cu, Hg, NH_3, Pb, TSP, PM_{10}, $PM_{2.5}$,	Emissions are not estimated because there is no emission factor or methodology description in the EMEP/EEA Guidebook
5D3	All	Assumed to not occur in Norway – the notation key should be changed to NO
5E	HCB	No emission factor is provided in the 2023 EMEP/EEA Guidebook
6A	All	Assumed to not occur in Norway – the notation key should be changed to NO

Table 1.6 Explanation to the Notation key IE

NFR category	Substance(s)	Further details
1A3ei	All	All emissions from pipelines are reported under NFR 1A1
2A5c	PM10, PM2.5, TSP	Emissions are reported under 2A6
2B1	NOx	Emissions are reported under 2B2
2C7d	All	Emissions are reported under 2C7c
3B4giii	All	Emissions are reported under 3B4giv
5C1bi	CO, NOx, SO2	Emissions are reported under 1A2
5C1bi	Other pollutants	Emissions are reported under 5C1a until 2015
5C1bii	All	Emissions are reported under 5C1a
5C1biii	All	From 2006 er emissions reported under 5C1a

Table 1.7 Explanation to the Notation key NO

NFR category	Substance(s)	Further details
1A3di(ii)	all	from 1990
1A3eii	all	from 1990
1A5a	all	from 2021
2B1	NH3	from 1990
2B3	all	from 1990
2B7	all	from 1990
2C4	NOx, NMVOC, NH3, BC, Pb, Cd, Cu, Ni, Se Zn, PAH, PCB	from 1990
	SO_2, Particles, AS, Cr, Hg, CO	From 2003
2C5	all	from 1990
2C7a	all	from 1990
2H1	CO	from 2014
3B4a	All	from 1990
3Df	HCB, PCB	from 2009
5C1bvi	All	from 1990

2. Explanation of key trends

2.1 Acidifying substances and NMVOC

2.1.1 Total emissions of acidifying gases

Emissions 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 decreased by 34% since 1990, from 7 656 tonnes acid equivalents to 5 063 tonnes acid equivalents in 2022. SO_2 and NO_X emissions have gone down by 71 and 33% since 1990, respectively, while NH_3 emissions have declined by 6%. In 1990, NO_X constituted 56% of the acidifying emissions, NH_3 24% and SO_2 20%. While in 2022, NO_X, NH_3 and SO_2 were responsible for 57, 34 and 9% of these emissions, respectively.

The 2020 targets defined by the revised Gothenburg Protocol have been met for SO_2, NO_X and NMVOC, while NH_3 emissions are still somewhat above the Gothenburg 2020 target.

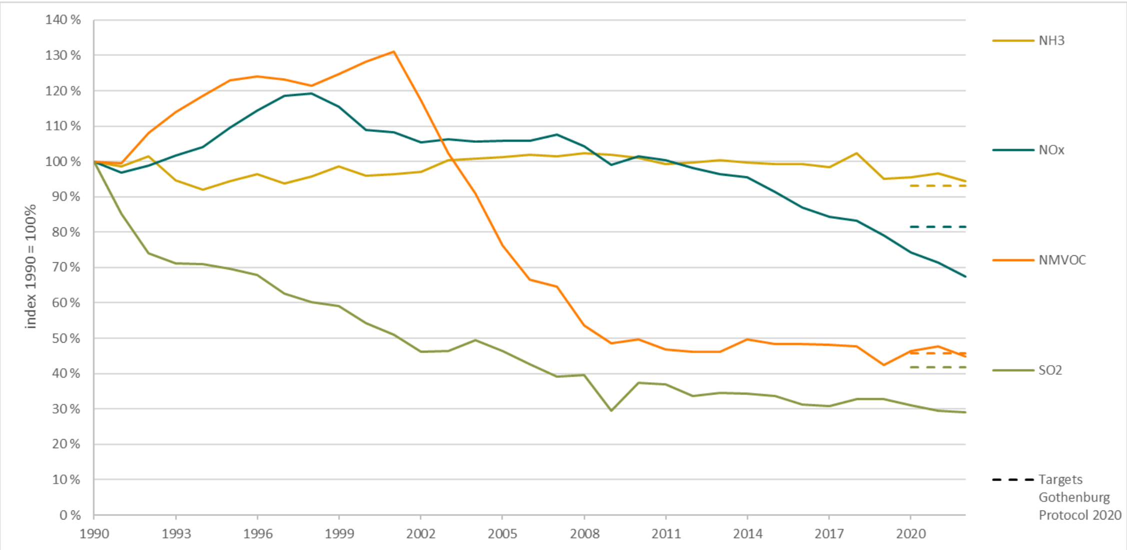


Figure 2.1. Trends in emissions for NOX, SO2, NH3 and NMVOC. 1990-2022. Index 1990 = 100%

Source: Statistics Norway/Norwegian Environment Agency

2.1.2 NO_X

- Commitment of the revised Gothenburg Protocol: a 23% reduction compared to emissions in 2005; limiting annual NO_x emissions to 160 142 tonnes from 2020.

Norway's NO_X emissions totaled 132 548 tonnes in 2022. NO_X emissions have been reduced by 33% since 1990 and by 36% since 2005. The biggest sources of NO_X emissions in 2022 were transport and combustion in energy industries, accounting for 38 and 30% of total emissions, respectively. Emissions from combustion in the energy industries sector overall have increased by 44% since 1990. Within the energy industries sector, manufacturing of solid fuels and other energy industries (NFR code 1A1c) accounts for most of the emissions, particularly oil and gas extraction which accounts for 94% of emissions from energy industries. Emissions from this emission source increased by 52% since 1990, mainly due to increased production of oil and gas.[3]

Overall NO_X emissions from the transport sector have decreased by 49% since 1990. There are, however, significant differences in trends within the sector. Whereas emissions from passenger cars, heavy duty vehicles and buses, light duty vehicles, railways and national navigation were lower in 2022 compared to 1990 levels, emissions from domestic and national aviation, as well as mopeds and motorcycles have increased. Emissions from domestic and international aviation were 57 and 60% higher in 2022 than in 1990 respectively. In 2020 and 2021, covid-19 related travel restrictions strongly influenced emissions in the transport sector, especially impacting emissions from aviation. From 2021 to 2022 emissions increased by 41 and 170% for domestic and international aviation respectively, bringing emissions in aviation almost back to pre-covid levels. Emissions from passenger cars, heavy duty vehicles and buses, and light duty vehicles contributed most to road transport emissions in 2022, although emissions from passenger cars and heavy duty vehicles and buses have been reduced by 66 and 74%, respectively, from 1990 to 2022.

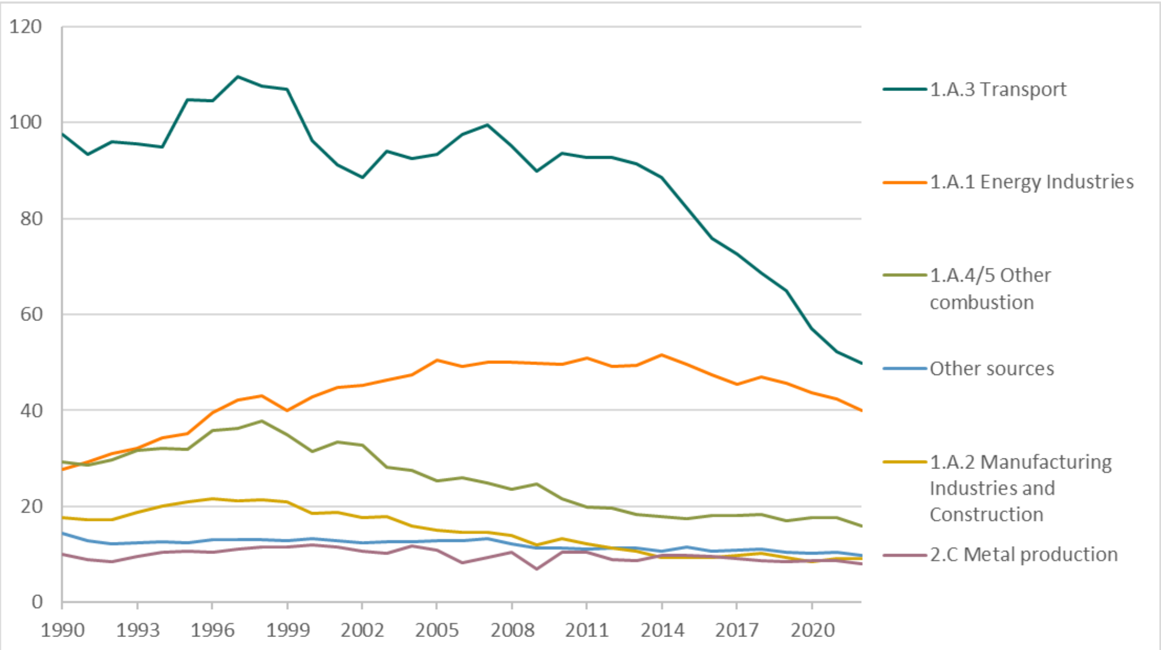


Figure 2.2. Trends in NOX emissions, 1990-2022. 1000 tonnes

Source: Statistics Norway/Norwegian Environment Agency

[3] https://factpages.sodir.no/en/field/TableView/Production/Saleable/TotalNcsYear

Emissions from aviation have increased since 1990 primarily due to increased traffic. Within road transport, traffic has also increased significantly from 1990. NO_X emissions have however been reduced due to policy measures. Stricter emission requirements for new passenger cars and heavy duty vehicles and buses is the main cause. In recent years, a higher share of electric and hybrid vehicles have also contributed to a reduction in road transport emissions, also due to policy measures.

Emissions from national navigation reached a peak in 1999. From 2010 to 2022, the emissions have decreased every year, except for in 2019. From 1990 to 2022, emissions from national navigation have been reduced by 21%. This is partly due to measures implemented by the NO_X Fund, which is financed by industry and businesses. These measures are not necessarily linked to fuel efficiency, and energy consumption in national navigation does therefore not show the same decline as the emissions.

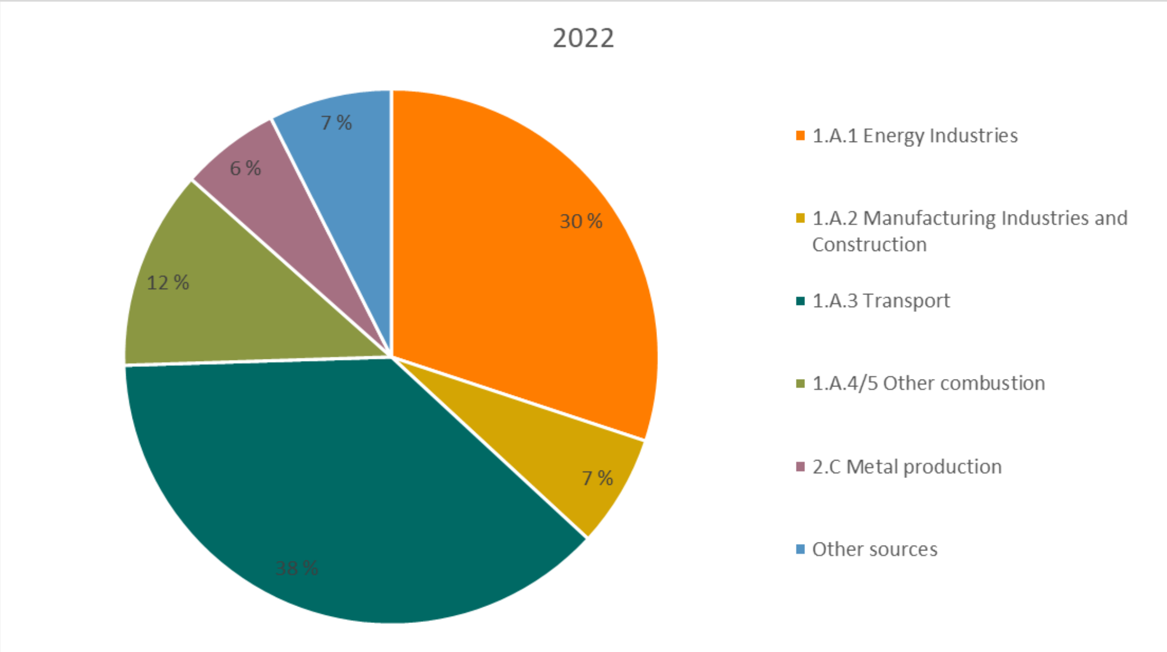


Figure 2.3. Distribution of NOX emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

2.1.3 SO_2

- Commitment of the revised Gothenburg Protocol: a 10% reduction compared to emissions in 2005; limiting yearly SO_2 emissions to 20 637 tonnes from 2020.

Norway's SO_2 emissions totaled 14 334 tonnes in 2022. The 2020 commitment of the Gothenburg Protocol for SO_2 emissions have been fulfilled since 2007.

The SO_2 emissions in Norway in 2022 have been reduced by 71% since 1990. This has been achieved by pollution control, the closure of pollution intensive businesses and a reduction of sulfur content in petroleum products. Emissions have decreased by 2% between 2021 and

2022, mainly due to a decrease in emissions from chemical industry, metal production and fugitive emissions from fuels.

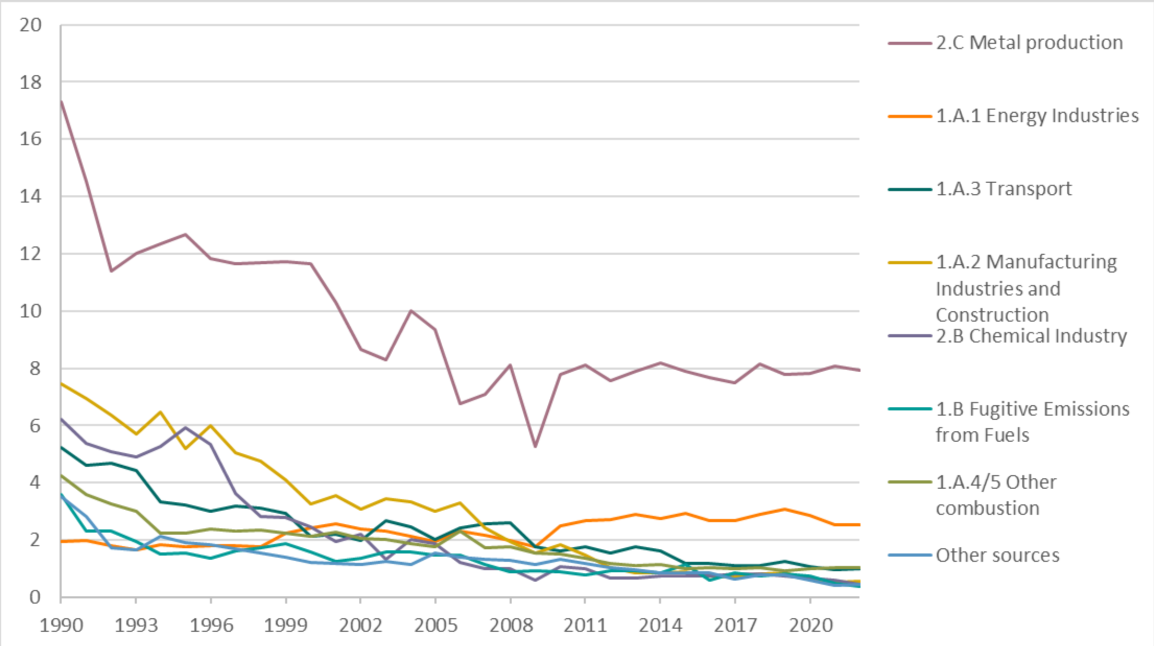


Figure 2.4. Trends in SO2 emissions, 1990-2022. 1000 tonnes

Source: Statistics Norway/Norwegian Environment Agency

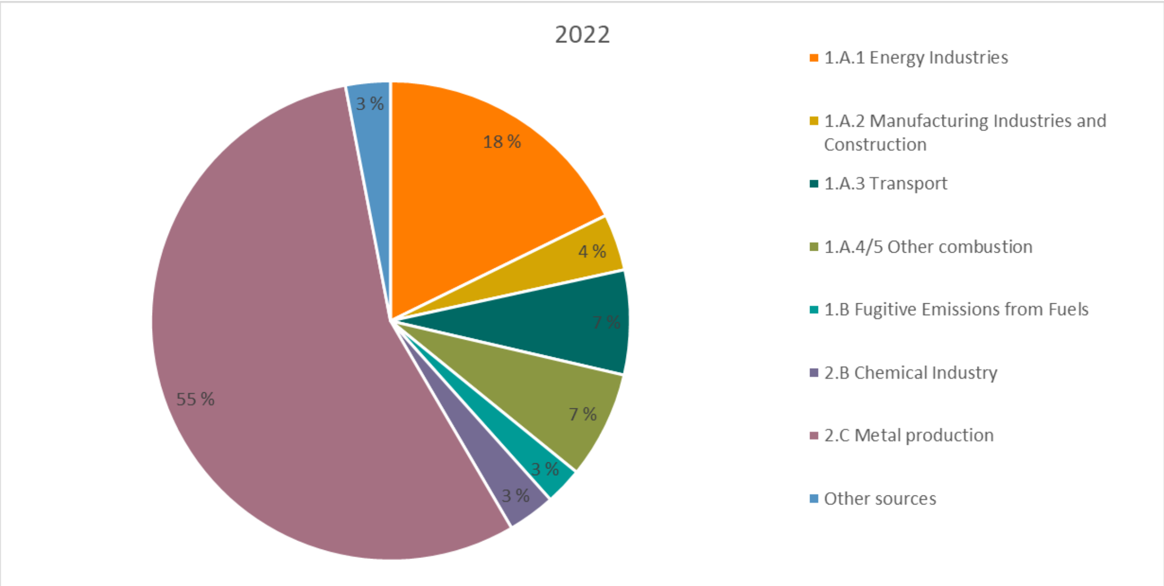


Figure 2.5. Distribution of SO2 emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

Metal production was the largest source of SO_2 emissions in 2022, representing 55% of total emissions. Emissions from this sector have been reduced by 54% since 1990, primarily due to reductions in the ferroalloys production. Nonetheless, the production of ferroalloys remains the most significant source of emissions within metal industry, being responsible for 74% of emissions from the metal industry in 2022. Emissions from ferroalloys production in 2022 increased by 1% compared to 2021, but total emissions from the metal industry declined by 2% between 2021 and 2022 due to decreased emissions from Other metal production and nickel production.

Combustion in energy industries is the second largest source of emissions in 2022, accounting for 18% of total emissions. Emissions from combustion in energy industries have increased by 32% since 1990. Within this sector, public electricity and heat production (1A1a) has been the largest source of SO_2 emissions since 1990. Electricity generation from fuel combustion has been the biggest contributor to the SO_2 emissions in the energy industries sector since 1990. Electricity is mainly produced by hydropower plants in Norway and fuel combustion represented only 2 % of the production in 2022. Heat plants has been the second largest emission source since 2010; these accounted for 40% and 29% of emissions from the sector combustion in energy industries in 2022, respectively.

Transport constituted 7% of total emissions of SO_2 in 2022. Emissions from transport have been reduced by 81% since 1990, mainly due to a lower sulphur content in fuels. Most of the reduction took place at the beginning of the period. In 1995, emissions were reduced by around 39% compared to 1990. Emissions from most transport subcategories have been significantly reduced since 1990. For 2022, the only subcategory that has not been considerably reduced compared to 1990 levels is domestic and international aviation, where 2022 emissions were 33% and 35% higher than the emission level in 1990, respectively. Compared to 2021 domestic aviation emissions were increased by 40% in 2022. Emissions from international aviation increased by 171% from 2021 to 2022. These are however both rather small sources of SO_2 emissions. Notably, there are currently only significant emissions from national navigation in this category, representing 91% of the SO_2 emissions in the transport category in 2022.

Emissions from combustion in manufacturing industries and construction have decreased by 93% since 1990, contributing to only 4% of the total SO_2 emissions in 2022. Similarly, process emissions from chemical industries, including carbide production, have decreased by 93% since 1990, contributing to 3% of the total SO_2 emissions in 2022. The decline is a result of lower production and the closure of two plants.

2.1.4 NH_3

- 2020 commitment of the revised Gothenburg Protocol: an 8% reduction compared to emissions in 2005; limiting annual NH_3 emissions to 29 059 tonnes.

Norway's NH_3 emissions totaled 29 474 tonnes in 2022. The 2020 commitment of the Gothenburg Protocol for NH_3 emissions has not yet been fulfilled, and still require further actions.

The Norwegian emissions of NH_3 were 6% lower in 2022 than in 1990. Agriculture is the dominant source and was responsible for 95% of the NH_3 emissions in Norway in 2022. Animal manure is the most predominant source of emissions. 53% of the total Norwegian emissions of NH_3 originated from agricultural soils in 2022, of which application of animal manure to soils accounted for 78%. In addition, 40% of total NH_3 emissions in 2022 originated from manure management. Within this sector, cattle is the most important source of emissions, dairy cattle and non-dairy cattle representing respectively 32% and 38% of the emissions from this sector in 2022.

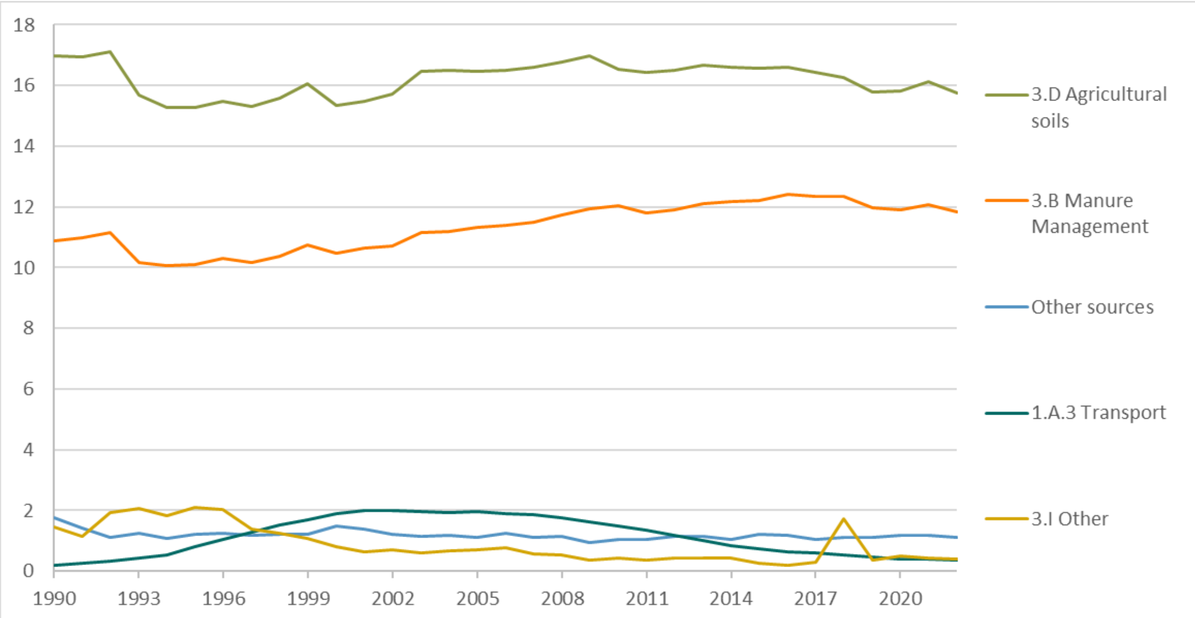


Figure 2.6. Trends in NH3 emissions, 1990-2022. 1000 tonnes

Source: Statistics Norway/Norwegian Environment Agency

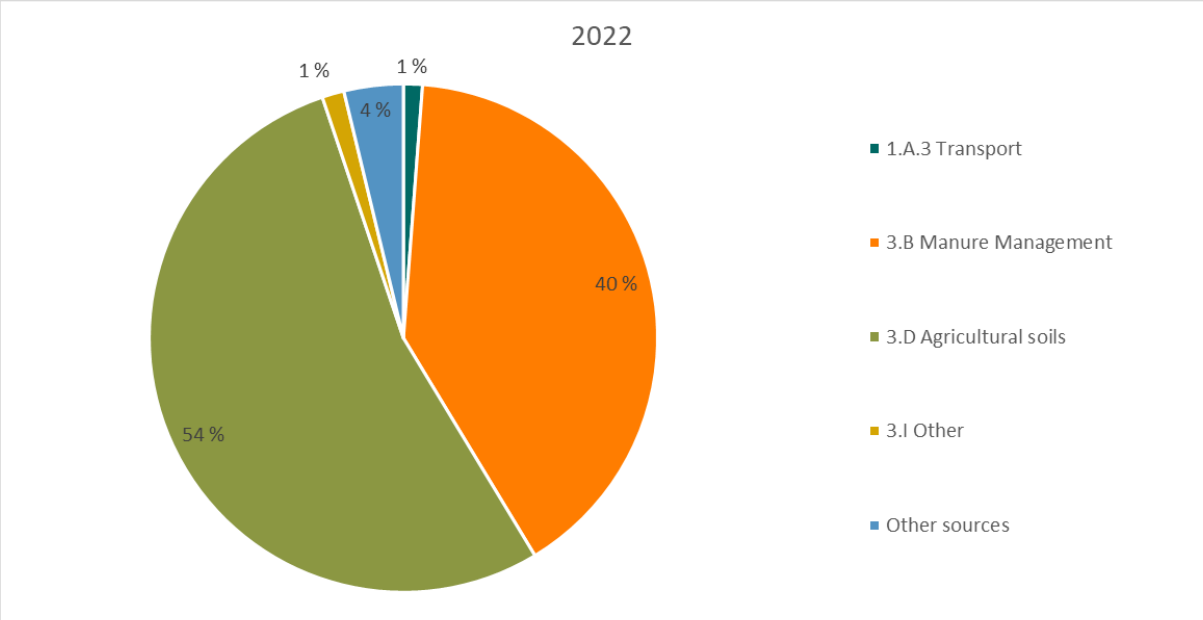


Figure 2.7. Distribution of NH3 emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

Emissions of NH_3 from passenger cars increased up to a level of around 2000 tonnes in the early 2000s due to the introduction of three-way catalytic converters. However, emissions from cars have since decreased considerably, partly due to improved catalyst technologies and partly due to a shift from petrol to diesel cars.

2.1.5 NMVOC

- 2020 commitment of the revised Gothenburg Protocol: a 40% reduction compared to emissions in 2005; limiting annual NMVOC emissions to 145 825 tonnes.

In 2022, Norway's NMVOC emissions totaled 143 26 tonnes and therefore fulfilled the 2020 commitment of the Gothenburg Protocol for NMVOC emissions for 2022.

NMVOC emissions have been reduced by 55% since 1990, and by 66% since the peak in 2001. Loading of crude oil offshore was the main reason for the increase in emissions from 1990 to 2001. Measures to prevent these emissions resulted in an 86% decrease in fugitive emissions from fuels from 2001 to 2011. Fugitive emissions from fuels represent 20% of total emissions of NMVOC in 2022.

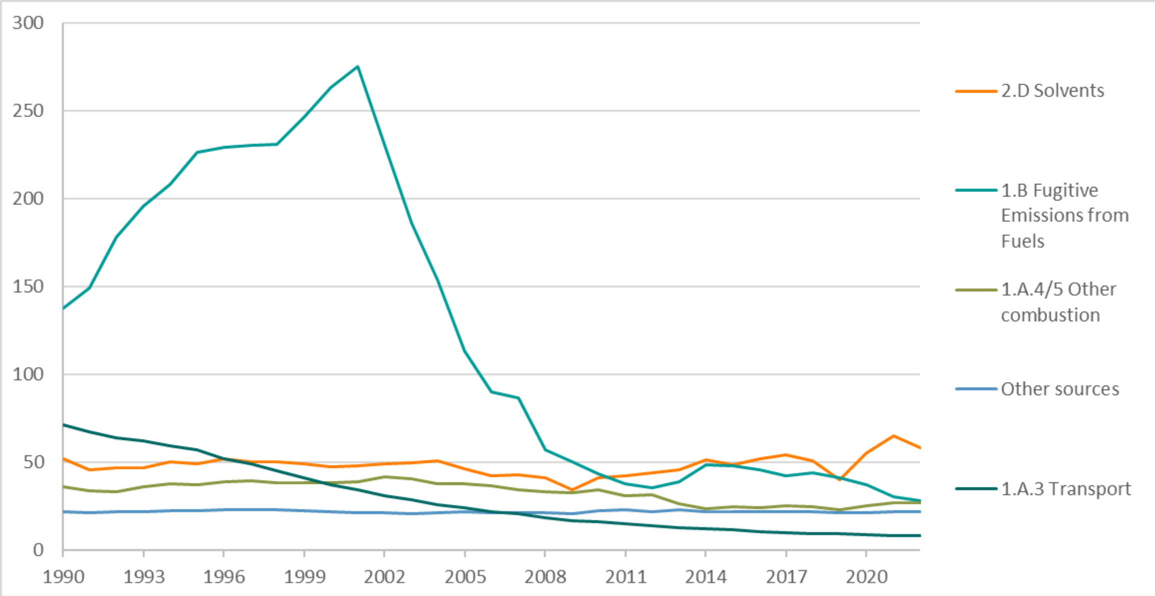


Figure 2.8. Trends in NMVOC emissions, 1990-2022. 1000 tonnes

Source: Statistics Norway/Norwegian Environment Agency

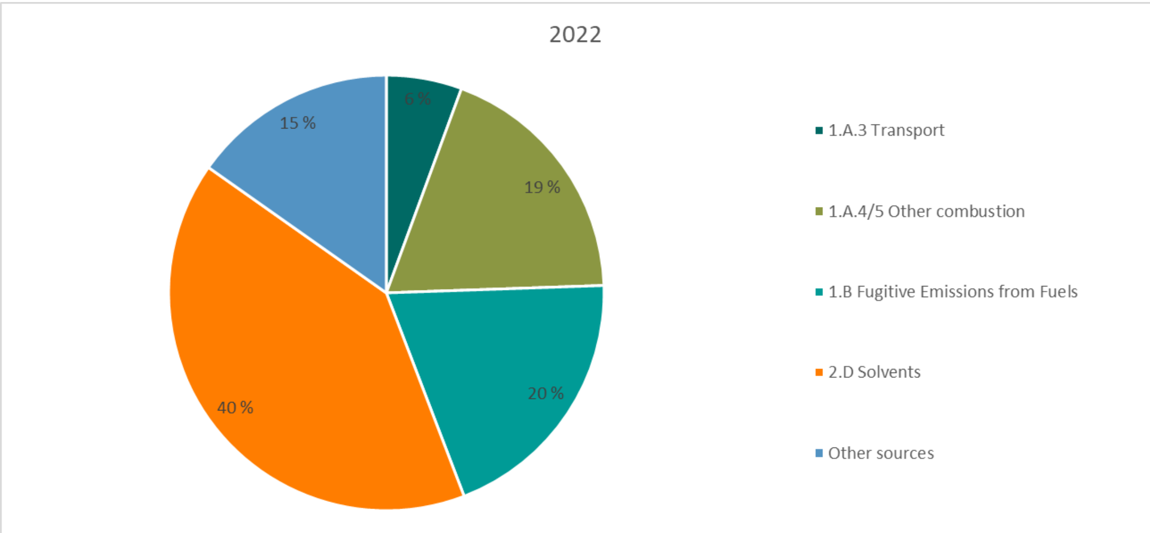


Figure 2.9. Distribution of NMVOC emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

41% of the NMVOC emissions in 2022 originated from product use (solvents etc.). The most important subcategories within product use are “other solvent use” (2D3i), accounting for 51%, while "domestic solvent use including fungicides", accounting for 37% of emissions within this sector. "Other solvent use" emissions decreased by 19% from 2021 to 2022. This category includes the use of antibacterial products, which increased significantly during covid-19. Thus, the decline from 2021 to 2022 was expected.
The category “other combustion” (NFR 1A4 and 1A5) accounted for 19% of total emissions of NMVOC in 2022. The two most significant sources of emissions within the sector are

household and gardening (mobile) and wood burning in private households (residential stationary plants). These two subsectors were responsible for around 97% of emissions within this sector.

NMVOC emissions from transport have decreased by 89% since 1990, mainly due to reductions in emissions from passenger cars and gasoline evaporation. Stricter emission standards for petrol passenger cars were implemented in 1989 and led to reduced emissions. In addition, the increased share of diesel cars within the vehicle fleet has strengthened the downward trend.

2.2 CO

Emissions of carbon monoxide, CO, amounted to 417 530 tonnes in 2022. They have gone down by 47% since 1990 and down by 2% since 2021. The reduction from 1990 is mainly due to lower emissions from transport, which have been reduced by 91% since 1990. Emissions from passenger cars represented 83% of the transport sector in 1990. They have been reduced by 95% since 1990, primarily due to stricter emission standards. Emissions from light duty vehicles have also been significantly reduced (96% since 1990), albeit from a lower absolute level.

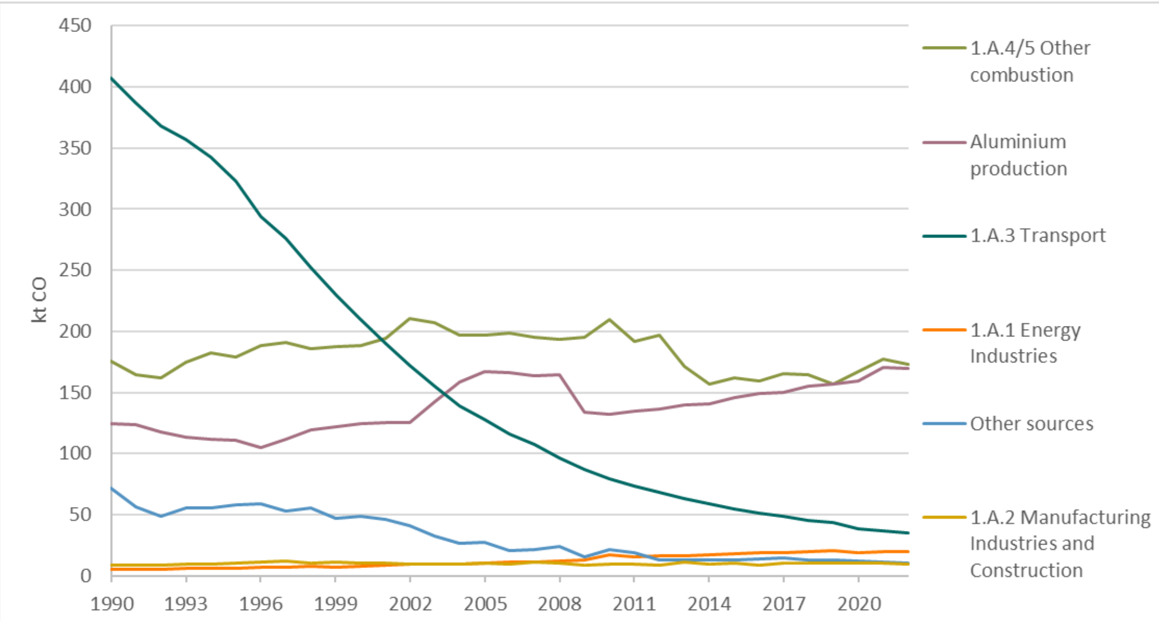


Figure 2.10. Trends in CO emissions, 1990-2022. 1000 tonnes

Source: Statistics Norway/Norwegian Environment Agency

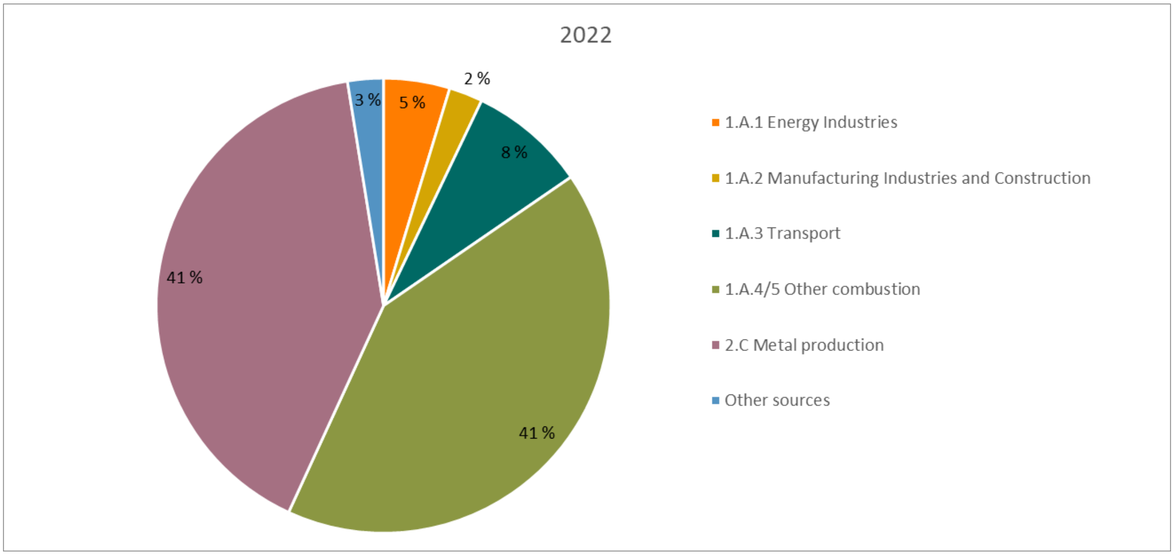


Figure 2.11. Distribution of CO emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

The category “other combustion” (NFR 1A4 and 1A5) and the metal industry were the largest sources of emissions in 2022, each representing 41% of the CO emissions.
The two most significant sources of emissions within “other combustion” are household and gardening (mobile) and wood burning in private households, which accounted for 35 and almost 62% of the total emissions of the sector, respectively, in 2022. Emissions from household and gardening (mobile) in the residential sector have decreased by 5% since 1990. Emissions from stationary plants in the residential sector were 2% higher in 2022 than in 1990 and 23% lower than the emission peak in 2010. The reduction is partly due to an increased share of new technology in wood burning appliances and partly due to reduced consumption of firewood.

Within the metal industry the only source of CO emissions in 2022 is aluminium production. Emissions from aluminium production have increased by 62% since 1990.

2.3 PM, POPs and heavy metals

Emissions of BC, particulate matter (PM_{10} and $PM_{2.5}$), PAH-4, dioxins, HCB, PCB, and all heavy metals except copper, although fluctuating throughout the period, are much lower than in 1990.

Since 2021, PAH-4, dioxin and HCB have decreased, while PCB, PM_{10}, BC and $PM_{2.5}$ emissions have increased.

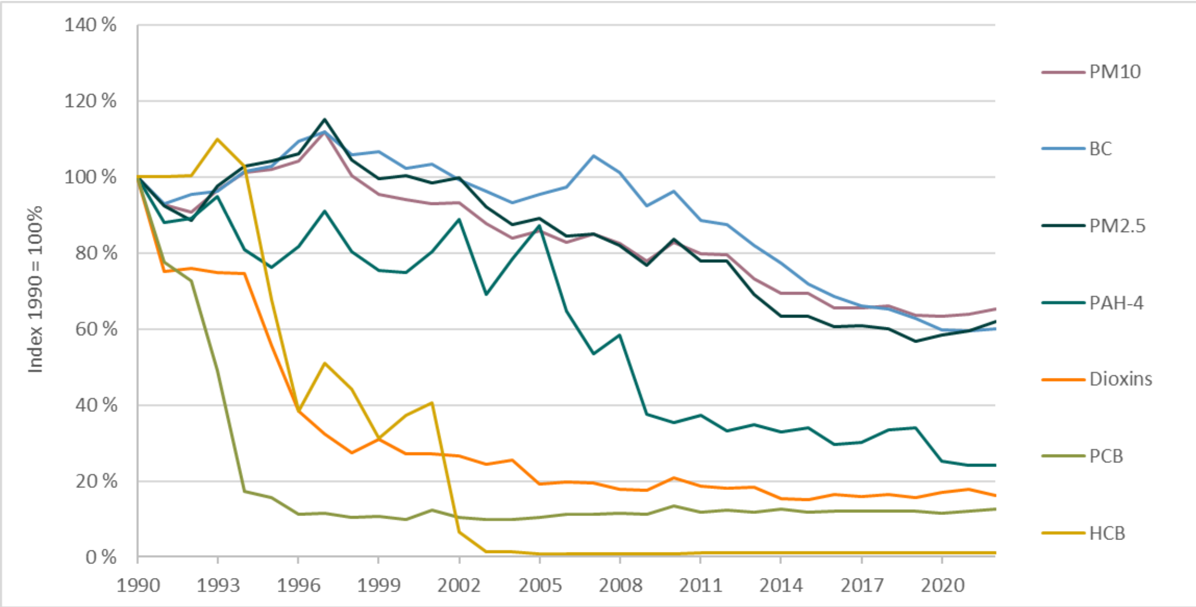


Figure 2.12. Trends in emissions for Particles, PAH-4, dioxins, PCB, HCB and BC. 1990-2022. Index 1990=100%

Source: Statistics Norway/Norwegian Environment Agency

The emissions of several hazardous substances including PAHs (polycyclic aromatic hydrocarbons) have been considerably reduced since 1990. The cause of the decrease is primarily reduced emissions within manufacturing and mining. Cleaning measures, changes in production processes and lower activity in some industries have all resulted in reduced emissions. Norway has a national target to phase out the use and emissions of the substances listed in the Priority List of Hazardous substances.[4] Internationally, Norway implements obligations under the Stockholm Convention on POPs, the Convention on Long-range Transboundary Air Pollution (LRTAP), the Minamata Convention and other international treaties in national law.

[4] Den norske prioritetslista for kjemikalier - Miljødirektoratet (miljodirektoratet.no)

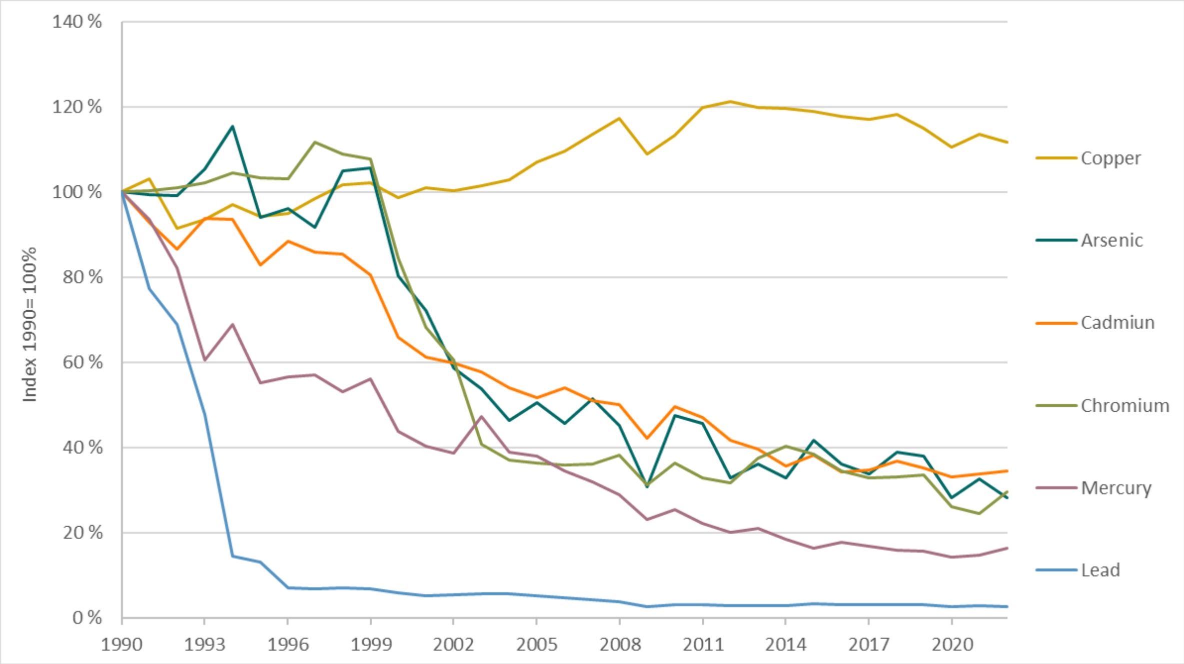


Figure 2.13 Trends in emissions for heavy metals. 1990-2022. Index 1990=100%

Source: Statistics Norway/Norwegian Environment Agency

2.3.1 PM_{10}

Emissions of particulate matter (PM_{10}) totaled 43 928 tonnes in 2022. PM_{10} emissions have decreased by 35% since 1990.

The most important source of PM_{10} emissions is wood burning in private households, included in "other combustion" (NFR 1A4 and 1A5). Emissions from "other combustion" amounted to 16 797 tonnes of PM_{10} in 2022, of which 93% stems from wood burning in private households. Emissions from wood burning have been reduced by 32% since 1990. Since 2000, the reduction in particle emissions has been higher than reductions in wood consumption, due to an increased share of new technology in wood burning appliances.

Emissions from transport amounted to 11 779 tonnes in 2022 which makes up 27% of the overall PM_{10} emissions that year. Road abrasion and tyre and break wear contributed to 85% of emissions in transport, and 11% originated from national navigation. Emissions from transport have been reduced by 42% since 1990.

Emissions from the industrial processes and product use sector (NFR code 2) amounted to 9 485 tonnes in 2022. The largest sources were mineral industry and metal industry, which accounted for 58 and 24% of the emissions in this sector, respectively. Emissions from metal industry have decreased by 63% since 1990, mainly due to reduced production, whereas emissions from mineral industry have increased by 33% since 1990. Emissions from the mineral industry category are mainly from sandpit and rock-crushing plants.

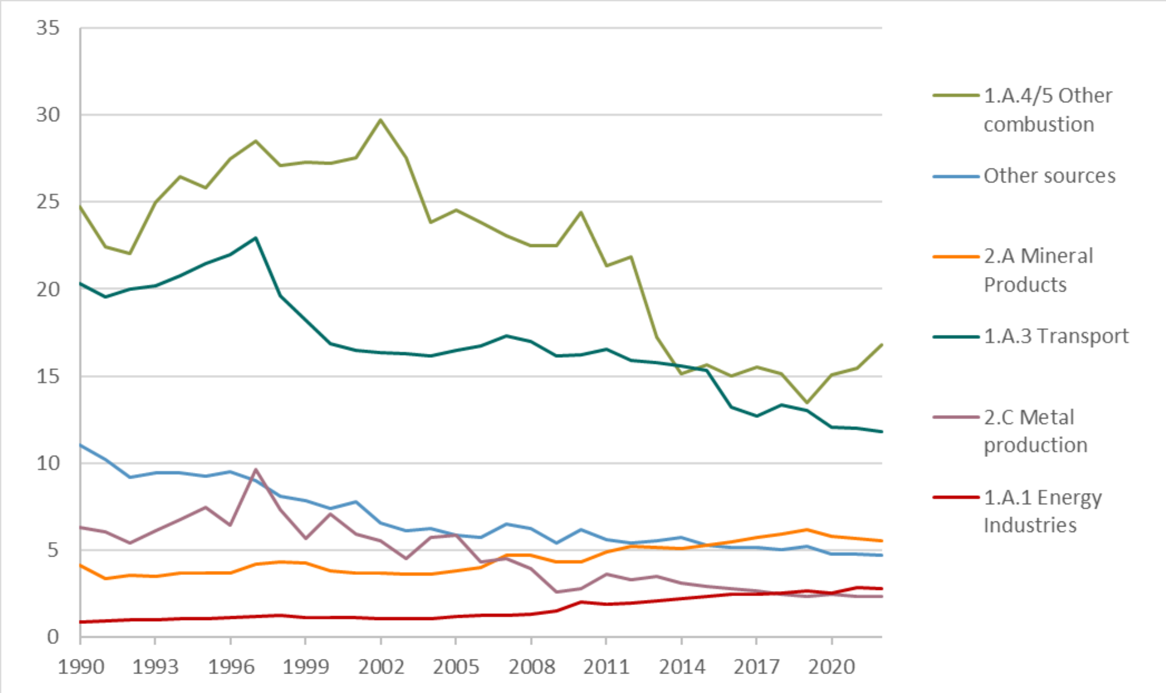


Figure 2.14. Trends in PM_{10} emissions, 1990-2022. 1000 tonnes

Source: Statistics Norway/Norwegian Environment Agency

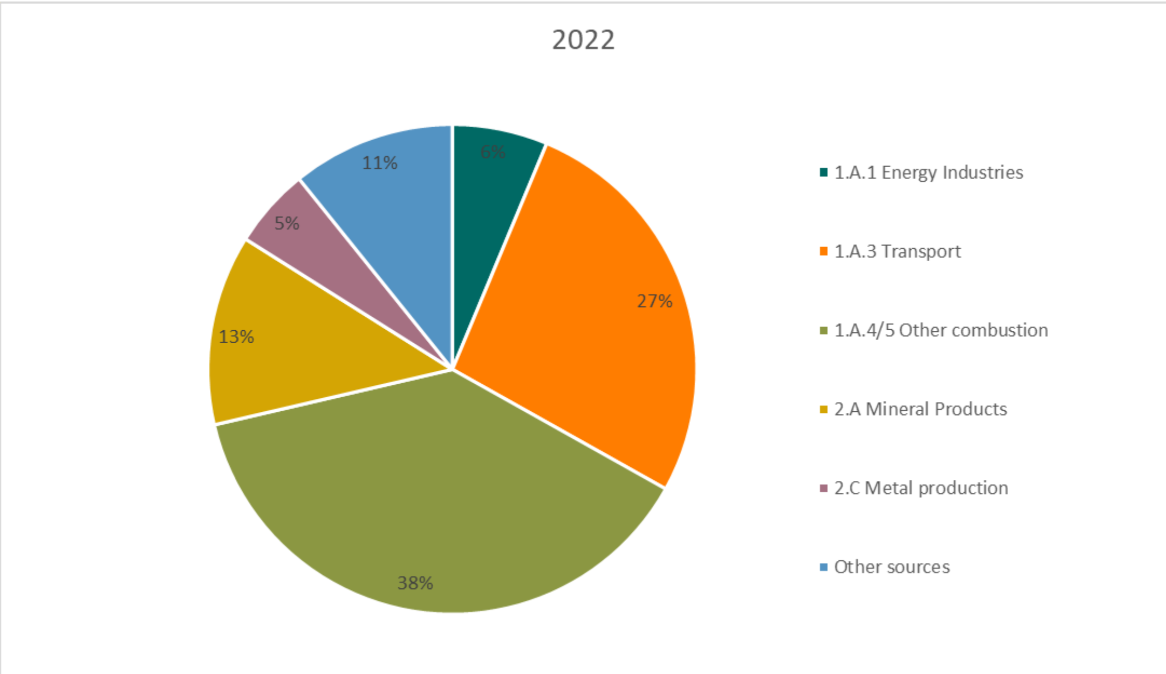


Figure 2.15. Distribution of PM_{10} emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

2.3.2 PM2.5

- 2020 commitment of the revised Gothenburg Protocol: a 30% reduction compared to emissions in 2005; limiting annual $PM_{2.5}$ emissions to 27 342 tonnes.

Emissions of $PM_{2.5}$ follow the same trend as PM_{10} emissions. Norway's emissions totaled 27 145 tonnes in 2022. The 2020 commitment of the revised Gothenburg Protocol has been fulfilled since 2014.

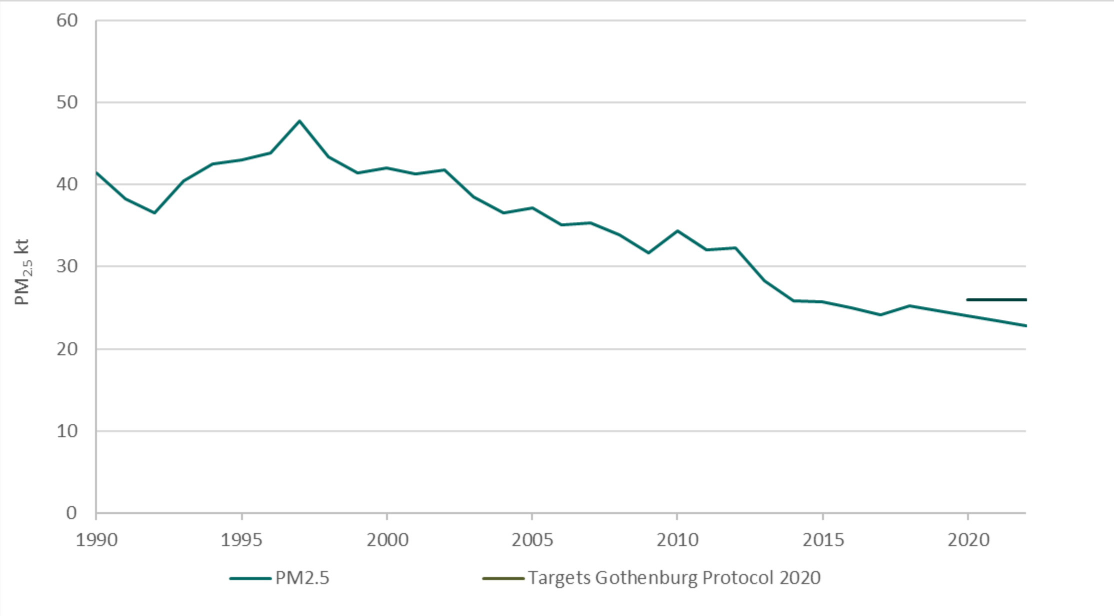


Figure 2.16. Trends in PM2.5 emissions, 1990-2022. 1000 tonnes

Source: Statistics Norway/Norwegian Environment Agency

2.3.3 Black carbon (BC)

The total emissions of BC amounted to 3 122 tonnes in 2022, which is almost the same level as in 2021, but a reduction of 40% since 1990.

In 2022, the most important source of emissions was "other combustion" (NFR 1A4 and 1A5), contributing to 42% of the total emissions. From this category, 73% of emissions originated in 2022 from wood burning in private households. From 1990 to 2022, emissions from wood burning have been reduced by 13%.

In 2022, the second most important source of emissions was transport. It contributed to 33% of the total BC emissions. The greatest share of emissions within the transport sector stems from national navigation with 47% of the emissions. Then follows road abrasion, contributing to 26% of emissions, and passenger cars and light duty vehicles, both contributing to 8% of emissions in 2022. From 1990 to 2022, emissions from national navigation have increased by 22%. Emissions from road abrasion have decreased by 43%, in spite of increased traffic activity in the period. This is mainly due to decreased shares of studded tyres during winter. Emissions from passenger cars and light and duty vehicles have been reduced by 7 and 66% respectively since 1990.

Combustion in the energy industries, which in 2022 accounted for 13% of the total BC emissions, have increased by 283% since 1990 due to increased production. The most prominent sources of emissions within this category are oil and gas extraction (within 1A1c, Manufacture of solid fuels and other energy industries) and heat plants (within 1A1a, Public electricity and heat production) representing 50 and 47% of the sector emissions in 2022, respectively.

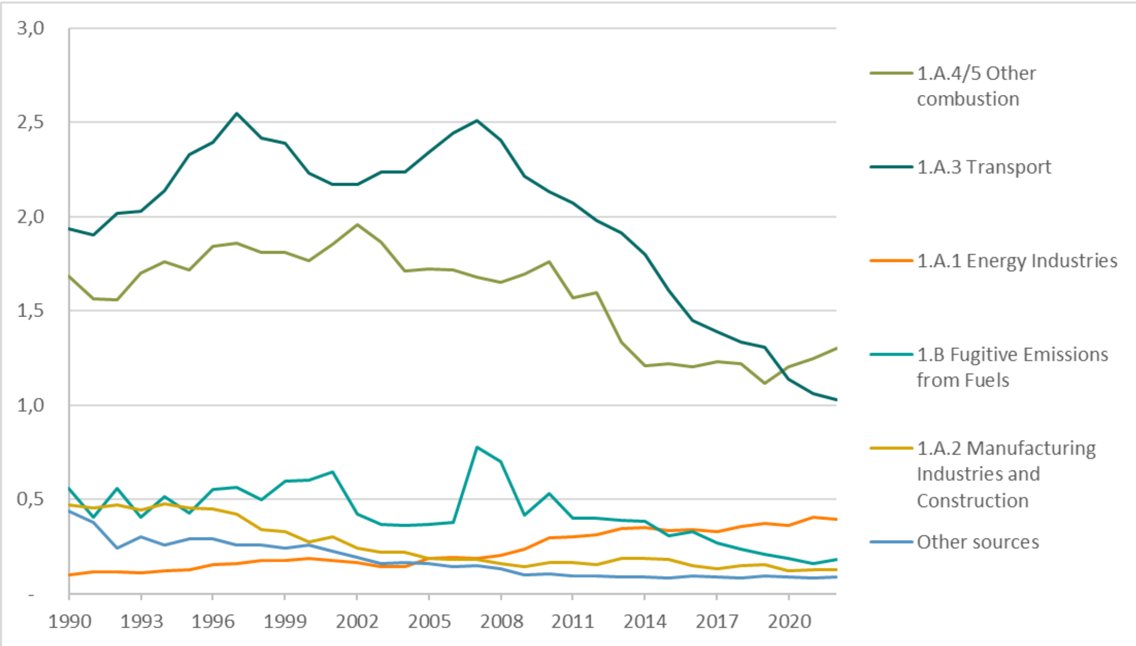


Figure 2.17. Trends in BC emissions, 1990-2022. 1000 tonnes

Source: Statistics Norway/Norwegian Environment Agency

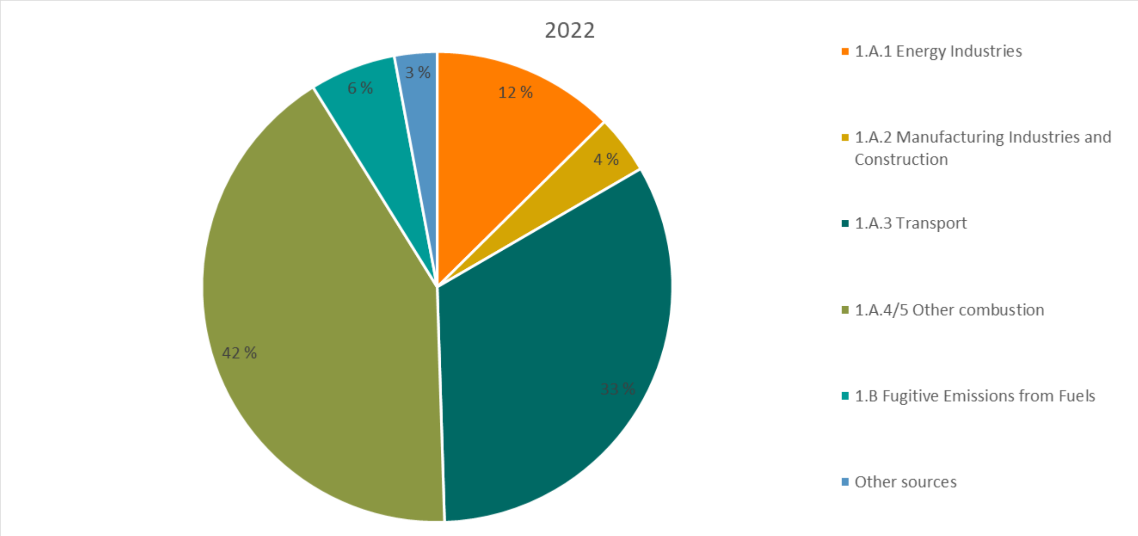


Figure 2.18. Distribution of BC emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

2.3.4 Dioxins

In 2022, 19.7 grams of dioxins were emitted. Since 1990, emissions of dioxins have decreased by 84%. A large proportion of the reduction from 1990 is due to the closure of industrial plants and mines. In addition, emissions from combustion in energy industries were reduced by 86% from 1990 to 2005 due to the introduction of cleaning measures at waste incineration plants. Since 2005, the emissions in the energy industries have increased, of which oil and gas extraction and heat plants were the main contributors. Between 2021 and 2022, emissions from combustion in energy industries decreased by 37% due to a reduction in emissions from heat plants.

From 1990 to 1996, the largest source of dioxins emissions was the category other industrial processes (2H) due to an ore mine with high dioxin emissions which was closed down in 1996. Since the closure, dioxins emissions from the source category 2H have been reduced to zero.

In 2022, the largest source of dioxins emissions was the category "other combustion" (NFR 1A4 and 1A5) contributing to 41%. Within this category, wood burning in private households contributed with almost 85% of the total dioxins emissions in 2022. National fishing, which is also included in this category, contributed 14% to the category.

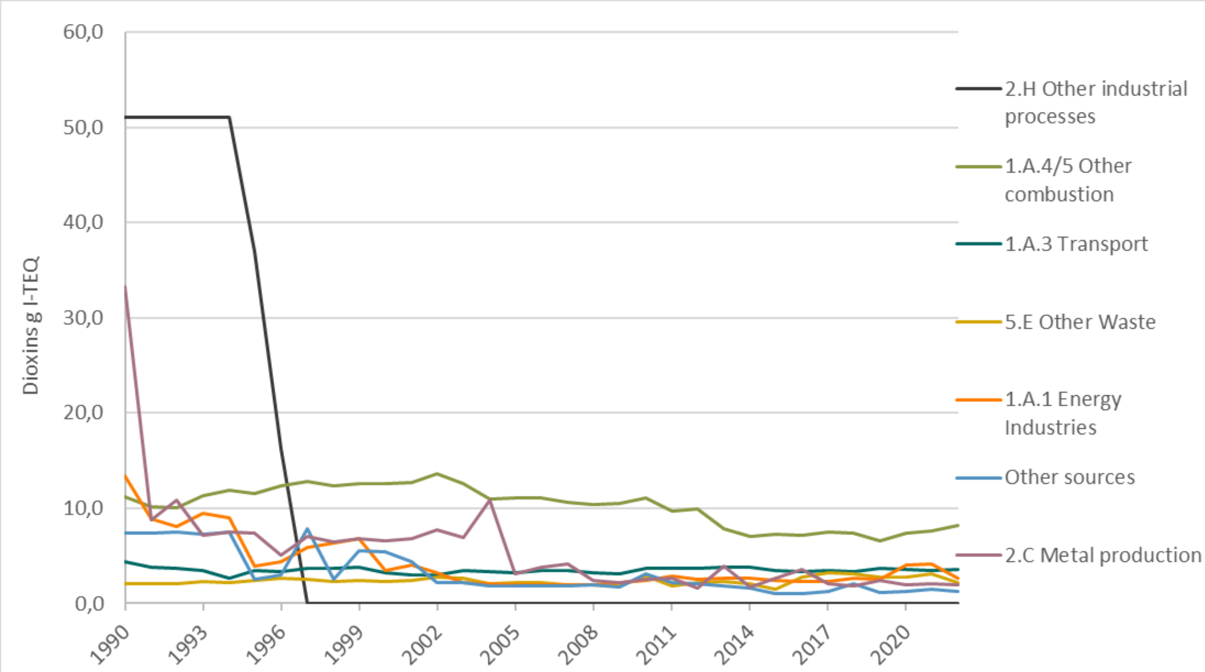


Figure 2.19. Trends in dioxins emissions, 1990-2022. Gram I-TEQ

Source: Statistics Norway/Norwegian Environment Agency

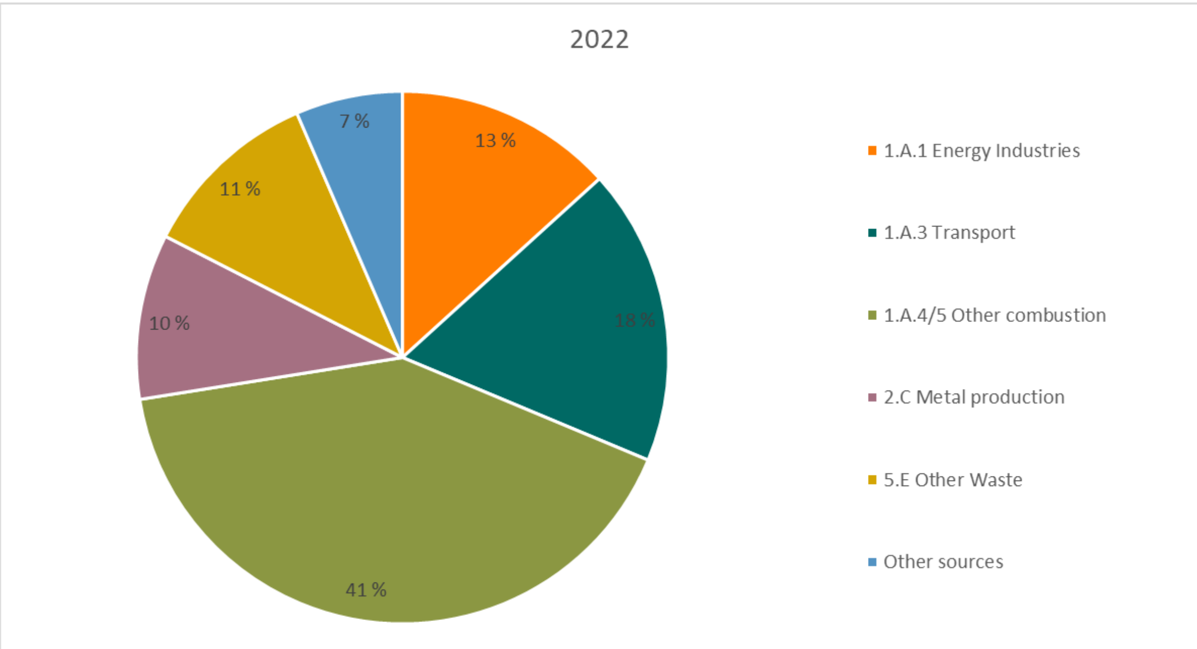


Figure 2.20. Distribution of dioxins emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

Transport was responsible for 18% of total dioxin emissions in 2022. National navigation (shipping) is by far the most significant source of emissions within this category, representing 91% of the transport emissions. Emissions from passenger cars, which contributed to 46% of emissions within this category in 1990, declined rapidly from 1990 to 1996. Since then, they have been on approximately the same absolute level. In 2022, emissions from passenger cars were 93% lower than in 1990.

Dioxins emissions from combustion in energy industries were responsible for 13% of total emissions of dioxins in 2022. There has been a significant decrease in emissions from public electricity and heat production since 1990; emissions in 2022 were 93% lower than in 1990. In 2020, emissions from this source went up by 195% from 2019, which resulted in total emissions from combustion in energy industries going up by 61% in the same period. The large increase was caused by emissions from a waste incineration plant. From 2021 to 2022 however, emissions from this source were again reduced by 63%.

Emissions from oil and gas extraction (within 1A1c, Manufacture of solid fuels and other energy industries) is the largest source of emissions within combustion in energy industries, and heat plants (within 1A1a, Public electricity and heat production) is the second largest emission source. In 2022, these two sources were responsible for respectively 61 and 35% of dioxins emissions within the energy industries category. Emissions from oil and gas extraction have increased by 147% since 1990.

Emissions from other waste (5E), which accounted for 11% of the total dioxins emissions in 2022, have increased by 3% since 1990.

Process emissions from metal production accounted for 10% of the total emissions of dioxins in 2022 and have decreased by 94% since 1990.

2.3.5 PAH-4

The Norwegian emission inventory for polycyclic aromatic hydrocarbons (PAH) includes four PAHs: benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene. The total emissions of PAH-4 in 2022 amounted to approximately 4.9 tonnes, which is a reduction of 76% since 1990. From 2021 to 2022 emissions were almost unchanged.

In 2022, benzo(b)fluoranthene contributed to 48% of PAH-4 emissions while benzo(a)pyrene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene contributed to 20, 17 and 15%, respectively.

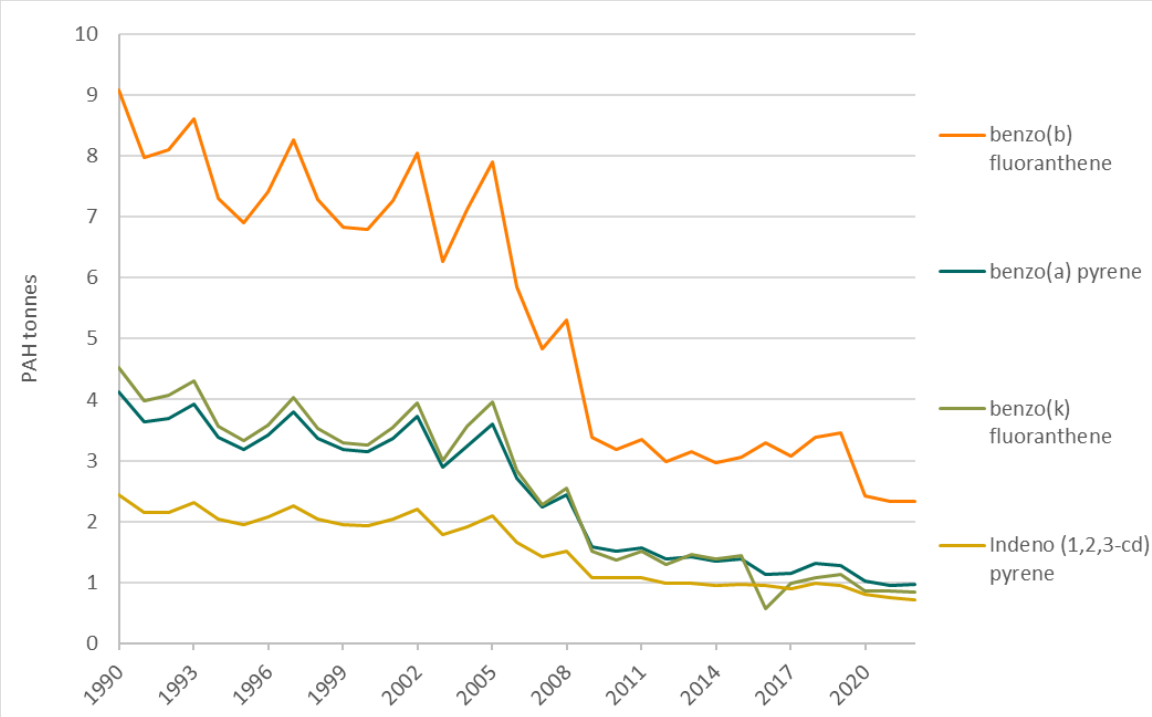


Figure 2.21. Trends in PAH emissions, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene, 1990-2022. Tonnes

Source: Statistics Norway/Norwegian Environment Agency

Process emissions in aluminium production (in 2C Metal industry) is the most dominant source of PAH-4 emissions. It contributed to 70% of the total PAH-4 emissions in 1990 and to 32% in 2022. The PAH-4 emissions decreased primarily because of the discontinuation of Soederberg technology in the aluminium production. Emissions from aluminium production have been reduced by 89% since 1990.

Road transport contributed to 31% of the PAH-4 emissions in 2022. This includes both road abrasion and tyre and brake wear. There is a general trend with increasing emissions from transport since 1990, although emissions have gone slightly down every year from 2016 to 2020, with a higher decrease in 2020 probably largely due to reduced travel because of covid-19 restrictions. In 2021 transport emissions increased by 3.3% from 2020 but was still lower than in 2019. From 2021 to 2022 transport emissions were unchanged. Since 1990, emissions from passenger cars (without tyre and brake wear) have increased by 26%, emissions from light duty vehicles have increased by 223% whilst emissions from heavy duty vehicles and buses have increased by 57%.

Wood burning in private households is by far the most significant source of emissions within the category “other combustion” (NFR 1A4 and 1A5), and accounted for almost 26% of PAH-4 emissions in 2022. They have however been reduced by 55% since 1990, due to the increasing share of new technology in wood burning appliances.

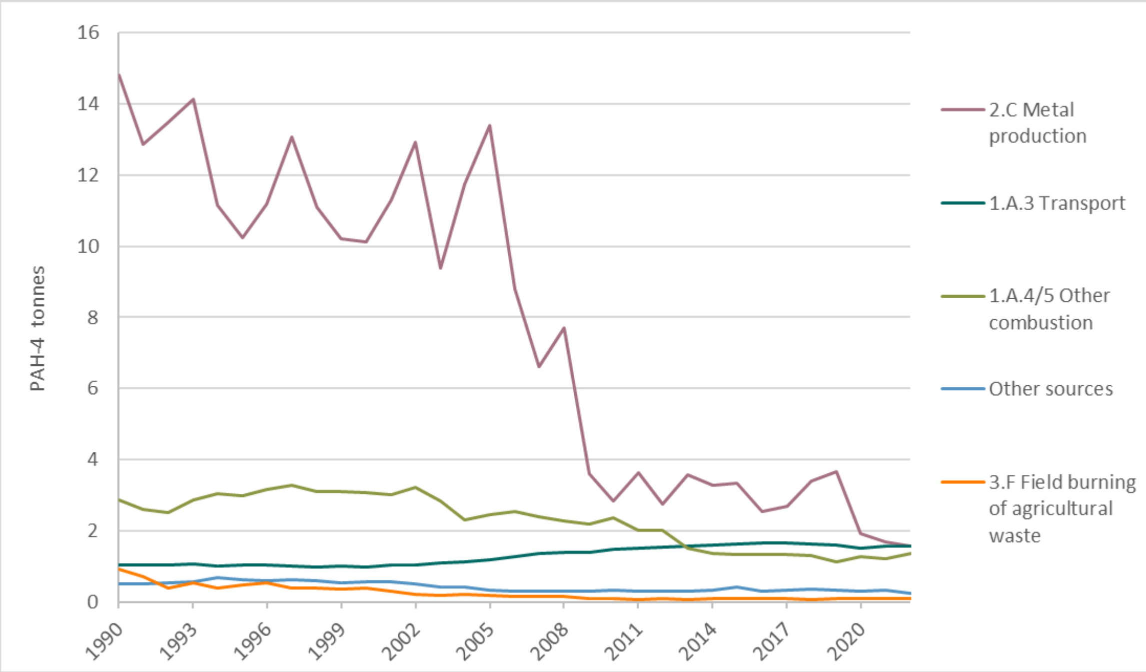


Figure 2.22. Trends in total PAH-4 emissions, 1990-2022. Tonnes

Source: Statistics Norway/Norwegian Environment Agency

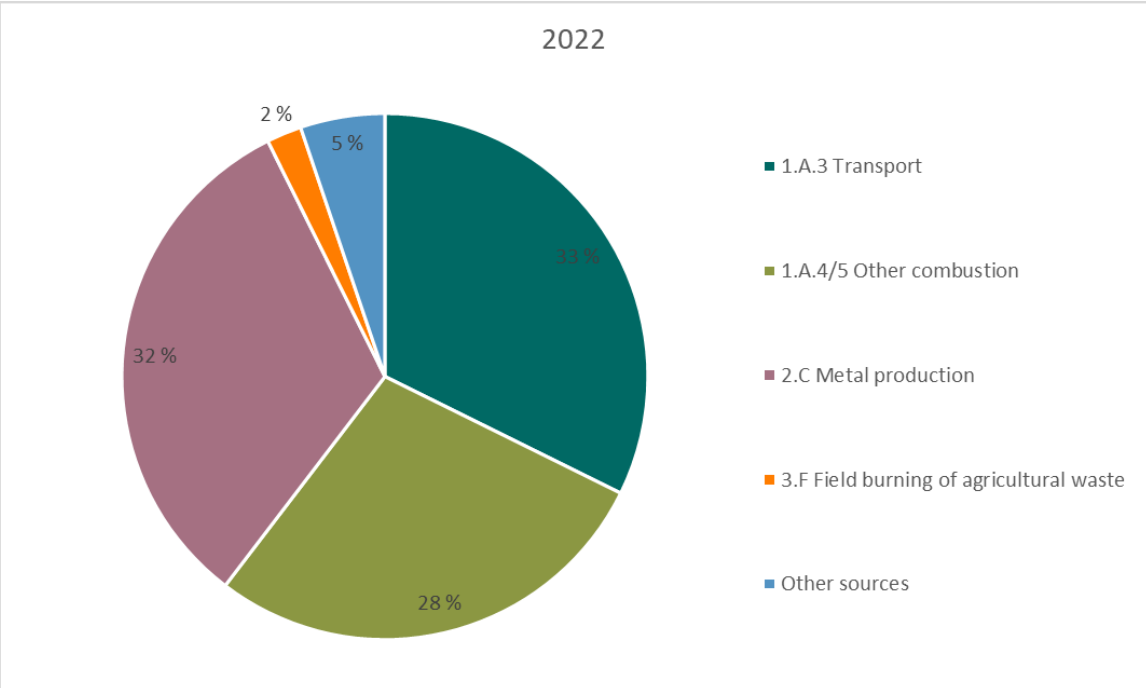


Figure 2.23. Distribution of total PAH-4 emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

2.3.6 HCB

Estimated HCB emissions in Norway amounted to 1.3 kilograms in 2022, and has decreased by 99% since 1990. Emissions decreased mainly due to the closure of magnesium production which contributed to almost 99% of total HCB emissions in 1990.

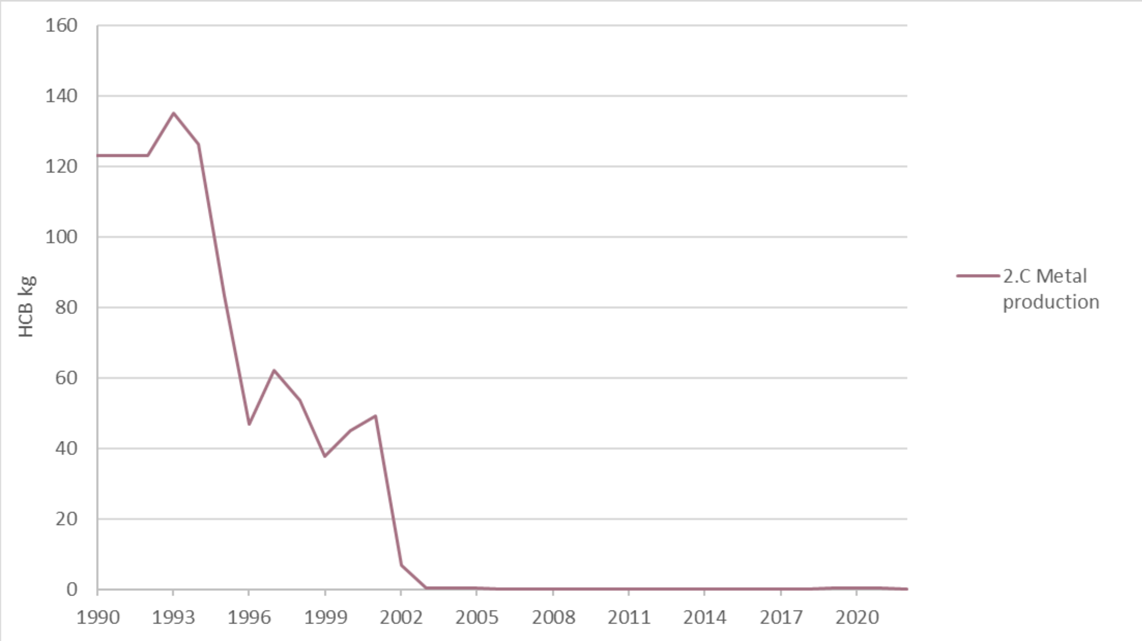


Figure 2.24. Metal industry, trends in HCB emissions, 1990-2022. Kilogram

Source: Statistics Norway/Norwegian Environment Agency

The most important source of emissions of HCB in 2022 was road transport, which contributed to 52% of total emissions. Emissions from road transport have increased significantly since 1990, partly due to increased traffic activity and partly due to a shift from petrol to diesel cars. For instance, HCB emissions from passenger cars were more than fifteen times higher in 2022 than in 1990. Emissions from petrol engines are insignificant.

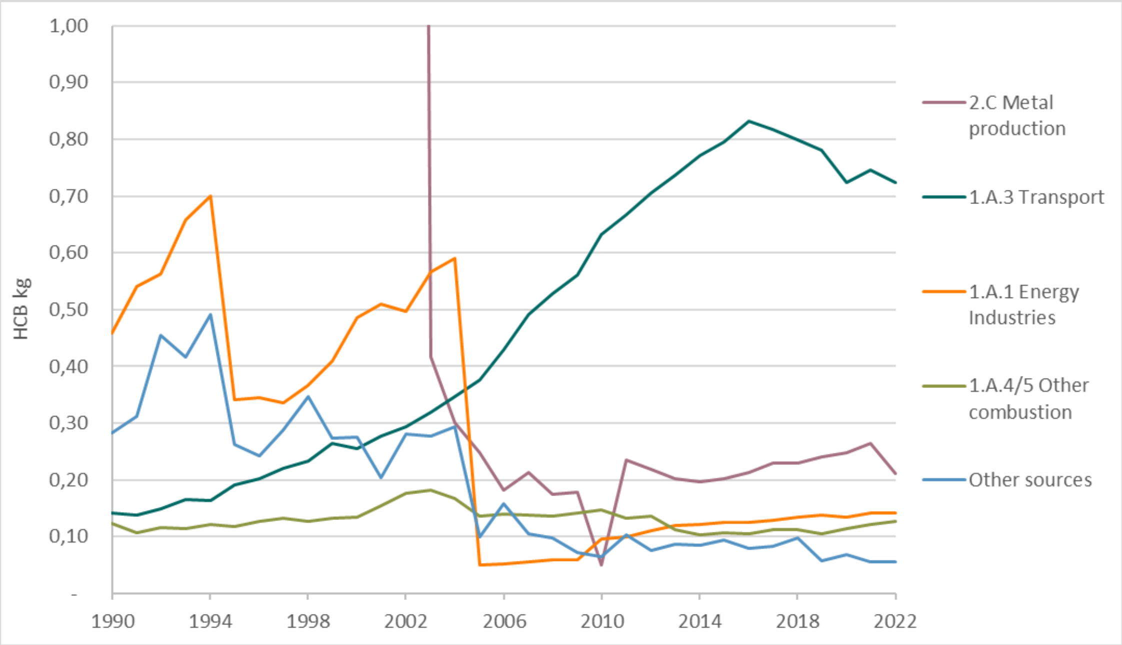


Figure 2.25. Trends in total HCB emissions, 1990-2022. Kilogram

Source: Statistics Norway/Norwegian Environment Agency

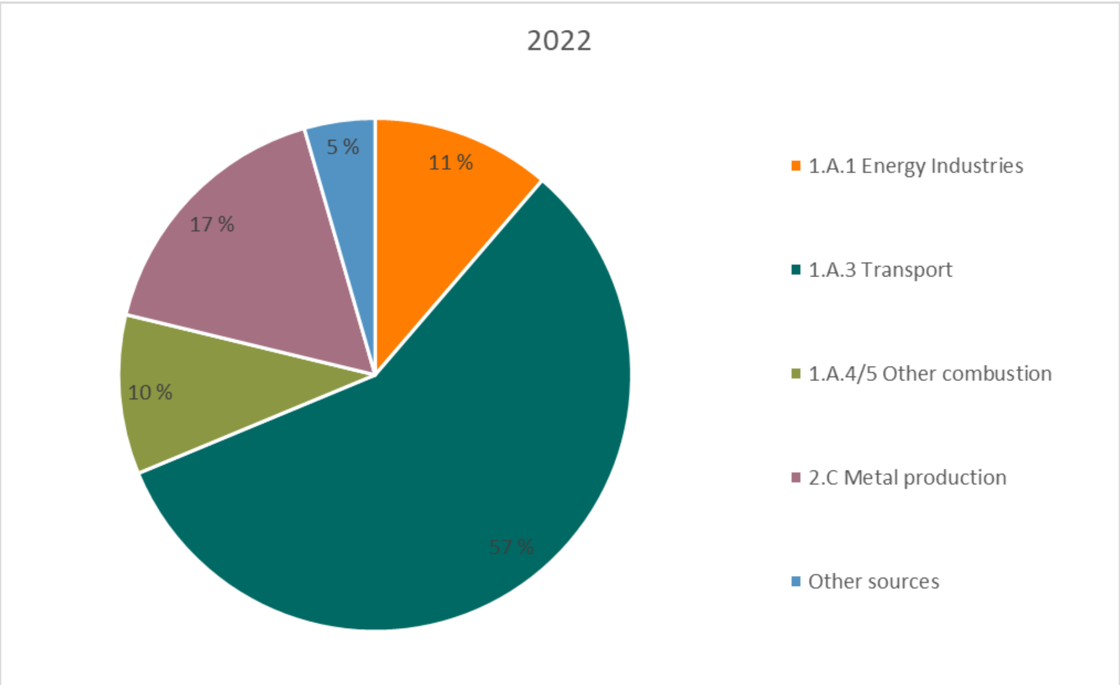


Figure 2.26. Distribution of HCB emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

2.3.7 PCB

Estimated PCB emissions in Norway amounted to 26.2 kilograms in 2022. Emissions have decreased by 87% since 1990. Emissions from passenger cars, which accounted for 78% of the total PCB emissions in 1990, decreased from 163 to 0.9 kilograms from 1990 to 2022.

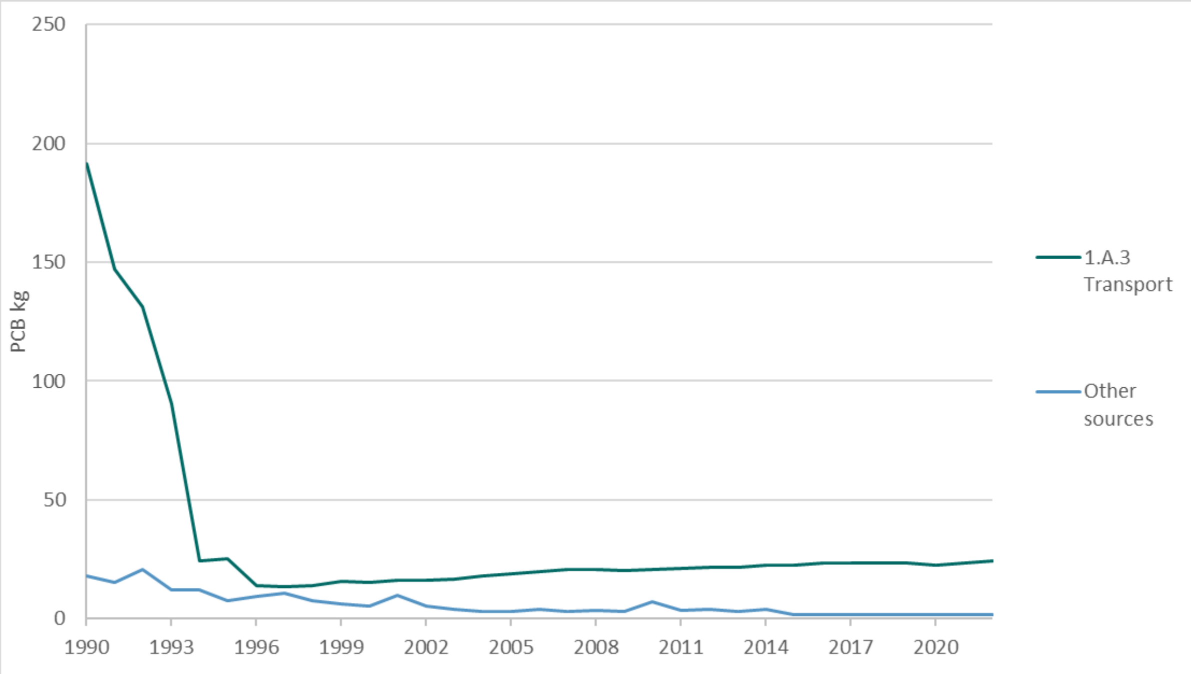


Figure 2.27. Trends in total PCB emissions, 1990-2022. Kilogram

Source: Statistics Norway/Norwegian Environment Agency

Despite large reductions, road transport remained the most important source of emissions of PCB in 2022. It contributed to 92% of total emissions.

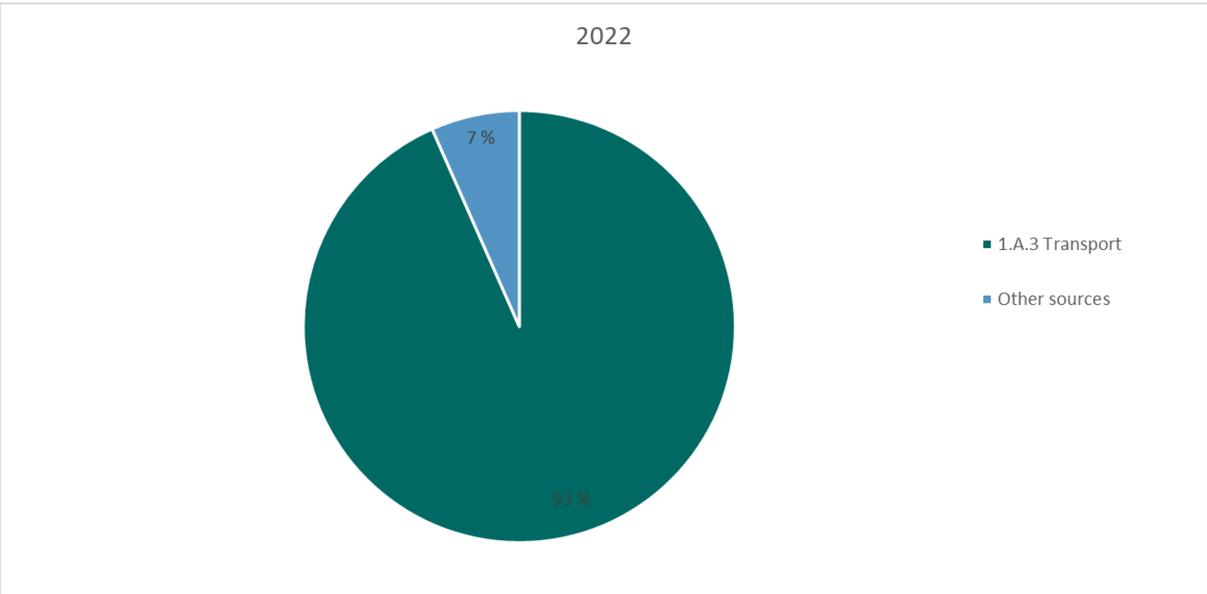


Figure 2.28. Distribution of PCB emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

2.3.8 Lead

Lead emissions totaled 5.3 tonnes in 2022 and have been reduced by 97% since 1990. Regulations on lead content in fuels are the main reason for this reduction. Indeed, emissions from passenger cars constituted 79% of the total in 1990, and only 2% in 2022. Emissions of lead have been relatively constant in recent years.

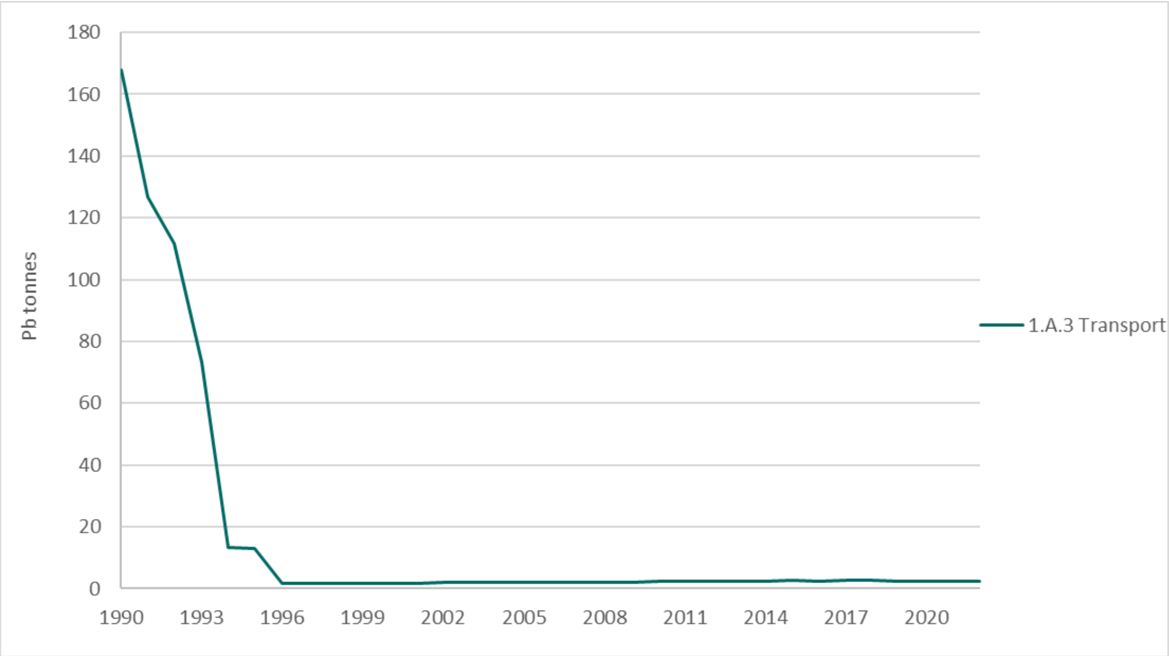


Figure 2.29. Transport, trends in lead emissions, 1990-2022. Tonnes

Source: Statistics Norway/Norwegian Environment Agency

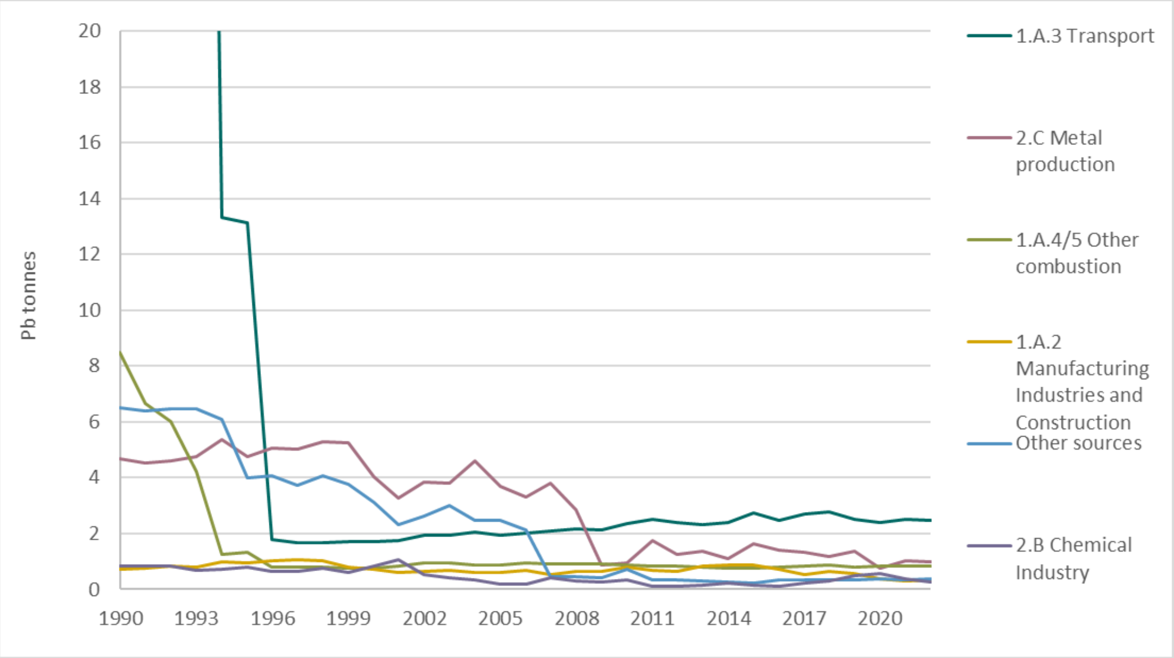


Figure 2.30. Trends in lead emissions, 1990-2022. Tonnes

Source: Statistics Norway/Norwegian Environment Agency

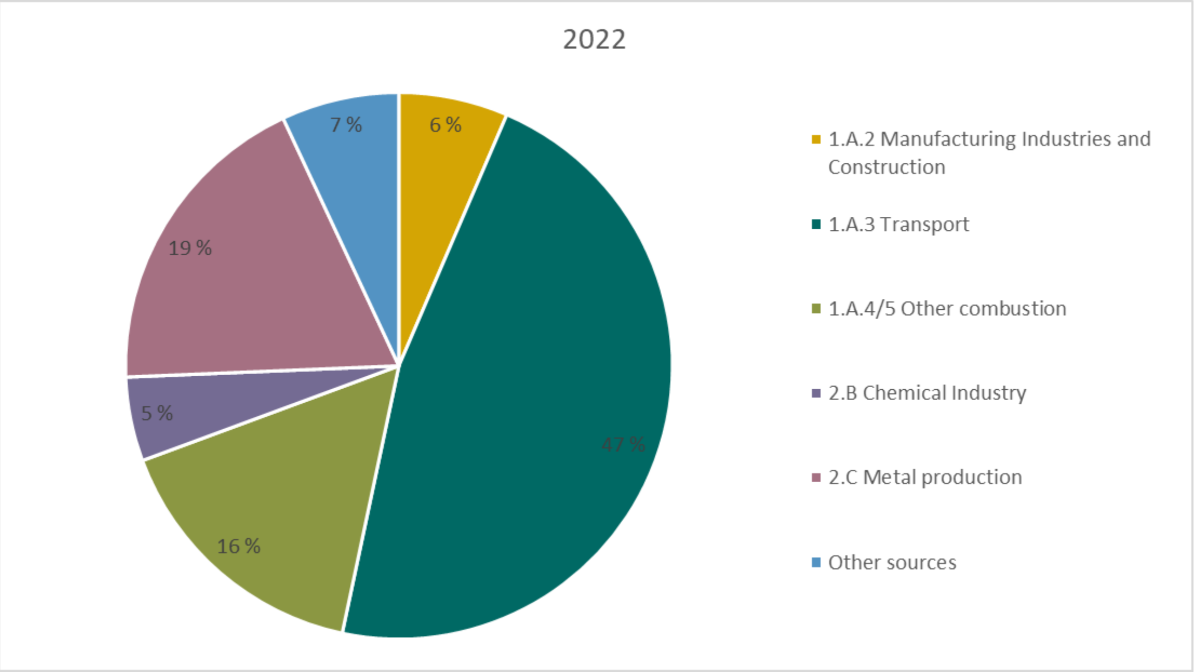


Figure 2.31. Distribution of lead emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

Transport has remained the largest source of lead emissions. However, since 1996 tyre and brake wear has been the most important source within the transport sector, as opposed to combustion of fuels in previous years, being responsible for 32% of lead emissions in 2022.

In 2022, process emissions from metal industry, process emissions from chemical industry, and emissions from combustion activities within manufacturing industries and construction constituted 19, 5 and 6% of the total lead emissions, respectively. The category "other combustion" (NFR 1A4 and 1A5) accounted for 16% of total lead emissions in 2022.

2.3.9 Cadmium

Emissions of cadmium totaled 0.69 tonnes in 2022, a 2% increase from 2021, and a 65% reduction from 1990. The emission reduction since 1990 is primarily due to reduced emissions in metal industry and field burning of agricultural waste.

Process emissions from production of iron, zinc, steel and ferroalloys have been reduced due to reduction efforts and closing down of production plants. Metal industry was responsible for 6% of cadmium emissions in 2022, compared to 28% in 1990. Cadmium emissions from metal industry increased by 5% from 2021 to 2022.

Cadmium emissions from field burning have been significantly reduced from 1990. In 2022, it contributed to 6% of total Norwegian cadmium emissions, compared to 18% in 1990.

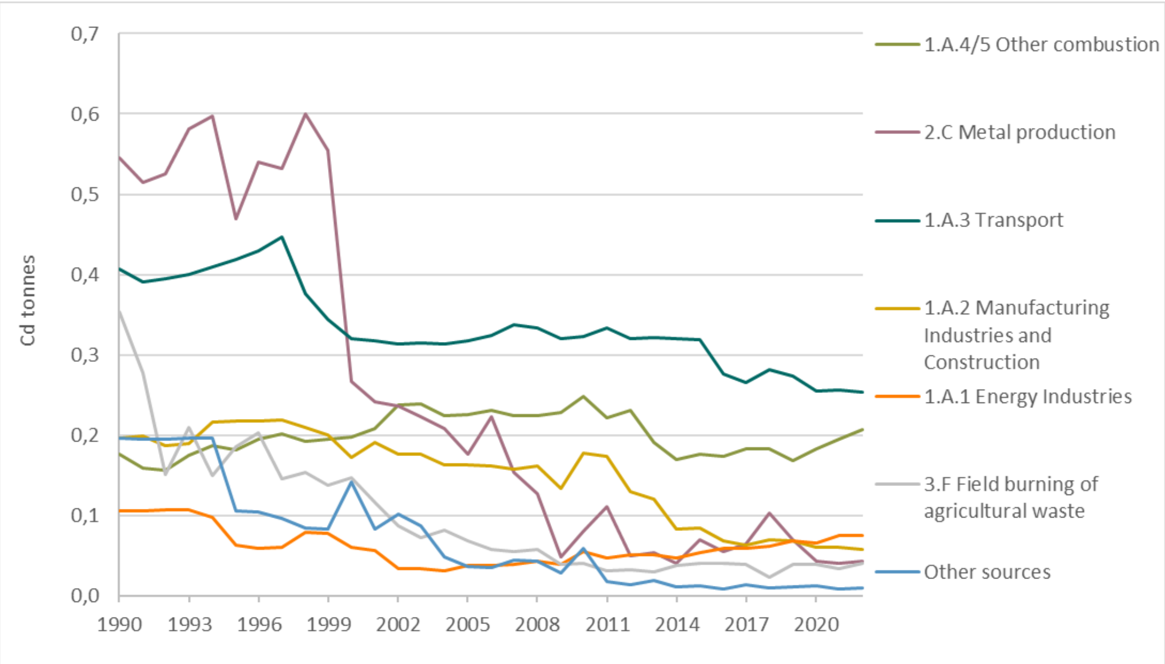


Figure 2.32. Trends in cadmium emissions, 1990-2022. Tonnes

Source: Statistics Norway/Norwegian Environment Agency

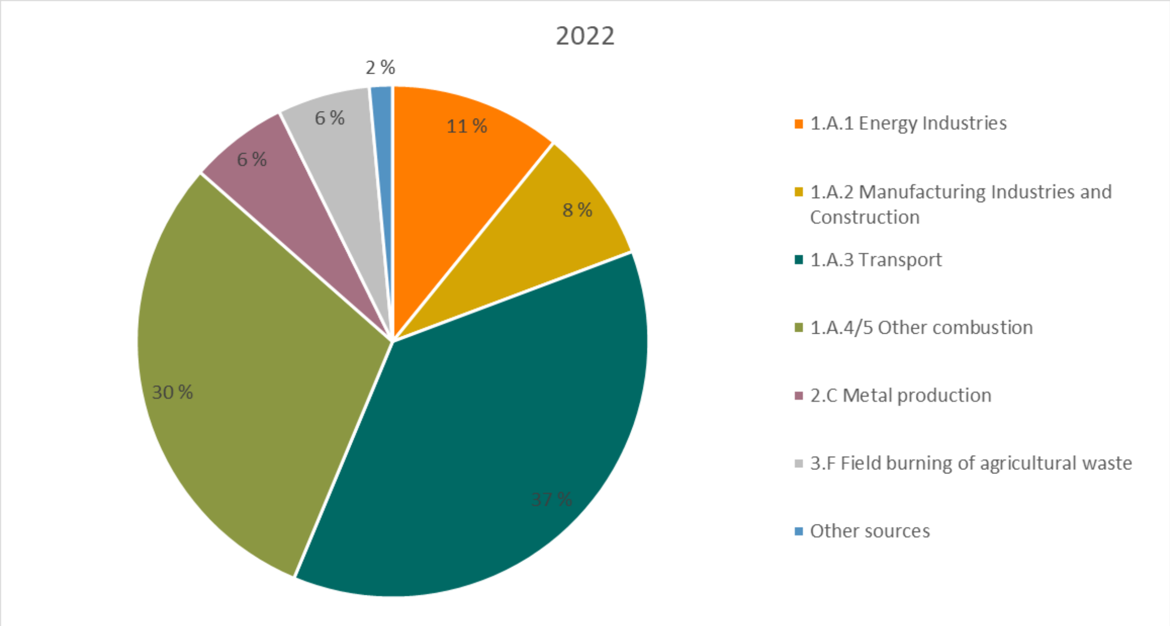


Figure 2.33. Distribution of cadmium emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

In 2022, the largest source of cadmium emissions was transport, contributing to 37% of emissions. Road abrasion accounted for 84% of the emissions within transport. The second largest source of cadmium emissions in 2022 was the category "other combustion" (NFR 1A4 and 1A5), contributing to 30% of the emissions. Wood burning in private households was the main source of emissions within "other combustion", contributing to almost 90%. Combustion in energy industries and combustion in manufacturing industries and construction are also large sources of cadmium emissions. In 2022, they contributed to 11 and 8% of the total emissions, respectively.

2.3.10 Mercury

Emissions of mercury amounted to 0.2 tonnes in 2022, which is an 84% reduction from 1990. The decrease is mainly due to reductions within the metal industry sector (2C) and use of tobacco included in “Other product use” (NFR 2G). These sectors contributed, respectively, to 42 and 20% of total mercury emissions in 1990 and have been reduced by 94 and 97%, respectively, since then.

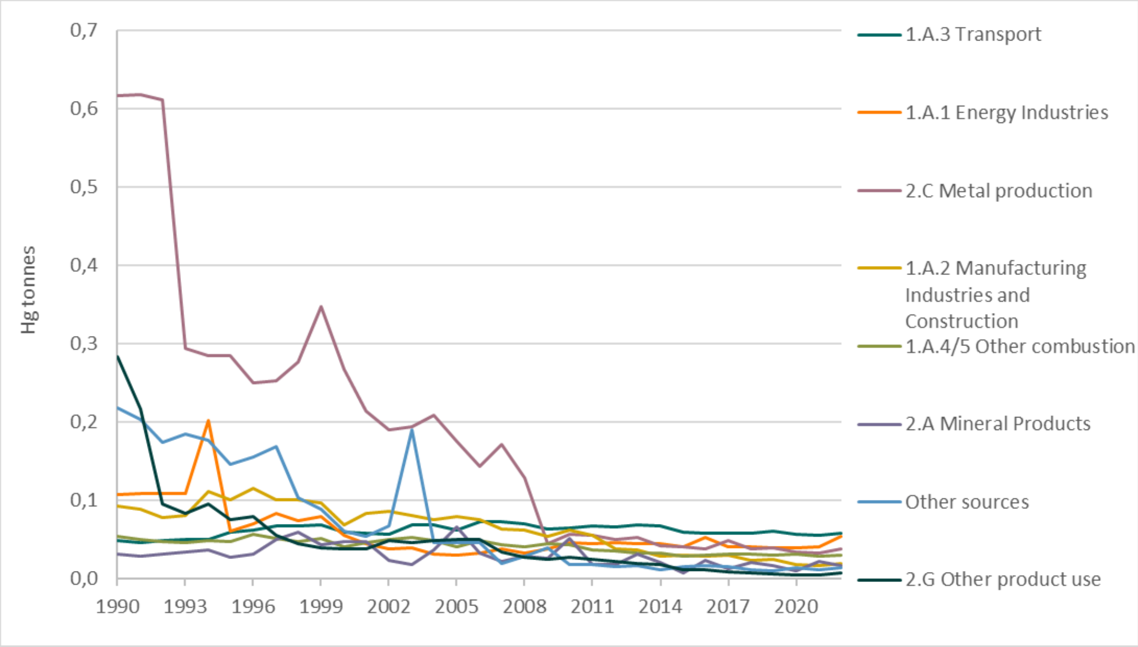


Figure 2.34. Trends in mercury emissions, 1990-2022. Tonnes

Source: Statistics Norway/Norwegian Environment Agency

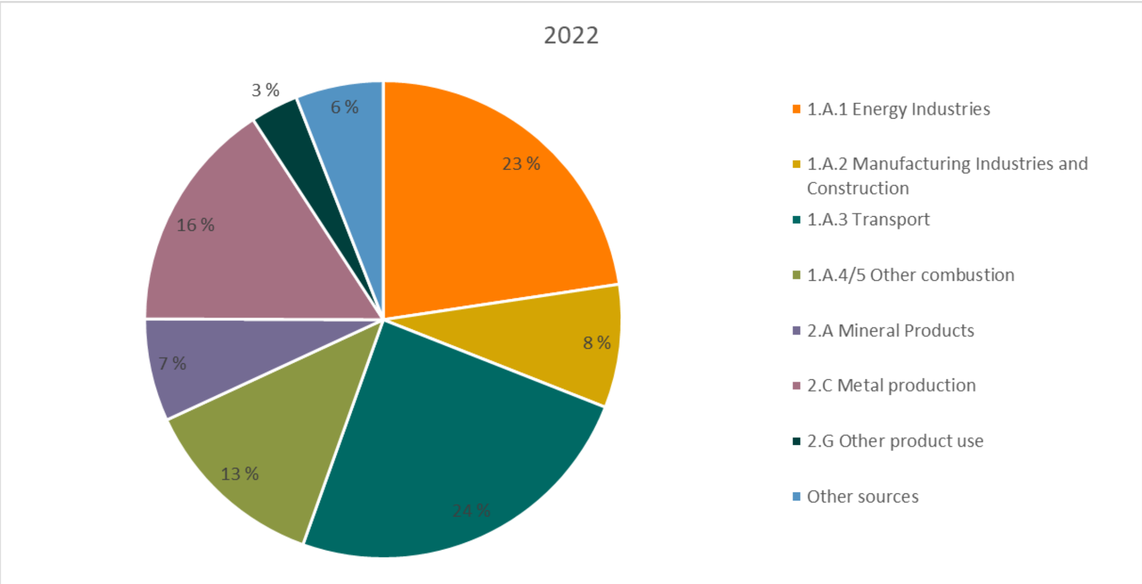


Figure 2.35. Distribution of mercury emissions between emission sources, 2022. Per cent

Source: Statistics Norway/Norwegian Environment Agency

Mercury emissions originate from a wide range of sources. The most important source of mercury emissions in 2022 was the transport sector. The emissions from this source have remained relatively stable since 1990.

2.3.11 Copper, chromium, and arsenic

Emissions of copper were 27 tonnes in 2022, an increase of 12% since 1990 and a 2% decrease from 2021. Tyre and brake wear within road transport is the most dominant source of emissions of copper.

Emissions of chromium amounted to 3.4 tonnes in 2022, an increase of 21% since 2021. Emissions have been reduced by 70% since 1990. Emissions increased between 2021 and 2022 due to increase of fireworks.

In 2022, 1.0 tonne of arsenic was emitted, a decrease of 14% from 2021 and a reduction of 72% since 1990. For the past few years, the variation in arsenic emissions is due to varying arsenic content in raw materials and reducing agents used in metal production.

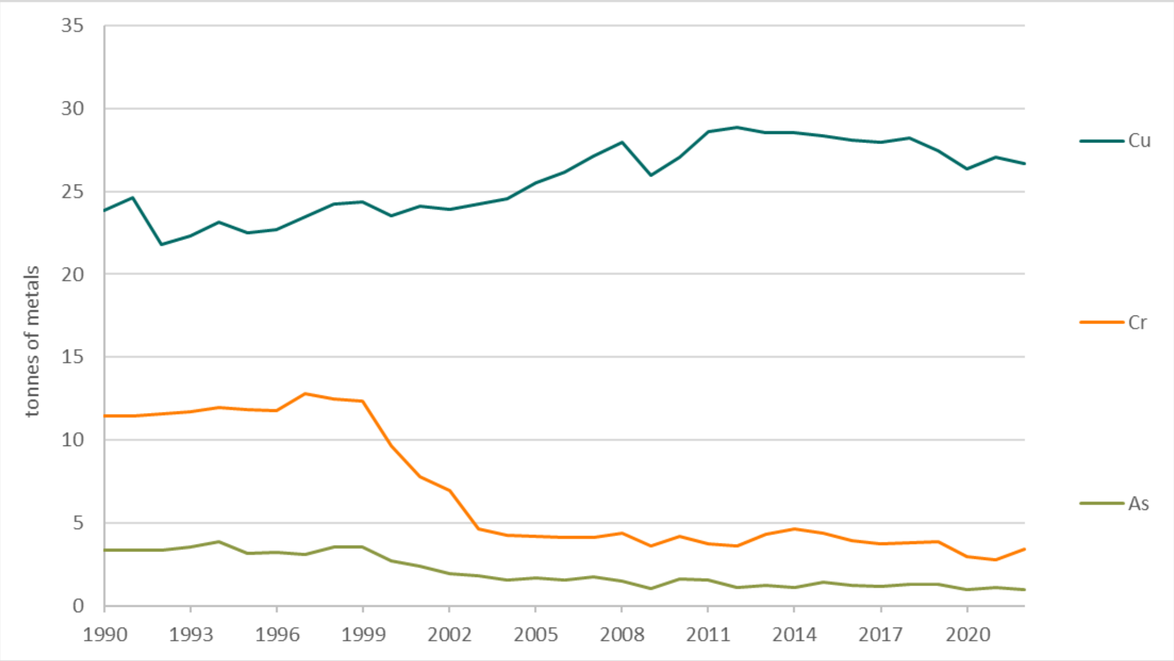


Figure 2.36. Trends in copper, chromium, and arsenic emissions, 1990-2022. Tonnes

Source: Statistics Norway/Norwegian Environment Agency

3. ENERGY (NFR sector 1)

Last update: 19.02.24

3.1 Overview

This chapter provides descriptions of methodologies used to calculate emissions from the energy sector. The disposition of the chapter follows 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.

Recalculations, as well as planned improvements to the inventory system, are described in Chapter 8.

3.2 Energy combustion

NFR 1A
Last update: 19.02.2024

3.2.1 Overview

Combustion of fossil fuels and biomass leads to emissions of SO_2, NOX, NMVOC, CO, particulate matter[5], heavy metals, PAH, dioxins and NH_3.

Table 3.1. Energy combustion emissions as per cent of total emissions, 2022

Pollutant	Per cent of emissions
SO_2	36
NO_X	87
NMVOC	28
CO	57
NH_3	1
PM_{10}	73
BC	91

Source: Statistics Norway/Norwegian Environment Agency

The emissions of SO_2, NMVOC and CO from the energy sector have been significantly reduced since 1990. The reduction of SO_2 emissions has taken place in all sectors due to reduced sulphur content in fuels. NMVOC and CO emissions have been reduced mainly due to reductions in emissions from petrol passenger cars.

Emissions of NOX and particles increased during the 1990s but have reduced since around 1997.
Catalysts in petrol passenger cars cause NH_3 emissions.

[5] If not otherwise specified, the emissions of particulate matter do not include the condensable component

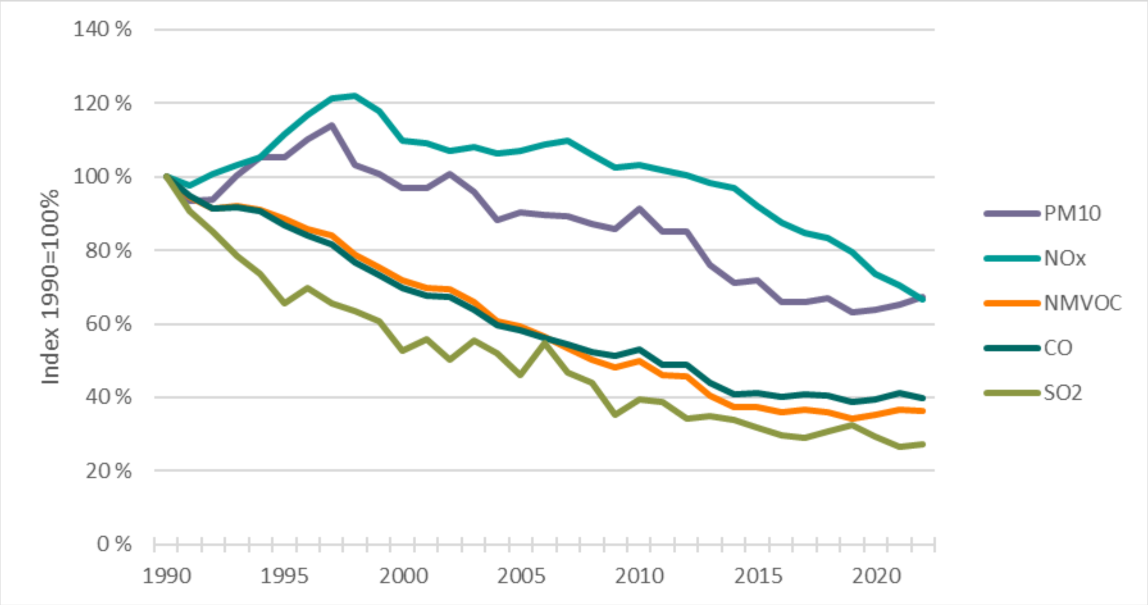


Figure 3.1. Trends for the emissions for most of the long-range transboundary air pollutants from energy combustion. Index 1990 = 100%

Source: Statistics Norway/Norwegian Environment Agency

Emissions from energy combustion include contributions from all sources addressed in the UNECE Guidelines. 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. Coal and coke used as reducing agents and gas used for production of ammonia (non-energy part) are accounted for under industrial processes (section 3). Flaring of natural gas and fuel gas in chemical industry is reported in section 4.3. Other flaring outside the energy sectors is described in section 6.4. The same applies to emissions from accidental fires etc. Emissions from burning of crop residues and agricultural waste are accounted for and described in section 5.6. Emissions from tobacco are described in section 4.5.6.

The main data source for calculation of emissions from energy combustion is the energy balance, which is prepared annually by Statistics Norway.

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 by the companies to the Norwegian Petroleum Directorate. Other energy producers, such as oil refineries and district heating plants, also report their own energy use to Statistics Norway and the Norwegian Environment Agency.

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; in some cases, surveys from earlier years are used to estimate current distribution of consumption between sectors. For manufacturing industries, however, Statistics Norway’s annual survey on all types of energy use, based on reports from plants that are responsible for approximately 96 per cent of the energy use in these sectors, combined with estimations for the remaining plants, provide figures of high quality.

3.2.1.1 Method

3.2.1.1.1 General

Emissions from energy combustion are estimated at the sectoral level in accordance with the IPCC sectoral approach Tier 2/Tier 3. Total fuel consumption is often 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 densities are listed in Table 3.2.

*Table 3.2 Average energy content (NCV) and density of fuels**

Energy product	Theoretical energy content	Density
	GJ/tonne	**Tonne/m^3**
Coal	28.1	:
Coke	28.5	:
Petrol coke	35	:
Crude oil	42.7	0.85
Motor gasoline	43.9	0.74
Aviation gasoline	43.9	0.74
Kerosene (heating)	43.1	0.81
Jet kerosene	43.1	0.81
Auto diesel	43.1	0.84
Marine gas oil/diesel	43.1	0.84
Light fuel oils	43.1	0.84
Heavy distillate	43.1	0.88
Heavy fuel oil	40.6	0.98
Bitumen	40.2	:
Lubricants	40.2	:
Natural gas (dry gas) (land)[1]	35.3	0.74[1]
Natural gas (rich gas) (offshore)[1]	40.3	0.85[1]
LPG	46.1	0.53
Refinery gas	47.3	:
Blast furnace gas[1]	7.5-11	:
Fuel gas[3]	60	:
Landfill gas[2,4]	50.4	:
Biogas[2,4]	50.4	:
Fuel wood[2]	16.8	0.5
Ethanol[2]	26.8	0.79
Biodiesel[2]	36.8	0.88
Wood waste[2]	16.8	:
Black liquor[2]	7.2 - 9.2	:
Wood pellets[2]	17.3	:
Municipal waste	11.5	:
Special waste	40.6	0.98

Source: Energy statistics, Statistics Norway

**The theoretical energy content of a particular energy commodity may vary; Figures indicate mean values. All data are net calorific value (NCV)*

[1] *kg/Sm^3 = standard cubic metre (at 15 °C and 1 atmospheric pressure)*

[2] *Non-fossil emissions, not included in the inventory CO2 totals. Value is given for wood including a water content of 18%, wood waste 8%, and pellets 8%. Values for black liquor are given not including water content.*

[3] *In this inventory, fuel gas is a hydrogen-rich excess gas from petrochemical industry.*

[4] *Landfill gas and other types of biogases are reported as methane content in the energy balance.*

Handbook of Emission Factors (HBEFA; (INFRAS 2022)) describes methodologies used for road traffic. Several documentation reports have been published describing the methodologies used for road traffic (Holmengen and Fedoryshyn 2015) and navigation

(Tornsjø 2001, Flugsrud, Hoem et al. 2010). The methodology for aviation is described in two internal documents from Statistics Norway (Skullerud 2014, Thovsen 2017).

3.2.1.1.2 Delimitation towards industrial processes etc.

The energy combustion sector borders to several other source categories. This section presents the demarcation with other sectors used in the inventory.

Energy consumption reported as activity data in the emission inventories is generally delimited in the same way as emissions. In cases where different substances are handled differently, the delimitation of energy consumption follows the delimitation of CO_2 emissions.

Flaring is not reported as energy use in 1A. Instead, flaring is reported in the following source categories:

- Flaring in refineries and in exploration/extraction is reported in 1B – Fugitive emissions.
- Flaring in manufacturing industries is reported in 2 – Industrial processes, particularly in 2B – Chemical industry. (In the energy balance, flaring in manufacturing is reported as "losses".)
- Flaring of landfill gas is reported in 5C – Waste incineration.

Combustion of solid waste and hazardous waste is reported in the energy section (district heating in 1A1a and in several manufacturing industries). No significant combustion of solid or hazardous waste occurs without energy recovery.

Combustion of landfill gas with energy recovery is reported in the energy section (mainly in 1A4a Commercial/Institutional). Flaring is reported in 5C waste incineration, as mentioned above.

Some special problems relating to allocation of reported total plant emissions are discussed in section 3.2.1.1.4.

3.2.1.1.3 Emissions reported by plants: overview

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 with general emission factors 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.

Emissions are reported to the Norwegian Environment Agency under several different reporting obligations.

In the general equation

(3.1) *Emissions (E) = [(A - APS) × EF] + EPS*

EPS represents the reported emission data, while APS represents the energy consumption at the plants. Note that for most plants, reported emissions are used only for a limited number of compounds. For the remaining substances in the inventory, the general method with standard emission factors is used. 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 is 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.

3.2.1.1.4 Emissions reported by plants: Energy data

Energy data for plants with reported emissions (A_{PS} in equation (2.2)) should be consistent both with the energy balance that is used for activity totals A and with the reported emission data. Consistency with emission data means that the energy data should correspond to the same activity as the reported emissions.

In most cases, figures on plant energy use in the inventory are based on data reported from the plants to Statistics Norway. This ensures consistency with the energy balance. However, for some plants, some of the energy data may differ between reports to Statistics Norway and data reported together with emissions to the Norwegian Environment Agency. In some cases, this may lead to problems with consistency.

3.2.1.1.5 Emissions reported by plants: Allocation to combustion/ processes

In some cases, emissions are reported as a plant total which includes both combustion and process emissions. All emissions of particulates, heavy metals and POPs are entered into the inventory as process emissions. Emissions from combustion are set to 0 to avoid double counting.

3.2.1.1.6 Emissions reported by plants: Allocation to fuels

For some plants and substances, emissions are reported by fuel, but in most cases reported combustion emissions are entered as a plant total. The emissions are then allocated to fuels bases on standard EFs using equation 3.1:

(3.2) $E_{PS,f} = E_{PS} \cdot A_{PS,f} \cdot EF_f \, / \sum_f (E_{PS} \cdot EF_f)$

where the subscript f denotes fuel type.

This means that any deviations in data will be distributed across all fuels at the plant. Typical situations include:

- Plants with atypical fuels which differ from standard emission factors.
- Plants with errors or other inconsistencies in energy data.

In such cases, implied emission factors may deviate from the standard range also for other fuels than the one which is really affected. Plants/substances which are entered by fuel currently include among others:

- Particulate matter from manufacturing of wood products.
- Heavy metal and POP emissions from combustion of municipal solid waste and special waste.

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. The energy balance defines the total energy consumption for which emissions are accounted. However, a large part of the total emissions is based on reports from plants that use much energy, i.e. offshore activities, and energy-intensive industries onshore. Energy consumption in these plants is included in the energy balance, but this consumption 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.

3.2.1.2.1 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 Offshore Directorate (NOD). 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.

3.2.1.2.2 Liquid fuels: LPG and secondary 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 construction and households are based on sales figures, collected annually from the oil companies. Use in agriculture are prior to 2005 taken from agriculture statistics (Gundersen 2005). From 2005 and onwards, total consumption is given by the annual sales statistics for petroleum products and distributed to agriculture industry using the share of direct sales in 2009-2012. Until further work is done, the same distribution formula is applied to all these years.

Use of refinery gas is reported to Statistics Norway from the refineries. The distribution between the sources direct-fired furnaces, flaring and boilers for the years prior to 2009, is based on information collected from the refineries in the early 1990's. From 2009, the energy consumption is reported according to the energy use at each plant. From June 2021, there is only one refinery left in Norway, which imply a somewhat lower consumption of refinery gas since then. Emissions from combustion for energy purposes are reported under Petroleum refining (NFR 1A1b), emissions from flaring under fugitive emissions from Flaring (NFR 1B2c) and emissions from cracker coke burn-off are reported under Refining/Storage (NFR 1B2aiv).

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. A petrochemical plant generates *fuel gas* derived from ethane and LPG. Most of the gas is burned on-site, but fuel gas is also sold to several other plants. All use of fuel gas is reported as energy consumption in the inventory.

One of the petroleum refineries is also generating CO-rich gas as a by-product from coke burn-off in catalytic crackers. The gas is partly utilized as energy. In the energy balance, production, and energy consumption of gases from coke burn-off in refineries, is recorded as "petroleum coke burn-off" and is included in "Other oil products". In international reporting however, this is reported as petroleum coke used as refinery fuels.

3.2.1.2.3 Liquid fuels: Oil products

Total use of the different oil products is based on Statistics Norway's annual sales statistics for petroleum products. The statistics are based on annual reports from the oil companies and import data from the external trade statistics at Statistics Norway. This is also the data source for consumption in industries that do not collect their own data. For the time series from 1990 to 2009, monthly sales data are used in the energy balance. These data are also reported to Statistics Norway by the oil companies, but they do not contain as much information as the annual reports. In the monthly sales data, industrial distribution is specified by the oil companies but there is no information on individual buyers, such as organization number, name, or address.

The annual sales data are considered reliable since all major oil companies selling oil products report to these statistics and have an interest in the quality of the data. The statistics are corrected for direct import by other importers or companies.

The use of sales statistics provides a total for the use of oil products. The use in the different sectors must sum up to this total. 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. In the statistics on sales of petroleum products there is a breakdown of sales by industry. Direct sales to end users are linked to industries or households using the organisation number or other identifiers in the data from the oil companies, while sales to distributors of solid, liquid, and gaseous fuels remain attributed to the distributors. However, in the energy balance all consumption must be broken down, also that which is sold via distributors. Thus, the breakdown by industry is therefore different in energy balance and in the statistics on sales of petroleum products. The method for this breakdown is described in the report "Energy Accounts and Energy balance – Documentation of statistics production since statistics year 1990" (Kittilsen, Moe et al. 2018).

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. From 1. January 2020 it is not allowed to use kerosene or heating oil for heating purposes in households, except for cottages which are not connected to the electricity grid.
Mobile combustion is distributed between several different sources, described in more detail in section 3.2.4 Transport.

Petrol coke is not included in the sales statistics. Consumption data are collected as part of the coal and coke statistics, see below.

Use of *waste oil* is recorded together with waste as "other fossil fuels", see below.

Generally, in Norway there has been a continuous 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. Due to the ban of use of kerosene or heating oil for heating purpose in 2020, this is a minor issue in the years after 2020.

3.2.1.2.4 Coal, coke and petrol coke

Use of coal, coke and petrol coke in manufacturing industries is reported annually from the plants to Statistics Norway. The statistics cover all main consumers and are considered of high quality. More than 90 per cent of the coal and coke consumption in Norway is used as a reductant, so only a small part is used for combustion. Combustion takes place partly in direct-fired furnaces, partly in boilers. The minor quantities burnt in small ovens in private households were estimated based on sales figures from coal/coke retailers until 2008. After 2008 this has not been recorded in the energy balance because of very small amounts. In addition, an insignificant figure of coal use in the agricultural sector has formerly been collected from the farmers. Since 2002, coal has not been used in Norwegian agriculture. Several metallurgical plants generate blast furnace gas that is either burnt on-site or sold to adjacent plants. The gas is generated as a by-product from using coal or coke as a reductant in metal production. Some plants utilise the gas for energy purposes either directly on-site, or for electricity production or they sell it to other companies. Two ferroalloy plants sell parts of their blast furnace gas to other plants (an ammonia producer, a district heating plant, iron and steel producers and mineral industry), where it is used for energy purposes. Thus, these amounts are reported as energy consumption in the inventory. In addition, there is a small amount of coal used in a few veteran trains in Norway. This is considered as cultural services and are not a part of the transport sector.

3.2.1.2.5 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. For the years before 2005 and for 2012, the use of wood in households is based on the annual survey on consumer expenditure which gives the amount of wood burnt. The statistics cover purchase in physical units and estimates for self-harvest of wood. 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 2005-2011, the figures are based on responses to questions relating to wood burning in Statistics Norway's Travel and Holiday Survey. The figures in this 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. Since 2013 the figure used in the emission calculations is the average of 3 quarterly surveys. Figures on some minor use in agriculture and in construction have been derived from earlier surveys for these sectors. Combustion of wood product takes place in boilers and in small ovens in private households. 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).
Sewage treatment plants and waste disposal sites utilize *biogas* extracted at the plant, and reports quantities combusted (in turbines). Emissions are estimated by Statistics Norway, using the same emission factors as for combustion of natural gas in turbines (expressed as kg CO2 /kWh).

3.2.1.2.6 Other fossil fuels: Waste and waste oil

District heating plants and incineration plants report annually 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 must report emission data for SO_2, NOx, CO, NH_3, particles, heavy metals and dioxins, and the amount of waste incinerated 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.
Data on the 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 on the use of waste oil as a fuel source. Activity data for *waste oil* are reported together with waste in the category "other fossil fuels".

3.2.1.2.7 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 aviation and navigation abroad is also included, while the energy used by foreign transport industries 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 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.

An important difference between figures presented in the energy balance sheet (EBS) and figures used in the emission calculations (EC) is that coal/coke used for non-energy purposes as a reductant: Non-energy consumption of coal/coke is specified in the EBS and included in "final consumption", while coal/coke use as a reductant is included in final energy consumption together with coal/coke combustion. The 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 listed by Statistics Norway, see link in appendix B. Emission factors for SO_2 are independent of combustion technology. In cases where technology for removal 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.

3.2.1.3.1 SO2

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 uncleaned emissions; in cases where the emissions are reduced through installed cleaning measures, this will be reflected in emission figures reported from the respective plants.

3.2.1.3.2 PM

Information of whether the emission factors used/emission data for PM10 and PM2.5, include the condensable component, is given where available. Currently, this implies only emissions from fuelwood in 1A4b.

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 QA/QC

The emission sources in the energy sector are subjected to the QA/QC procedures described in section 1.6.

3.2.2 Energy industries

NFR 1A1

Last update: 19.02.2024

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.

3.2.2.2.1 Waste incineration

- *NOX*

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 (SFT 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 from the period 1994/1995. Before 1994 there is only national totals. For estimating the emissions of dioxins for each plant before 1994 an emission factor is derived 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.

- *PCB*

PCB emissions are not reported to the Norwegian Environment Agency. A country specific emission factor has been used to estimate PCB. To take into accounts emission reduction systems implemented in incinerators, this emission factor decreases during the period, following the trend of dioxins emission factor.

- *Heavy metals*

Emissions 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 not detailed 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 faced 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

3.2.2.3.1 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.

3.2.2.3.2 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 Offshore 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 activity data from the field operators are used.

3.2.2.3.3 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, emissions from Russian activities are also 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.

3.2.2.3.4 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 first 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 Offshore Directorate (figures on flaring at one plant is reported to the Norwegian Environment Agency).

3.2.2.3.5 Gas power plants

Norway has one major gas power plant and several minor ones. One large plant was opened in 2007 and ran intermittently, depending on electricity and gas prices, to 2011. The plant was permanently closed in 2014. A second large plant was opened in 2010 and closed down normal operations in autumn 2022. A third plant opened in 2007 and is still in operation. 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. In addition, there are gas power plants within the oil and gas extraction industry which are reported there.

3.2.2.3.6 Oil refineries

The oil refineries annually report their use of different energy carriers to Statistics Norway and the Norwegian Environment Agency. 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 industries are listed by Statistics Norway, see link in appendix B. For some industries and components more information about the derivation of the emission factors is given in this section.

3.2.2.4.1 SO2

- *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 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 NOX

- *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

	Before 2000 kg NO_X/tonne fuel	**After 2000 kg NO_X/tonne fuel**	**Previous default 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.

3.2.2.4.3 TSP, PM10 and PM2.5

- *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.

- *Waste incineration*

Emissions of particles from district heating plants are reported to the Norwegian Environment Agency.

3.2.2.4.4 BC

For energy industries, BC emissions are estimated as fractions of $PM_{2.5}$-emissions. The share of BC has been given by IIASA (Kupiainen and Klimont 2007) as it is used in the GAINS model.

- *Waste incineration*

The share of BC among TSP proposed in Kupiainen and Klimont (2004) has been used to estimate BC emissions. It gives a mass share of 0.9 percent of BC in $PM_{2.5}$.
For incineration of special waste, the same BC share as for heavy fuel oil combustion in residential, commercial, services and agriculture has been used.

3.2.2.4.5 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, Troost 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 used for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene are the emission factor recommended in EEA (2023). Chapter 5C1, table 3-1. Is used for the years 1990-1995, and table 3-2 is used for the years after 1995.
PAH emissions from waste incineration are calculated by emission factors and amount of waste burned. We have no plant or country specific emission profile of PAH from waste incineration at district heating plants in Norway.

3.2.2.4.6 PCB

In order to take into account emissions regulation in waste incineration, which was first implemented in 1995 and reinforced in 2006, the PCB emissions factor decreases along the period. From 1990 to 1994, the value given in the EMEP/EEA guidebook (2007) has been used to estimate PCB emissions from municipal waste and special waste.

In 2010, a PCB emission factor for municipal waste was estimated from emission measurements of waste incinerators. This emission factor has been considered for the estimations of PCB emissions after 2006. For the period 1995-2005, an emission factor has been derived from the dioxins trend observed during the same period.
As no measurements have been done for incineration of special waste, emission factors for the years after 1995 has been estimated using the same trend as for municipal waste. Table 3.4 presents PCB emissions factors.

Table 3.4. Emission factors for PCB from waste incineration plants, mg/tonn of waste

	1990-1994	**1995-2005**	**2006 ->**
Municipal waste	0.82	0.00064	0.000032
Special waste	5	0.0039	0.0002

Source: Statistics Norway, EEA (2007)

3.2.2.4.7 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.

3.2.2.4.8 HCB

For energy industries, HCB emissions have been estimated for the use of coal, light fuel oil, wood waste, black liquor, municipal and other waste. Emission factors used for the energy sector are given in Appendix B.

- *Waste incineration*

HCB emissions are not reported by waste incineration plants. In order to take into account emissions regulation in waste incineration, which was first implemented in 1995 and reinforced in 2006, the HCB emission factor decreases along the period. Most of installations have anticipated 2006 regulation. Therefore, the emission factor from waste incineration in Denmark (Nielsen, Lyck et al. 2010) has been considered since the year 2005. For 1995, emission factor has been estimated using the reduction trend of dioxins emission factor observed between 1995 and 2004. This emission factor has been used for the period 1995-2004. For the period 1990-1994, an emission factor from a former guidebook (EEA 2007) has been considered. Emission factors are presented in the Table 3.5.

Table 3.5. Emission factors for HCB from waste incineration plants, mg/tonn of waste

	1990-1994	**1995-2004**	**2005 ->**
Municipal waste	2	0.9	0.045
Other waste	10	4.5	0.2

Source: Statistics Norway, Nielsen, Lyck et al. (2010), EEA (2007)

- *Extraction of oil and natural gas*

HCB emissions from the use of marine gas oil in offshore platform have been estimated using the same emission factor as for the use of marine gas oil in ship (0.08 mg HCB/tonn of gas oil).

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 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:

- *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: 29.02.24

3.2.3.1 Description

A description of the general method used for estimating emissions from fuel combustion is given in equation 3.1. Emissions from the sector of manufacturing industries and construction include industrial emissions originating to a large extent from the production of raw materials and semi-manufactured goods (e.g., iron and steel, non-ferrous metals, chemicals (e.g., methanol, plastics), fertilizers, pulp and paper, mineral industries, food processing industries, building and construction industry). These emissions are related to fuel combustion only, i.e., emissions from use of oil or gas for heating purposes. Consumption of coal as feedstock and reduction medium is not included in 1A2 but is accounted for under the industrial processes sector (chapter 4).

The sectors included in 1A2 are listed in Table 3.6. Since all the sectors are treated equally, they are described as a group.

Table 3.6. Sectors included in 1A2

NFR Code	Long name
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, paper, and Print
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages, and tobacco
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals
1A2gvii	Mobile Combustion in manufacturing industries and construction
1A2gviii	Stationary combustion in manufacturing industries and construction

Source: ANNEX 1: National sector emissions (EEA/EMEP)

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 the energy balance. This may, in some cases, cause inaccuracies in IEFs, but generally, this should not be regarded as an important issue.

The interannual variation in implied emission factors for heavy metals and dioxins in 1A2 are 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 listed by Statistics Norway, see link 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 decreased since 2010. 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. The IEF increased between 1990 and 2014 but has since dropped sharply.
For some glass production plants, the reported emissions of Pb are not separated into emissions from process and combustion. In these cases, all the emissions are placed on the source that is thought to be the most prominent.
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 during 2001.

3.2.3.2 Activity data

Most of the emission figures are calculated based on 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 sample 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 are not 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, accounting for 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 in both 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, auto diesel 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 auto diesel in the manufacturing industries and on reported sales of duty-free auto diesel 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 1A2g vii.

3.2.3.3 Emission factors
Emission factors used for the manufacturing industries are listed by Statistics Norway, see link 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 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: 20.02.2024

3.2.4.1.1 Method
The calculation methodology applied is described in an internal document at Statistics Norway (Thovsen 2017). According to the IPCC Good Practice Guidance the methodology used is Tier 3a, based on the detailed methodology in the EMEP/EEA Guidebook 2019 (EEA 2019). The method is based on Eurocontrols “Advanced Emission Model”- AEM, combined with data from all aircraft movements to and from Norwegian airports. The method has

“bottom up” estimates and allows estimation of emissions and fuel consumption from traffic data, emission factors and energy use factors for aircraft types (kg/km) according to the engine type.

These calculations make a distribution basis for the majority (> 95%) of total sales of jet kerosene and aviation gasoline within the categories of use (domestic/foreign), nationality (Norwegian/foreign companies) and flight phase (LTO/Cruise). The remaining jet kerosene and aviation gasoline are distributed based on assumptions about place of use and nationality in invoice information in sales data from the oil companies. The invoice information also contains information that forms the basis for the economic distribution of all consumption. There is also a distribution of consumption on the type of aircraft (helicopter, jet engine, small aircraft), which is needed to calculate emissions.
All movements below 1000 meters are included in the “Landing Take Off” (LTO) cycle. Movements over 1000 meters are included in the cruise phase. All emissions from the LTO cycle from domestic and international aviation are included in national totals. Emissions from the national and international cruise cycle are reported separately as memo items (see section 3.2.6.3).

The calculation method described is only valid from 2010 and onwards due to missing traffic data for previous years. The methodology used for the time series 1990 to 2009 is Tier 2 (Skullerud 2014), adjusted by adding some industries that have previously been missing in the activity data, where there is sufficient information to rewrite consumption within these industries. This will have a small effect on the overall distribution between domestic and foreign aviation. No further adjustments have been made to the domestic/foreign distribution.

3.2.4.1.2 Activity data

The types of fuel used in aircrafts are both jet kerosene and aviation gasoline. The latter is used mostly in small aircrafts. The total sales of jet kerosene and aviation gasoline are retrieved from the sales statistics of petroleum products and are believed to cover the actual sales of fuel at Norwegian airports. Helicopter data is collected from several Norwegian airlines as the data source with aircraft movements has incomplete helicopter data. Fuel used in military aircrafts is collected from the Norwegian Defense Research Establishment. Domestic consumption prior to 1995 is estimated by extrapolation based on domestic kilometers flown and is more uncertain. The time series for liquid fuels used in aviation is given in Table 3.7.

Table 3.7. Liquid fuels in aviation, 1990-2022. TJ

	1 A 3 a ii (i) Domestic aviation (LTO)	1 A 3 a i (i) International aviation (LTO)
1990	2 706.19	1 728.84
1995	3 438.85	1 393.28
2000	4 216.40	1 997.84
2005	3 605.36	1 850.01
2006	3 753.51	2 175.62
2007	3 829.49	2 200.73
2008	4 118.29	2 127.03
2009	3 992.53	2 007.35
2010	3 914.73	2 369.70
2011	3 940.22	2 497.09
2012	4 108.76	2 731.94
2013	3 823.02	2 755.27
2014	4 148.22	2 862.50
2015	4 068.97	2 830.82
2016	3 838.76	2 871.99
2017	3 878.38	2 967.89
2018	4 162.49	3 218.17
2019	3 958.35	3 109.63
2020	2 818.91	1 053.33
2021	2 779.93	932.61
2022	3 803.15	2 469.45

Source: Statistics Norway

3.2.4.1.3 Emission factors

Emission factors used are listed by Statistics Norway, see link in Appendix B.
The Norwegian Petroleum Industry Association provides emission factors for SO_2 for the combustion of jet fuel and gasoline (Finstad, Flugsrud et al. 2002). The emission factor for SO_2 varies annually depending on the sulphur content of the fuel used.

New aircraft and flight phase specific emission factors for NO_X, CO, VOC and particles are given in EEA (2023). All particles are found to be less than $PM_{2.5}$ (EEA 2023). The detailed emission factors are combined with the specific fuel consumption for each aircraft and flight phase (EEA 2023), flight data by aircraft type and route from Avinor and the airports (Statistics Norway Annually) and route distances to give weighted emission factors on an aggregated level. There are separate factors for LTO and the cruise phase. The share of BC is assumed to amount to 48 per cent of total PM (EEA 2023). The new emission factors for civil aircraft except helicopters have been used in the inventory back to 1990. Emission factors for helicopters and military aircraft were kept unchanged (EEA 2001, Finstad, Flugsrud et al. 2002).

The weighted emission factors are combined with the activity data (fuel consumption) to estimate emissions from civil aircraft.

3.2.4.1.4 Uncertainties

The uncertainty estimates are listed in Appendix C.
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). However, the new emission model used from 2010 is assumed to have lower uncertainty because of better activity data. As described above, data before 1995 are more uncertain than for later years. This may also to a certain degree affect the time series consistency.

3.2.4.1.5 Source specific QA/QC

The data are annually updated with emission factors and fuel consumption factors for new aircrafts in domestic and international traffic. The trend in CO2 emissions is compared to the trend in domestic and international flights. If available, the consumption data is annually compared to the reported sales of jet kerosene to the Norwegian Tax Administration.

3.2.4.2 Road transport

NFR 1A3b i-v
Last update: 05.02.2024

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 is described in more detail in Holmengen and Fedoryshyn (2015). The methodology corresponds to a Tier 3 methodology from the EMEP/EEA Guidebook (EEA 2023), 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 CO_2 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. Since 2012, a NO_X – component was added to the passenger cars taxation. The share of diesel cars sold has since then been strongly reduced.

Norwegian political incentives for many years have resulted in an expanding purchase of electrical vehicles and plug-in hybrid vehicles, mainly passenger cars. In 2022, there were more than 599 thousand electric passenger cars in Norway, a share of 21 per cent of the total fleet of passenger cars.

In Norway it is required a minimum volume percent of biofuel in the total fuel sold to road transport. Biogas is not included. In 2022, the requirement was 24.5 volume percent. In the requirement, advanced biofuel is counted double, and the actual share of biofuel amounted to about 13 per cent.

3.2.4.2.2 Method

The consumption of gasoline, including bioethanol, for road traffic is estimated as total sales minus consumption for other uses, i.e., a top-down approach. Other uses for gasoline including bioethanol are e.g., leisure boats, snow scooters and motorized equipment. For auto diesel, the total consumption in road traffic is all auto diesel, including biodiesel, charged with auto diesel tax. Consumption on CNG is based on a survey reported by suppliers of CNG. Consumption of LPG is estimated based on figures from the sales statistics on petroleum products and figures from "Drivkraft Norge", a Norwegian association for the fuel and energy sector in Norway.

Pollutants other than CO_2 and fuel-related substances such as SO_2 and heavy metals, are estimated by the emission model of the Handbook of Emission Factors (HBEFA; (INFRAS 2022)). The current inventory uses HBEFA version 4.2. The model uses a mileage approach: Emissions = mileage * emission per km. The model results are used directly without any adjustment for discrepancies between the estimated fuel consumption and the fuel consumption from the Norwegian energy balance.

The HBEFA model provides emission factors and calculate emissions on segments and sub-segments for six vehicle classes: passenger cars, light commercial vehicles, heavy commercial vehicles, urban buses, coaches, and motorcycles (including mopeds). The segments are based on technology. Segments for motorcycles also includes engine volumes, while segments for heavy goods vehicles, urban buses and coaches includes total weight, and light commercial vehicles includes tare weight. The segments are further disaggregated to subsegments based on emission concepts (e.g., Euro-1 – Euro-6). The segments used for Norway in the HBEFA model are given in Table 3.8

Table 3.8. Segments used for Norway in the HBEFA

Vehicle class	Segment	Fuel type	Segment split based on	Engine volume/weight class
Passenger car	PC petrol	Petrol	-	All engine volumes
	PC PHEV petrol	Petrol	-	All engine volumes
	PC diesel	Diesel	-	All engine volumes
	PC PHEV diesel	Diesel	-	All engine volumes
	PC LPG	LPG	-	All engine volumes
	PC BEV	Electric	-	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
	LCV BEV M+N1-I	Electric	Tare weight	< 1305 kilos
	LCV BEV N1-II	Electric	Tare weight	>= 1305-1760 kilos
	LCV BEV N1-III	Electric	Tare weight	>= 1760-3859 kilos
Heavy goods vehicles	RT petrol	Petrol	-	All 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
	RigidTruck BEV <7,5t	Electric	Gross weight	<= 7.5 tonnes
	RigidTruck BEV 7,5-12t	Electric	Gross weight	> 7.5 - 12 tonnes
	RigidTruck BEV >12	Electric	Gross weight	> 12 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
	Tractor for AT BEV	Electric	-	All gross weights
Coach	Coach Std <=18t	Diesel	Gross weight	<= 18 tonnes
	Coach 3-Axes >18t	Diesel	Gross weight	> 18 tonnes
	Coach Electric Std <=18t	Electric	Gross weight	<= 18 tonnes
	Coach Electric 3-Axes >18t	Electric	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 CNG Std >15-18t	CNG	Gross weight	>15 - 18 tonnes
	Ubus CNG Artic >18t	CNG	Gross weight	> 18 tonnes
	Ubus Electric Midi <=15t	Electric	Gross weight	<= 15 tonnes
	Ubus Electric Std >15-18t	Electric	Gross weight	>15 - 18 tonnes
	Ubus Electric Artic >18t	Electric	Gross weight	> 18 tonnes
Motorcycles and mopeds	Moped <=50cc (v<50kmh)	Petrol	Engine volume	<= 50 cc
	MC 2S <=250cc	Petrol	Engine volume	<= 250 cc
	MC 4S <=250cc	Petrol	Engine volume	<= 250 cc
	MC 4S > 250cc	Petrol	Engine volume	> 250 cc

Source: Statistics Norway/Norwegian Environment Agency

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 (free flow, heavy, saturated, stop and go, stop and go II). 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. 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). Fuel consumption in road transport is given in Table 3.9.

- *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 is 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 Anually). 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, 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 several years, 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 collected from an annual report on transport volumes in Norway from the Institute of Transport Economics. 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 2022).
- *Transformation patterns* are calculated using information from Statistics Norway' Road goods transport survey on use of trailers and trailer size (Statistics Norway 2022).
- *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), road gradients 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 (free flow, heavy traffic, saturated traffic, stop and go and heavy 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.

- *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 3.9. Fuel consumption in road transport, 1990-2022. TJ

Year	Petrol	Diesel	LPG	Gaseous fuels	Biofuels
1990	74 464	26 532	-	-	-
1995	72 291	27 062	-	-	-
2000	70 520	29 204	-	22	-
2005	69 697	32 332	124	54	116
2006	68 938	31 628	140	73	231
2007	67 508	34 588	175	102	1 273
2008	70 113	37 035	174	99	3 384
2009	68 770	38 041	182	69	3 992
2010	69 430	40 454	360	106	4 855
2011	68 816	46 801	253	109	4 800
2012	66 659	46 539	215	137	5 516
2013	69 163	50 837	294	145	5 320
2014	68 519	52 368	305	189	5 315
2015	67 693	55 101	246	240	5 865
2016	67 239	59 557	335	528	12 886
2017	64 740	64 231	281	626	20 517
2018	62 071	70 570	275	640	15 084
2019	58 668	76 900	253	847	19 072
2020	54 700	78 706	242	894	16 027
2021	51 122	79 997	269	976	14 738
2022	47 938	86 152	275	1 076	13 970

Source: Statistics Norway

3.2.4.2.4 Emission factors

Emission factors are from the Handbook of Emission Factors (HBEFA). Factors are given as emission per vehicle kilometres for detailed combinations of subsegments and traffic situations. HCB emissions have been estimated using an emission factor extracted from a former version of the EMEP guidebook (EEA 2007). PCB emissions factors from Andrijewski, Bar et al. (2004) has been used to estimate emission from road transport. Table 3.10 presents PCB emissions factors.

Table 3.10. PCB emissions factors for gasoline and diesel combustion

Leaded gasoline	106	mg/tonne
Unleaded gasoline	0.02	mg/tonne
Diesel light vehicles	0.00000005	mg/tonne
Diesel, heavy vehicles	0.00000539	mg/tonne

Source: Andrijewski, Bar et al. (2004)

It has been assumed that PCB emissions vary with the gasoline lead content. Therefore, PCB emissions factor for combustion of gasoline in cars varies from 1990 to 1997 as it is presented in Table 3.11.

Table 3.11. PCB emissions factors for gasoline combustion for the period 1990-1997. Mg PCB/ tonne

	1990	1991	1992	1993	1994	1995	1996	1997
mg/tonne	106	82	74	49	8	8	0.2	0.02

Source: Statistics Norway

Biofuels for transport are handled as separate fuels.
Average factors are listed on Statistics Norway's website, see link in appendix B.

3.2.4.2.5 Uncertainties

The uncertainty estimates are given in Appendix C.

The total sale of fuel in Norway is well known. There are uncertainties concerning the allocation between road and non-road consumption in the energy balance. The total emissions may be sensitive to this allocation, due to different emission calculation methodologies. There is no reason to believe that this has a major impact on the consumption in road transport.

The comparison of bottom-up estimates of fuel consumption from HBEFA with total sales (source specific QA/QC) reveals a discrepancy of 3-20 per cent for petrol, and 0-27 per cent for diesel from 1990-2022. This discrepancy is handled differently for different emission components. Guidelines for greenhouse gas reporting, the IPCC guidelines (IPCC 2006), states that CO_2 emissions should be calculated using fuel consumption, and that sold amount of fuel should form the basis. However, calculations of emissions of NO_X, particulates and several other emissions reported to CLRTAP 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 (e.g., 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. Biofuels are not handled as separate fuels in HBEFA. The estimated fuel consumption for the country can be compared with fuel sold from the sales statistics for petroleum products and the energy balance (including biofuels). The petrol consumption in HBEFA is lower than in the energy balance.

The difference in diesel consumption is fluctuating in the time series, but from 2010 the consumption in HBEFA is lower than in the energy balance and the discrepancy is higher.

It is not known why there is a discrepancy between the consumption in the 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 the road transport emission model:

- *Fuel purchased by foreign vehicles.* Foreign vehicles driving on Norwegian roads are not included in the Norwegian vehicle register statistics. Similarly, no fuel bought by Norwegian vehicles abroad is sampled. 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 driving abroad. There has been an issue that the proportion of heavy vehicles with foreign vehicles increases. Better data related to foreign vehicles driving in Norway and Norwegian vehicles driving abroad would strengthen or refute the current assumption that these two balance each other out. It is likely that there are some "fuel tourism" across the Norwegian border, as the diesel price in Norway is lower than in Sweden. The amount is unknown.
- *Driving patterns.* There may be elements in the driving patterns that causes fuel consumption per kilometre 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 underestimate consumption. These data are however available only for the latter part of the series and cannot explain the discrepancies in the 1990s.

Whether the emission calculations should be corrected for differences in fuel consumption depends on the pollutants in question. 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 whether 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. However, if the discrepancy is due to an underestimation of the fuel consumption per kilometre, the emission estimates should not be corrected unless one finds a clear correlation between changes in consumption per kilometre and emissions per kilometre 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.

In the previous model (SFT 1993, SFT 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 from 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 in the energy balance or not. There is no reason to believe that the total run lengths on Norwegian vehicles are underestimated, and we consider it likely that the reason for the discrepancy lies in the estimates of fuel consumption per kilometre. The energy balance is based on the assessment that Norwegian purchases abroad correspond to foreign purchases in Norway, and the same assessment is applied to the emission calculations.

3.2.4.2.6 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 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 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.

In 2023, the HBEFA is used as source to the BC emissions, and the time series 1990-2021 is recalculated. The time series of $PM_{2,5}$ from diesel has also been recalculated, and is now assumed to be 100 per cent of PM_{10} according to the EMEP/EEA Guidebook (EEA 2023) on road transport.

3.2.4.3 Railways

NFR 1A3c
Last update: 09.02.24

3.2.4.3.1 Description

Railway traffic in Norway uses mainly electricity. 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 diesel used in rail transport is based on sales statistics for petroleum products. Consumption of coal is estimated based on information from different museum railways, and the same figure is used for all years from 1990. The diesel consumption is halved from the level in the early 1990's.

Table 3.12. Fuel consumption in railways, 1990-2022. TJ

	Liquid fuels	Solid fuels
1990	1 342,3	3.9
1995	1 359,3	3.9
2000	835,2	3.9
2005	670,4	3.9
2006	641,0	3.9
2007	664,7	3.9
2008	684,7	3.9
2009	625,8	3.9
2010	529,6	3.9
2011	552,0	3.9
2012	559,0	3.9
2013	545,5	3.9
2014	552,1	3.9
2015	618,4	3.9
2016	611,0	3.9
2017	622,9	3.9
2018	630,9	3.9
2019	614,5	3.9
2020	586,5	3.9
2021	594,3	3.9
2022	716,0	3.9

Source: Statistics Norway

3.2.4.3.4 Emission factors

Emission factors for NO_X, HC and CO 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 factors for PM, BC and NH_3 are from the EMEP/EEA guidebook (EEA 2023). The other emission factors are the same as for diesel machinery in mining and quarrying (see section 3.2.4.7.4.

General emission factors for coal are used in the calculations.

3.2.4.3.5 Uncertainties

The uncertainty estimates are given in Appendix C.

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

3.2.4.3.6 Source specific QA/QC

The diesel consumption from the Energy balance is annually compared with data on consumption reported to Statistics Norway on rail transport statistics.

In 2023, a review on the PM and BC factors revealed that the factors were outdated, and they were updated according to the EMEP/EEA guidebook 2023 (EEA 2023).

3.2.4.4 Electric railway conductors

NFR 1A3c

Last update: 01.09.05

3.2.4.4.1 Method

Electric railway conductors 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 (now called Vy Group).

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 kilometres. 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 kilometre.

Table 3.13. Emission factor for electric railway conductors. g/km

	Emission factor (g/train kilometers)
Cu	0.03

Source: Norwegian Environement Agency

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 million 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 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: 29.01.24

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 guidelines (IPCC 2006).
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.

Fuel sales to the oil and gas extraction sector includes stationary and mobile consumption at offshore facilities as well as consumption at supply ships and other supporting vessels. These sales are split between navigation and energy industries. Information on use for drilling, stationary combustion etc., is reported from the oil companies into the reporting tool Footprint. Consumption for these activities is reported under Energy industries (CRF 1A1c-ii). Only the remaining part of sales, assumed to be for drilling rigs during transit, supply ships, etc., is included with Navigation.

Use of natural gas in navigation, which was introduced in 2003 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 3.14.

Table 3.14. Fuel consumption in national navigation, 1990-2022. TJ

	Liquid fuels	**Gaseous fuels**
1990	22 633	-
1995	32 111	-
2000	31 574	-
2005	31 400	337
2006	33 642	333
2007	33 348	1 586
2008	30 866	1 869
2009	30 018	1 992
2010	35 457	2 091
2011	35 948	2 475
2012	36 406	3 169
2013	36 603	3 730
2014	36 612	4 370
2015	33 913	4 522
2016	32 166	4 056
2017	32 688	4 231
2018	32 607	3 291
2019	35 487	3 154
2020	34 456	3 139
2021	33 570	3 206
2022	34 781	4 164

Source: Statistics Norway

3.2.4.5.4 Emission factors

Emission factors used for navigation are listed by Statistics Norway, see link in appendix B.

- *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 3.15. 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 factors from Marintek are valid for engines with no particular NO_X reduction measures. The NO_X factors used in the inventory are documented in Flugsrud, Hoem et al. (2010).

The method outlined above is used for the years up to 2007. From 2008 onwards, a large number of NO_x reducing technologies have been installed, funded through the NO_x fund and certified by emission measurements. Annual emissions are reported by companies to the NO_x fund and/or to the Norwegian Tax Administration as part of a national NO_x tax system. In 2016, data on NO_x emissions and consumption of fuel in the third quarter of 2016 were collected from companies participating in the NO_x fund with ships operating in Norwegian coastal traffic. The data were made available to Statistics Norway for inventory preparation. The NO_x emissions in these data are mainly based on ship-specific measurements. For ships without measurements, a slightly adjusted version of the Marintek factors were used[6]. Based on these data, an average NO_x factor for domestic navigation in 2016 was calculated. Emission factors for 2008-2015 were obtained by linear interpolation. A similar data collection was performed by the NOx fund in 2020 and an average NOx factor for domestic navigation in 2020 was calculated. Emission factors for 2017-2019 were obtained by linear interpolation. The emission factor for 2021 is projected with the same development as the last five years.

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) and is used in the calculations for the years prior to 2011.From 2011 -2015 the NOx factor is calculated annually based on the average factor for LBDSI/LPDF engines of 7,5 kg NOx/ tonne LNG with the share of ships with new engines and the factor 5,6 kg NOx/ tonne LNG with the share of old engines (MARINTEK

[6] Medium speed engines 200-1000 rpm and high speed engines >1500 rpm used factors from table 3.14. Slow speed engines <200 rpm used 100 kg NO_x/tonne. Medium/high speed engines 1000-1500 rpm used 50 kg NO_x/tonne. (Norwegian Tax Administration, http://www.skatteetaten.no/globalassets/saravgifter/avgiftsrundskriv/2016-nox.pdf)

2017). The share of new engines has been kept constant from 2015 since few new LNG-ships have been built in later years.
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 listed by Statistics Norway, see link in appendix B.

- *NH_3*

Emissions of NH_3 from navigation are reported as "Not Estimated". The EMEP/EEA Guidebook (EEA 2023) 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 3.16.

Table 3.16. 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.[7])

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, Haakonsen 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.

- *BC*

BC emissions are estimated using shares of $PM_{2.5}$ as emission factors. Factors from the IIASA (Kupiainen and Klimont 2007) have been used.

Table 3.17. BC emission factors for oil operated vessels

Fuel	**Emission factor**	
	$PM_{2.5}$ (kg/t)	**BC**
Marine gas oil, light fuel oils	1.5	40%
Heavy fuel oil, heavy distillate	5.1	43%

Source: IIASA (Kupiainen and Klimont 2007)

As no share for BC was found in the literature for the use of natural gas in navigation, BC share has been set to be 50 per cent of $PM_{2.5}$. Indeed, the amount of $PM_{2.5}$ is assumed to be equally shared between BC and organic mass (OM).

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

- *HCB*

HCB emissions from the use of heavy fuel oil and marine gas oil have been estimated using the EMEP-EEA guidebook (2013).

Table 3.18. HCB emission factors for oil operated vessels

Fuel	**Emission factor HCB (mg/t)**
Marine gas oil	0.08
Heavy fuel oil	0.14

Source: EEA guidebook (2013).

- *PCB*

PCB emissions from the use of heavy fuel oil and marine gas oil are considered higher in the navigation sector due to the presence of chlorine in the air. Emission factors determined by Cooper (2004) have been used to estimate PCB emissions.

Table 3.19. HCB emission factors for oil operated vessels

Fuel	**Emission factor PCB (mg/t)**
Marine gas oil	0.36
Heavy fuel oil	0.60

Source: Cooper (2004)

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 NOX 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 NOX factors for different engine types to ±5 per cent. Uncertainties in emission factors are shown in Table 3.20.

Table 3.20. 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 (2001)

3.2.4.5.6 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 has not 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 facilities 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 1A2 g-vii etc.

Last update: 15.02.24

3.2.4.7.1 Description

The category "motorized equipment" comprises off-road transportation and other machinery, which are all mobile combustion sources except on road, sea, air, and railway. Agricultural and construction equipment are the most important categories. Other categories include mines and quarries, forestry, snow scooters, leisure boats and miscellaneous household equipment.

Emissions from motorized equipment are reported under several categories:

Table 3.21. Motorised equipment categories

	NFR
Manufacturing and construction	1A2g-vii
Commercial and institutional	1A4a-ii
Households	1A4b-ii
Agriculture/Forestry/Fishing	1A4c-ii
Military	1A5b

Source: Statistics Norway/Norwegian Environment Agency

Primarily consumption of gasoline (including bioethanol) and diesel is considered.

3.2.4.7.2 Method

Emissions are estimated through the general methodology described in section 3.2.1.1, involving consumption figures and appropriate emission factors.

3.2.4.7.3 Activity data

Consumption of gasoline and diesel are handled differently. They are both based on data from the energy balance. Diesel used in off-road vehicles are tax-free from 1994, and tax-free diesel in the years 1990-1993 are extrapolated based on the split between diesel with or without tax in 1995-1998.

<u>1A4b-ii households</u>

The consumption of gasoline and tax-free diesel in leisure boats is estimated based on a model using data on size of the fleet, type of fuel, 2- and 4-stroke engine, size of engine, and the expenses on fuel. The data is collected from a boating survey (Båtlivsundersøkelsen) in 2011 and 2017, and the time series are extrapolated. The consumption has been assigned to households. For the data year of 2022 the model was not used as normal. This was due to uncertainty about the quality of the results emerging from the model when updated with 2022-data from The boating survey. Instead, an estimate for the development in total fuel consumption for leisure boats from 2021–2022 was used. The method for leisure boats is being revised in 2024. The gasoline consumption in snow scooters is based on the number of scooters, annual mileage, and consumption per kilometres on 2- and 4-stroke engines. The fleet data is obtained annually from the Norwegian Public Roads Administration. Annual mileage is assumed to be 850 km/year per scooter. The consumption (l/km) on 2- and 4-stroke engines are based on data from importers of snow scooters. The petrol consumption has been assigned to households. Smaller motorized equipment on gasoline (e.g., chainsaws and lawn mower) is calculated using 2% of the gasoline consumption in households (including bioethanol) deducted consumption for leisure boats.

<u>Motorized equipment other than household</u>

The figures for consumption of off-road diesel in agriculture (e.g., in tractors) come from Statistics Norway's Sample Survey of Agriculture and Forestry (LU). This is a form-based sample survey where agricultural holdings report how much diesel they have used in their business activity. Questions regarding energy are only included in LU every 3–4 years. Activity data for intervening years is calculated by using the percentage change in quantities in the aggregate accounts for diesel of the Budget Committee for Agriculture as calculated by the Budget Committee for Agriculture (Nibio).

Consumption of off-road diesel in forestry, manufacturing and construction, commercial and institutional is covered by the annual statistics on sales of petroleum products. Distributor sales are broken down by industry according to distribution formulas.

3.2.4.7.4 Emission factors

Emission factors used are listed by Statistics Norway, see link in appendix B.
For diesel machinery, emission factors for HC, CO, and PM10 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. For diesel, emission factors from a Danish report (Winther and Nielsen 2006) is used. NMVOC factors were calculated by subtracting an assumed CH4 fraction of 0.3 g/kg diesel. The emission factors used in the emission model for tractor and construction machinery are calculated from the basic factors in Winther and Nielsen (2006), weighted by the age and engine rating distribution of the tractor and construction machinery populations, as well as assumptions on motor load and operating hours and the introduction scheme for emission regulations by the EU (Stage I, II, III and IV). Emission factors for snow scooters are adapted from the factors for mopeds in the road traffic emission model (HBEFA).

3.2.4.7.5 Uncertainties

The estimates of consumption are considered quite uncertain. The total consumption of gasoline and tax-free diesel is well known, while the distribution between the motorized equipment is not. Consumption in leisure boats is the main factor to the uncertainty.

3.2.4.7.6 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.

3.2.4.8 Automobile tyre and brake wear

NFR 1A3b vi
Last update: 14.03.22

3.2.4.8.1 Tyre wear

- *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.

- *Method*

A Tier 1 method is used to estimate emissions from tyre wear as speed-dependency is not accounted for.

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.

- *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.

- *Emission factors*

Particles

The emission factors used for calculating the emission of particles are given by TNO (Institute of environmental and energy technology 2002). The emission factors are based on several Dutch and British studies. Recommended emission factors for TSP and PM_{10} are taken from 'Institute of environmental and energy technology (2002). Emission factor for $PM_{2.5}$ was set to be zero. A new report from TNO (TNO 2008) presents emission factors for all three fractions of particulate matter. The emission factors for TSP and PM_{10} are in the same range as the emissions factors given in 'Institute of environmental and energy technology (2002). In the Norwegian inventory, it has been chosen to include $PM_{2.5}$ emissions using the same ratio between PM_{10} and $PM_{2.5}$ as the ratio between PM_{10} and $PM_{2.5}$ from TNO (2008). The emission factors used are given in Table 3.22.

Table 3.22. 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, TNO 2008)

BC

BC is estimated as a fraction of $PM_{2.5}$. Emission factors depend on the type of vehicle. IIASA (Kupiainen and Klimont 2004) gives emission factors for Black Carbon and Organic Carbon as share of TSP. Since the sum of emissions of BC and OC must be lower than $PM_{2.5}$ emissions, the emission factors have been adjusted.

Table 3.23. Emission factors for BC from tyre wear in share of PM2.5. Particles are shown in kg/mill. km

	TSP	$PM_{2.5}$	BC
Passenger cars	69	0.69	30%
Light duty vehicles	90	0.9	30%
Heavy duty vehicles	371,25	3.71	30%
MC	34,5	0.35	30%

Source: IIASA (Kupiainen and Klimont 2004)

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 3.22). This gives the emission factors for the heavy metals As, Cd, Cu, Cr and Pb from tyre wear (Table 3.24).

Table 3.24. 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

Source: van den Brink (1996)

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, Haakonsen et al. 2001).

PAH

Emission factors for PAH are given in Finstad, Haakonsen 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 3.25. There are no data available for Benzo(a)pyrene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene. All PAH-4 emissions are assumed to be benzo(b)fluoranthene. The PAH-4 profile is given in table 3.25.

Table 3.25. Emission factors for PAH from tyre wear. g/mill. Km

	PAH	PAH-4
Light duty vehicles	10.4	6
Heavy duty vehicles	0.1	0,035

Source: Finstad, Haakonsen et al. (2001)

Table 3.26. PAH profile road dust, also used for tyre wear (only PAH-4 is shown)

	Per cent
Benzo(a)pyrene	..
benzo(b)fluoranthene	100
benzo(k)fluoranthene	..
indeno(1,2,3-cd)pyrene	..

Source:Finstad, Haakonsen et al. (2001)

- *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.
The heavy metal emission factors are based on the particle emission factors for PM10, 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.
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, Haakonsen 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.

- *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

- *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.

- *Method*

A Tier 1 method is used to estimate emissions from brake wear as speed-dependency is not accounted for.

<u>Particles</u>
Emissions of particles are calculated based on emission factors recommended by an annual mileage.

<u>Heavy metals</u>
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 kilometres and the brake blocks' metal content.

<u>Brake wear, private cars and vans</u>
To calculate emissions, brake wear first must 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 the front after 30 – 40 thousand kilometres and at the back after 60 – 80 thousand kilometres. A private car drives in average 12

thousand kilometres each year. Assuming that the brake blocks are changed after 60 thousand kilometres, 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 40 and 60 thousand kilometres, respectively. Brake wear per kilometre is given equations (3.4) and (3.5):

(3.4) Front brake blocks (private cars): 0.7*4*0.15/40 000

(3.5) Back brake blocks (private cars): 0.7*4*0.11/60 000

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

<u>Brake wear, heavy duty vehicles</u>

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 100 thousand kilometres when the brake blocks are worn 70 per cent.

<u>Metal content</u>

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 3.27). For heavy duty vehicles, the metal content is independent of age or type of brake block.

Table 3.27. 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

Source: Stockholms luft- och bulleranalys (1998)

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.

- *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.

- *Emission factors*

Particles

Emission factors recommended by TNO (Institute of environmental and energy technology 2002), based on different European studies, are used (Table 3.28).

Table 3.28. 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)

BC is estimated as a fraction of TSP from emission factors depending on the vehicle type, given by IIASA (Kupiainen and Klimont 2004).

Table 3.29. Emission factors for BC from tyre wear in share of TSP. Particles are shown in kg/mill. km

	TSP	**BC**
Passenger cars	6	1%
Light duty vehicles	7.5	1%
Heavy duty vehicles	32.25	1%
MC	3	1%

Source: IIASA (Kupiainen and Klimont 2004)

Heavy metals

Emission factors for Cr, Cu and Pb are derived based on the above information and are given in Table 3.30.

Table 3.30. Heavy metal emission factors for brake wear. g/mill. km

	Private cars and vans	**Heavy duty vehicles**
Cr	0.36	2.77
Cu	342.33	151.72
Pb	38.16	7.68

Source: Statistics Norway

- *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.

No other major emission components are assumed missing.

- *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: 14.02.24

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 and will whirl up when the road surface dries up. Bitumen is a mixture of a great number of organic components, including PAH components. The emissions of benzo(b)fluoranthene, 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 from the authorities about problems caused by PM, has reduced the numbers of cars with studded tyres 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 have been decreasing even though the annual total driving length has been increasing until recent years (affected by the pandemic). In contrast, emissions from automobile tyre and brake wear are calculated by multiplying the driving length with an emission factor, not taking into account the type of tyres. Since the driving length has been increasing, the emissions from this source category have followed a similar pattern. The most recent years have been affected by the Covid-19 pandemic and driving length and emissions went down in 2020 and up again in 2021 and 2022.

3.2.4.9.2 Method

The model calculating road abrasion in Norway has been reviewed and is updated in 2023. This work will continue in 2024 and further changes are expected.

Particles

PM_{10}

The method is prepared by TI/SINTEF and documented in SFT (1999) adjusted with parameters from the Nordic model 'Non-exhaust Road Traffic Induced Particle emissions' (NORTRIP) (Denby 2023).

To calculate average emission Q (ton/year) of PM10 formula (3.6) is used:

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

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: wet road scaling

α: amount of road wear that is PM_{10}

The SPS is the road wear caused by studded tyres given as gram per kilometre per vehicle, separately for light and heavy vehicles. The road surface has stronger wear resistance on roads with heavy traffic than on roads with little traffic and the value vary with the amount of traffic. It is also dependent on vehicle speed, the quality of stone materials used in the pavement and the weight of the studs. The studs have in the recent years become lighter. SPS values used in the calculations are currently set as 6 g/km for light vehicles, and heavy vehicles wear 5 times more than light vehicles (Denby 2023).

Annual traffic load ($n \bullet l$ 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 and Troms og Finnmark. In these counties, use of studded tyres is forbidden between 1st of May to 15th of October. It is assumed that studded tyres are used the whole period when it is allowed. This means that parameter *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 3.31. The use of studded tyres varies significantly over the years and there has been a decrease since 1990. The parameter *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 1995, Norwegian public roads administration 1995, Norwegian public roads administration 1998). 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, 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. In 1990 it is assumed that the studded tyre share was 90 per cent. Heavy vehicles have a studded tyre share of around 60 per cent of light vehicles (Denby 2023).

Table 3.31. 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**	
Oslo	51.9	32.4	21.2	31.3	29.2	28.4	24.0	
Drammen	49.6	48.7	52.1	41.8	42.3	40.6	31.5	
Stavanger	38.1	31.3	26.8	29.3	28.8	35.2	30.1	
Bergen	37.0	29.4	28.3	31.0	30.7	30.4	30.3	
Trondheim	67.0	64.4	62.1	44.4	40.2	38.8	38.1	
	2005/ 2006	**2006/ 2007**	**2007/ 2008**	**2008/ 2009**	**2010/ 2011**	**2011/ 2012**	**2012/ 2013**	**2013/ 2014**
Oslo	19.9	20.3	17.0	16.4	14.4	16.1	15.2	15.2
Drammen	27.0	28.0	27.3	22.9	25.2	25.0	20.6	20.6
Stavanger	32.2	28.4	33.2	19.6	27.9	28.9	26.8	26.8
Bergen	29.6	21.4	10.5	14.7	12.3	18.0	16.6	16.6
Trondheim	32.9	31.2	19.4	28.6	25.8	28.4	35.3	35.3
	2014/ 2015	**2015/ 2016**	**2016/ 2017**	**2017/ 2018**	**2018/ 2019**	**2019/ 2020**		
Oslo	15	15	13	11	9	9		
Drammen	20	20	20	18	17	16		
Stavanger	24	23	25	20	15	14		
Bergen	15	14	13	14	13	12		
Trondheim	36	36	35	31	27	24		

Source: The Norwegian Public Roads Administration

The parameter *w* reflects the loss of road dust through wet removal and other processes that are not suspension. It is assumed there is no emission when the roads are wet or snow covered. The road wear continues when the roads are wet, and this will be suspended once the roads dry out. There are a few low traffic roads that is ice covered and road wear will not occur (Denby 2023).

The fraction of road wear that is PM10 (parameter α) is set to 28 per cent based on laboratory experiments and dust sampling of road surfaces. They indicate that road wear occurs almost completely in the size < 200 µm and that around 25 - 30% of this is in the size fraction < 10 µm (Denby 2023).

Emissions of TSP and PM2.5 annually calculated based on PM10 (EEA 2023).

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

Emissions of Benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene (PAH-4) are calculated based on emission factors from Larssen (1985) and annually generated road dust of PM_{10}.

3.2.4.9.3 Activity data

The activity data used for calculating the emissions of TSP, $PM_{2.5}$, Cd and PAH are annually generated PM_{10} of road dust, see section 3.2.4.9.2.

3.2.4.9.4 Emission factors

The emission factors for particles can be derived from the parameters given under section 3.2.4.9.2. PM10 is assumed to be 50 per cent of TSP (EEA 2023) and PM2.5 is 16.7 per cent of PM10.

BC is estimated as a fraction of $PM_{2.5}$. Emission factors depend on the type of vehicle. IIASA (Kupiainen and Klimont 2004) gives emission factors for Black Carbon and Organic Carbon as share of TSP. Since the sum of emissions of BC and OC must be lower than $PM_{2.5}$ emissions, the emission factors have been adjusted.

Table 3.32. Emission factors for BC from tyre wear in share of TSP

	BC
Light duty vehicles	0.83%
Heavy duty vehicles	0.83%

Source: IIASA (Kupiainen and Klimont 2004)

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 3.33.

Table 3.33. PAH and Cd emission factors from road dust1. g/tonne. PM10 of road dust

	Emission factor (g/tonne PM_{10} from road dust)
Norwegian standard (PAH-total)	61.7
Benzo(a)pyrene,	..
benzo(b)fluoranthene	5,5
benzo(k)fluoranthene	..
indeno(1,2,3-cd)pyrene,	..
Cd	22.5

[1] Dry road surface.

Source: Finstad, Haakonsen et al. (2001)

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 3.33, 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

The uncertainties on the calculated PM emissions are expected to be reduced caused by the review and updates in the model during 2023 and 2024.

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 Source specific QA/QC

The model calculating road abrasion in Norway has been reviewed and is updated in 2023. This work will continue in 2024 and further changes are expected. The review revealed a large underestimation of PM emissions caused by parameters in the model that were outdated. These are currently replaced by parameters from the Nordic model 'Non-exhaust Road Traffic Induced Particle emissions' (NORTRIP).

3.2.5 Other sectors

NFR 1A4/1A5
Last update: 20.02.2024

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*

For the years before 2005 and for 2012, the use of wood in households is based on the annual survey on consumer expenditure which gives the amount of wood burnt. The statistics cover purchase in physical units and estimates for self-harvest of wood. The survey figures refer to quantities acquired, which do 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.
Use of fuelwood in households for the years from 2005 to 2011 and after 2013 is 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. For the period 2005 to 2011 the figure used in the emission calculations is the average of 5 quarterly surveys (1 survey per quarter plus a round of bonus questions in the 4th quarter). Since 2013 the figure used in the emission calculations is the average of 3 quarterly surveys (Quarters 1, 2, and 4). Household biomass combustion is minimal in the 3rd quarter, and therefore has little overall effect on results. Otherwise, the surveys used in 2005-2011 and after 2013 are identical.

All surveys used to gather data on household wood combustion have used the same methodology for sampling and controlling for bias in sampling and missing responses, reducing the risk for inconsistency in the time series. Combustion takes place in small ovens in private households. The general downward trend in emissions since 2012 can be attributed to reduced consumption of wood due to increased electrification of household heating, milder winters, and the phasing in of more efficient wood stoves using newer technology.

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 domestic 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*

Figures on LPG consumption prior to 2005 are taken from agriculture statistics. From 2005 and onwards, total consumption is given by the annual sales statistics for petroleum products and distributed to agriculture industry using the share of direct sales in 2009-2012. Until further work is done, the same distribution formula is applied to all these years. A figure on the minor use of coal was previously collected annually from the only consumer. Since 2002, however, there has been no 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. The survey was first carried out in 2004, but data on inland consumption of natural gas had been collected since 1994. Prior to 1994 the consumption was insignificant.

- *Fishing*

Consumption of petroleum products (marine gas fuel, heavy distillate and heavy fuel oil) is covered by the annual statistics on sales of petroleum products. Distributor sales are broken down by industry according to distribution formulas. Monetary figures on refunds and exemptions from the basic fee on mineral oil are used for distributing consumption of marine gas oil that is not sold directly to industries. Only industries where substantial amounts of marine gas oil are consumed are included: Fishing, extraction of crude petroleum and natural gas, domestic coastal transport, and international sea transport. It is assumed that the distribution of refunds and exemptions from the fee is representative for the distribution of consumption of marine gas oil, even though the refund data also cover small amounts of heavy distillates and residual fuel oil. The figures are not consistent and do not cover all the relevant industries until 2015. Thus, the figures for 2015 are used for the years 2010-2015.

- *Commercial and institutional sectors*

Consumption of petroleum products is retrieved from the statistics on sales of petroleum products. For stationary petroleum products like light heating oil and heating kerosene, more sales are made directly to users than via distributors. The distribution of the direct sales will then be used as distribution formulas, with the assumption that the direct sales have the same industrial classification as the distributor sales.
From 2005 and onwards, total consumption of LPG is given by the annual sales statistics for petroleum products and distributed using the shares of direct sales in 2009-2012, as for agriculture. It is assumed that LPG consumption in the transport industries, as well as sale and maintenance of vehicles, support activities for transportation and rental and leasing activities is used for transport. For the years prior to 2005 the source of LPG consumption is statistics on the construction industry.
Consumption of natural gas is collected in a separate survey. When necessary, assumptions are made to break down consumption in accordance with the detailed industrial classification. Calculated emissions from combustion of biogas at a sewage treatment plant are included for all years since 1993.

- *Military*

Fuel used in military aviation are collected annually 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 listed by Statistics Norway, see link in appendix B.
Emission factors for fuelwood 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 listed by Statistics Norway, see link in appendix B.
The country specific emission factor for PAH-4 is split into benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene based on information from Guidebook 2013, chapter 1A4.

Table 3.34. Emission factors for fuelwood, g/kg dry matter, BC in share of PM2.5 emissions

	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
$PM_{2.5}$	16.435	21.6	12.7
$PM_{2.5}$ large cities	16.435	16.5	11.6
BC	9% of $PM_{2.5}$	0.96	0.86
BC large cities	9% of $PM_{2.5}$	1.01	0.9
PCB	0.1184	0.1184	0.0156
Benzo(a)pyrene,	0.82	0.74	0.006
benzo(b)fluoranthene	1.29	1.16	0.01
benzo(k)fluoranthene	0.30	0.27	0.003
indeno(1,2,3-cd)pyrene,	0.59	0.53	0.005

Source: PAH : Finstad, Haakonsen et al. (2001), TSP, PM_{10}, $PM_{2.5}$ and BC from ovens : SINTEF (2013), TSP, PM_{10}, $PM_{2.5}$ and BC from fireplaces: Aasestad (2013), PCB: Nielsen, Plejdrup et al. (2015), other pollutants: Haakonsen and Kvingedal (2001). Condensables are included in the PM-emissions.

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 has also 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 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: 29.01.24

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

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. Use of natural gas in navigation is based on sales figures reported to Statistics Norway from the distributors. 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. Sales figures for international sea transport from Statistics Norway's natural gas survey are used for natural gas.

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 jet kerosene and aviation gasoline used international in the LTO and cruise phase. Memo item for civil aviation includes the domestic and international cruise phase.

In the time series from 2010 onwards, figures on total aviation fuel consumption are derived from sales data reported to Statistics Norway from the oil companies. The sales data do not distinguish between domestic and international consumption. As a basis to allocate the fuel consumption on domestic and international aviation, a "bottom-up" estimation is used based on traffic data, emission factors and energy use factors (described in section 3.2.4.1). In the time series before 2010, the consumption of aviation bunker fuel in Norway were estimated as the difference between total purchases of jet kerosene in Norway and domestic consumption, collected from airline companies operating domestic traffic.

3.2.6.3.2 Activity data

Aviation fuel consumption is derived from sales data reported to Statistics Norway from the oil companies. Data on fuel bought abroad are collected from Norwegian airline companies.

3.2.6.3.3 Emission factor

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

3.3 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, fugitive emissions from the gas terminals onshore and fugitive emissions in connection with venting and flaring offshore.
For most sources, only NMVOC emissions are reported. NMVOC is also the only pollutant for which fugitive emissions constitutes a major part of emissions from the energy sector: Up to 78 per cent around the year 2000, and 43-58 per cent in the last decade. For all other pollutants, fugitive emissions constitute less than 1 per cent of emissions from the energy sectors. These pollutants are reported from combustion in flaring in oil and gas extraction and in oil refineries, as well as in coal fires. Some additional particulate emissions are reported from coal handling.
Emissions of NMVOC rose from 1990 to a maximum in 2001 due to emissions from oil loading and storage. These emissions have since been significantly reduced and were down to 21 per cent of the 1990 level in 2022. Emissions of other pollutants have also been reduced since 1990, particularly for SO_2 where refinery flaring is the main source.

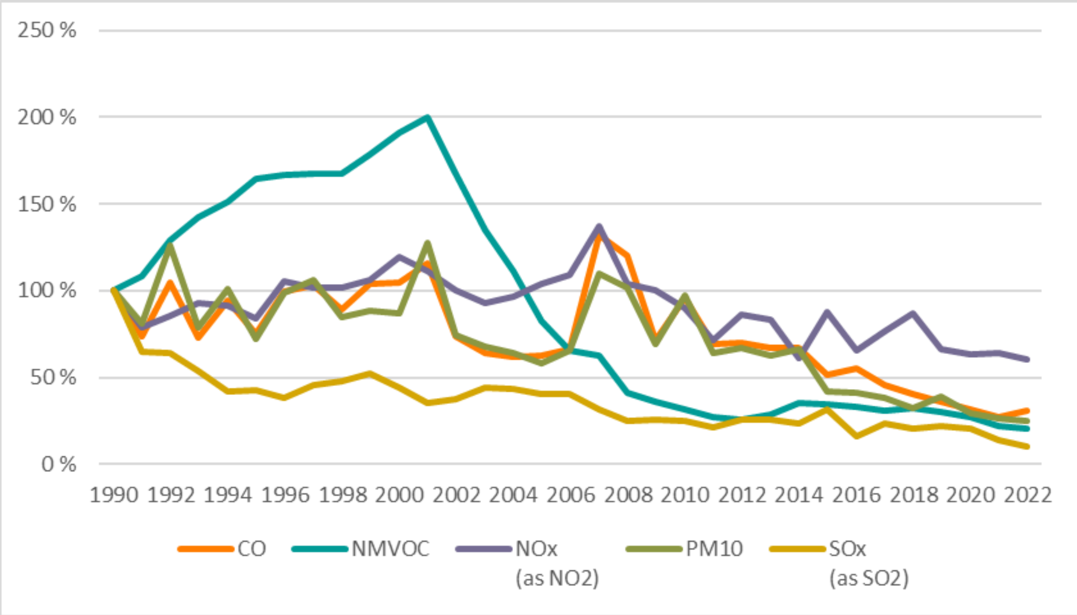


Figure 3.2. Trends for the fugitive emissions for most of the long-range transboundary air pollutants from fuels. Index 1990 = 100%. Source: Statistics Norway/Norwegian Environment Agency

3.3.2 Coal mining and handling

NFR 1B1

Last update: 14.03.22

3.3.2.1 Description

Coal has been shipped from Svalbard since 1907. Today there is one coal mine at Spitsbergen (the largest island in the Svalbard archipelago) operated by a Norwegian company. As the Norwegian emission 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 mines near Longyearbyen and at Pyramiden are defined as surface mines, whereas the mine in Barentsburg is an underground mine.
In 2005 there was a fire in one of the Norwegian coal mines and this caused that the production was almost halved from 2004 to 2005.

Russian production has since 2001 been considerably smaller than the Norwegian production. In 2008 a fire started in the Russian mine at Barentsburg. Shortly after the fire started, the mine was filled with water and hence there were no significant emissions from the fire. This is the reason why emissions from the fire are not estimated. The production in 2008 and 2009 was therefore 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. Emissions from fires are currently reported in 1B1b, see below.
Emissions from NMVOC and particles from handling of coal are included in the inventory.

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 (EEA 2023).

- *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(EEA 2023).

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 (EEA 2023). The Tier 2 factors used are 3 kg NMVOC per tonne coal for underground mines and 0.2 kg NMVOC per tonne coal for surface mines.

- *Particles*

Emission factors for particles are taken from EMEP/EEA Guidebook(EEA 2023). 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 Uncontrolled combustion and burning coal dumps

NFR 1B1b
Note: Emissions from a 2005 fire is reported in NFR category 1B1b *Solid fuel transformation*. This is due to a misreading of the IPCC 2006 guidelines, where the category 1B1b refers to

"Uncontrolled Combustion, and Burning Coal Dumps" (vol 1, table 8.2). However, in the CRF and NFR reporting tables, the classification from the IPCC 1996 guidelines where maintained, and 1B1b was retained as "Solid fuel transformation". The reporting will be revised in the next reporting cycle.
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 (see link in appendix B to factors listed by Statistics Norway) have been used in the calculations.
Emissions of BC have been estimated using the same share of $PM_{2.5}$ as used for coal burning.

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. Emission from fires in Russian coal mines on Svalbard are not included.

3.3.3.6 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: 04.03.21

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 offshore and at oil terminals onshore cause emissions of NMVOC. Non-combustion emissions from Norway's two oil refineries include NO_X, NMVOC, SO_2 and particulates. Gasoline distribution causes emissions of NMVOC, however, these emissions have decreased due to a reduced demand on gasoline from passenger cars. 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 differentiated tax on passenger cars (PC) from January 1st 2007. This resulted in diesel driven cars becoming less expensive than gasoline driven cars. The share

of new PCs that run on diesel increased from 48 per cent in 2006 to 74 per cent in 2007. The share of new diesel cars remained high until 2011; after this the diesel share started to decline, giving room to more and more new hybrid and electric cars.

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, BC, PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) 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 3.35 gives an overview over the calculations of the fugitive emissions of NMVOC and other gases.

Table 3.35 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	*CO_2*	*CH_4*	*N_2O*	*NMVOC*	*Method*	*Emission factor*	*Activity data*
1.B.2.a Oil							
i. Exploration	*IE*	*R*	*NO*	*R*	*Tier II*	*CS*	*PS*
ii. Production	*IE*	*R*	*NO*	*R*	*Tier II*	*CS*	*PS*
iii. Transport	*E*	*R/E*	*NO*	*R/E*	*Tier II*	*CS*	*PS*
iv. Refining/Storage	*R/E*	*R*	*NO*	*R*	*Tier II*	*CS*	*PS*
v. Distribution of oil products	*E*	*NE*	*NO*	*R/E*	*Tier II*	*C/CS*	*CS/PS*
vi. Other	*NO*	*NO*	*NO*	*NO*			
1.B.2.b Natural gas							
i. Exploration	*IE*	*IE*	*NO*	*IE*	*Tier II*	*CS*	*PS*
ii. Production	*IE*	*R*	*NO*	*R*	*Tier II*	*CS*	*PS*
iii. Processing	*IE*	*IE*	*NO*	*IE*	*Tier II*	*CS*	*PS*
iv. Transmission	*IE*	*IE*	*NO*	*IE*	*Tier II*	*CS*	*PS*
v. Distribution	*IE*	*E*	*NO*	*IE*	*Tier II*	*OTH*	*CS/PS*
vi. Other	*E*	*R*	*NO*	*R*	*Tier II*	*CS*	*PS*
1.B.2.c							
Venting							
i. Oil	*IE*	*R*	*NO*	*R*	*Tier II*	*CS/PS*	*PS*
ii. Gas	*IE*	*R*	*NO*	*R*	*Tier II*	*CS/PS*	*PS*
iii. Combined	*R/E*	*R/E*	*NO*	*R/E*	*Tier II*	*CS/PS*	*PS*
Flaring							
i. Oil (well testing)	*R/E*	*E*	*E*	*R/E*	*Tier II*	*CS*	*PS*
ii. Gas							
Gas and oil fields	*R/E*	*R/E*	*E*	*R/E*	*Tier II*	*CS*	*PS*
Gas terminals	*R*	*R*	*E*	*R/E*	*Tier I*	*CS*	*CS*
Refineries	*R*	*R*	*R/E*	*E*	*Tier I*	*CS*	*CS*
iii. Combined	*IE*	*IE*	*IE*	*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

3.3.4.2.1 Loading and storage of crude oil offshore and on shore

- *NMVOC*

Emissions from loading and storage of crude oil produced on the Norwegian continental shelf (NCS) are included in the Norwegian inventory. This includes oil loaded from oil fields that spans over both the Norwegian and United Kingdom's continental shelf when loading takes place on the Norwegian part of the shelf.

For the years 1990-2002 the emissions of CH_4 and NMVOC is calculated by Statistics Norway. The calculation is 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 used in the calculation were annually reported by the field operators. In addition, emission

figures were annually reported to the Norwegian Environment Agency and used in the QC of the emission figures calculated by Statistics Norway.
From 2003, emissions of CH_4 and 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 emissions factors are reported from each field operator into the database Footprint. The database is operated by Offshore Norway (the employer and industry organization for companies with activities related with the Norwegian continental shelf). Although the method of obtaining data changed in 2002, the figures will be comparable with the corresponding ones for 1990-2002.
Norway considers that the method for calculating the CH_4 and NMVOC emissions from loading and storage of crude oil is consistent for the period 1990-2022.
For the two Norwegian oil terminals onshore, the emissions from loading of crude oil are reported annually from the terminals to the Norwegian Environment Agency. At one of the terminals, a VRU for recovering NMVOC was installed in 1996, and at the other, a VRU was installed in 2008. The efficiencies of the VRU's are about 80% and 90%, respectively. The calculation of the emissions of CH_4 and NMVOC at both terminals is based upon the amount of crude oil loaded and oil specific emission factor dependent of the origin of the crude oil loaded.

3.3.4.2.2 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.

3.3.4.2.3 Gasoline distribution

- *NMVOC*

Emissions from gasoline distribution are calculated from the amounts of gasoline sold from the sale statistics and emission factors for, respectively, loading of tankers at gasoline depots, loading of tanks at gasoline stations, and loading of cars.

3.3.4.2.4 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 counting 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.

3.3.4.2.5 Venting

- *NMVOC*

Emissions of CH_4 and NMVOC from cold venting and diffuse emissions for each field are reported annually to the Norwegian Environment Agency from the field operator. The indirect CO_2 emissions are calculated by Statistics Norway.

To improve the understanding of fugitive emissions of methane and NMVOC (i.e., cold venting and diffuse emissions) from the upstream oil and gas facilities on the Norwegian Continental Shelf, the Norwegian Environment Agency conducted a study in October 2014 to March 2016 (Add Novatech AS 2016). The study resulted in a new method for calculation and reporting of venting and diffuse emissions from offshore oil and gas production fields in the field operators' annual reports from 2017 onwards (Offshore Norge 2023). For the years 1990-2016 recalculated emission estimates were reported in IIR 2020.

The annual emission inventory for *venting* from each petroleum facility is quantified (calculated) using methods currently available for each individual source (Offshore Norge 2023). For some vents, the emissions are measured using flow meters. Emissions that cannot be measured are determined by means of emission factors, by process simulation or by using tailormade software or by other adequate methods. All quantification methods used to establish vented methane emission inventories are subject to significant uncertainties, spanning from a few percent to several tens of percent for single sources. The largest percentages of uncertainty are those for emission sources with small emissions.

Diffuse emission (leaks of natural gas directly into the atmosphere) is quantified according to the "OGI leak / no leak" method, where high-sensitivity IR cameras are used to detect small gas leaks ((Offshore Norge 2023). All the facilities on the Norwegian continental shelf are scanned with such cameras on an annual or semi-annual basis. This is also the case for the onshore oil and gas facilities (refineries and gas terminals).

Table 3.36 illustrates the data in the annual report from the operators based on the study (Add Novatech AS 2016, Add Novatech AS 2016, Add Novatech AS 2016, Add Novatech AS 2016, Husdal, Osenbroch et al. 2016). The actual reporting is more detailed, with several sub sources for each main source. Small discrepancies between NFR data and the table are due to differences in updating status, etc.

Table 3.36. Venting emissions from offshore oil and gas production in 2022. Reported by field operators.

Source ID	**Main source**	**Sub source**	**Emissions**		
			CH_4 (t)	nmVOC (t)	CO_2 (t CO_2 eq.)[8]
1.1	Measured emissions	Measured common vent	2406	3315	74049
10.1	TEG[1] regeneration	TEG[1] degassing tank	0	0	0
10.2	TEG[1] regeneration	TEG[1]regenerator	50	546	2583
10.3	TEG[1] regeneration	Stripping gas	230	567	7631
20.1	MEG[2] regeneration	MEG[2] degassing tank	0	0	0
20.2	MEG[2] regeneration	MEG[2] regenerator	3	179	489
20.3	MEG[2] regeneration	Stripping gas	0	163	359
30.1	Amine regeneration	Amine degassing tank	0	0	0
30.2	Amine regeneration	Amine regenerator	0	0	0
40.1	Produced water handling	Produced water degassing tank	181	77	5201
40.2	Produced water handling	Flotation tank / CFU	146	37	4136
40.3	Produced water handling	Flotation gas	0	0	0
40.4	Produced water handling	Discharge caisson	1053	263	29786
50.1	Centrifugal compressor sealant oil	Degassing pots	0	0	0
50.2	Centrifugal compressor sealant oil	Sealing oil retention tank	1	0	35
50.3	Centrifugal compressor sealant oil	Sealing oil storage tank	1	1	29
60.1	Piston compressor	Separator chamber	18	21	554
60.2	Piston compressor	Crank shaft housing	16	19	486
70.1	Dry compressor seals	Primary seal gas	563	285	16237
70.2	Dry compressor seals	Secondary seal gas	39	11	1104
70.3	Dry compressor seals	Leakage of primary seal gas to secondary vent	139	117	4123
80.1	Flare gas that does not burn	Extinguished flare and ignition of flare	633	639	18969
80.2	Flare gas that does not burn	Non-flammable flare gas	210	117	6078
80.3	Flare gas that does not burn	Inert gas flushed open flare	162	144	4803
100.1	Purge and blanket gas	Purge and blanket gas	122	85	3567
110.1	Gas analysers and test stations	Gas analysers and test stations	28	13	806
130.1	Storage tanks for crude oil at FPSOs	Gas freeing in connection with tank inspection	96	51	2768
130.2	Storage tanks for crude oil at FPSOs	Abnormal operating situation	9	73	422
140.1	Gas freeing of process systems	Gas freeing of process systems	12	35	421
Totals			6118	6757	184635

[1]Triethyleneglyco, [2]Monoethyleneglycol l

Source: Footprint database

Table 3.37. Diffuse emissions from offshore oil and gas production in 2022. Reported by field operators.

Source ID	**Main source**	**Sub source**	**Emissions**		
			CH_4 (t)	nmVOC (t)	CO_2 (t CO_2 eq.)
90.1	Leaks in the process	Larger gas leaks	31	23	911
90.2	Leaks in the process	Small gas leaks	309	302	9241
120.1	Drilling	Drilling	39	39	1176
900.1	General addition	FPSO	32	23	940
910.1	General addition	Fixed facilities	56	65	1684
Totals			467	451	13951

Source: Footprint database

Venting and diffuse emissions in the years 1990-2016 were estimated using total oil and gas production (in Sm3 oil equivalents) as activity data and average emissions per oil equivalent 2017-2018 as emission factor.

3.3.4.2.6 Flaring

- *NOX, NMVOC, CO, particulates, BC, PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) and dioxins.*

Emissions from flaring of natural gas offshore are calculated by Statistics Norway based on 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 the Norwegian Environment Agency and reported data 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

3.3.4.3.1 Loading and storage of crude oil offshore and on shore

The amount of oil buoy loaded and stored on vessels offshore is reported by the field operators into the Footprint database to the Norwegian Environment Agency (NEA). From 2003 and onwards, the inventory is based on data reported through the Footprint system.

[8] Emissions of CO_2 equivalents include indirect CO_2 emissions from CH_4 and NMVOC, using conversion factors of 2,75 t CO_2/t CH_4 and 2,2 t CO_2/t NMVOC. The NMVOC conversion factor is a generic factor for indirect CO_2 calculations.

Before 2003, Statistics Norway gathered data on amounts of crude oil loaded at shuttle tankers and stored on storage vessels from the Norwegian Offshore Directorate. The data from each field are reported monthly by the field operators to the Norwegian Offshore Directorate

The amount of oil loaded at onshore oil terminals is also reported annually to the Norwegian Environment Agency.

3.3.4.3.2 Oil refineries

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

3.3.4.3.3 Gasoline distribution

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

3.3.4.3.4 Gas terminals

Activity data that the terminals use in their emission calculations are sampled through the terminals measuring and maintenance program, aimed at reducing leakages.

3.3.4.3.5 Venting

Activity data are used to estimate and report emissions from e.g. produced water degassing tank (accumulated quantity of produced water through the degassing point during the reporting period), common vent (e.g. volume of natural gas and volume waste gas from source quantified by source quantification) and drilling (number of wellbores), see guidelines (Norwegian Oil and Gas 2021)

3.3.4.3.6 Flaring

Amounts of gas flared at offshore oil and gas installations are reported monthly by the operators to the Norwegian Offshore Directorate. The amount of gas for 1990-99 are from the Norwegian Offshore Directorate and from the Footprint database for 2000 and onwards. Amounts of gas flared at the four gas terminals are reported to 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

3.3.4.4.1 Loading and storage of crude oil offshore and onshore

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 annually. 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.

Loading onshore: The emission factors are considerably lower at one of Norway's two oil terminals than at the other, because some of the crude oil is transported by shuttle tankers to the terminal and is stabilized at the offshore installations prior to transport. At the other terminal the oil is delivered solely by pipeline. The latter terminal installed a vapour recovery unit (VRU) in 1996 and the former installed VRU in 2008. The efficiencies of the VRU's are about 80 % and 90 %, respectively. This measure significantly reduces the NMVOC emissions at the terminals. However, the VRU technology is not designed to reduce methane and ethane emissions.

3.3.4.4.2 Oil refineries

The emission factor used in the calculation of methane emissions from the largest refinery is based upon measurements using DIAL (Differential absorption LIDAR). The IEF for 2021 is used for all previous years.

BC emissions have been estimated as a fraction of the $PM_{2.5}$. IIASA (Kupiainen and Klimont 2004) gives a fraction of 0.16 per cent.

3.3.4.4.3 Gasoline distribution

The emission factor for NMVOC from refuelling of gasoline in cars (1.48 kg NMVOC/tonne gasoline) is taken from the EMEP/EEA Guidebook 2001 (EEA 2001)

3.3.4.4.4 Venting

Emissions of CH4 and NMVOC from cold venting and diffuse emissions for each field are reported annually to the Norwegian Environment Agency from the field operators. The indirect CO2 emissions are calculated by Statistics Norway.

A new method for calculation and reporting of venting and diffuse emissions from offshore oil and gas production fields is used in the field operators' annual reports from 2017 onwards. For the years 1990-2016 recalculated emission estimates are reported. The new timeseries is assumed to be consistent throughout the reporting period.

Fugitive emissions of methane and nmVOC are calculated using a so-called "bottom-up" method. The annual emissions for *venting* and *diffuse emissions* from each petroleum facility is quantified (calculated) using methods for each individual source, see Offshore Norge (2023)

For the years 1990-2016, emissions are calculated by multiplying relevant EFs by activity data. EFs for all source categories are based on IEF for the years 2017-2021.

3.3.4.4.5 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 Bakken, Husdal et al. (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, Husdal et al. (2008). This gives an emission factor of 0.856 g PM_{10}/Sm^3.
BC: Emissions are estimated using the same methodology as PM_{10} emissions. The regression formula for the BC emission factor, given as a function of the heating value (GCV) is EF = 0.0578(HV) – 2,09. This gives an emission factor of 0.684 g BC/Sm^3.
Other emission factors from flaring of gas are listed by Statistics Norway, see link 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 Table 3.38.

Table 3.38. Emission factors for flaring of oil in connection with well testing

Compounds (unit)	**unit/tonnes flared oil**	**Source**
NO_X (tonnes) NMVOC (tonnes) CO (tonnes)	0.0037 0.0033 0.018	(OLF 2009), Norwegian Oil and Gas (2021)
TSP (tonnes) PM_{10} (tonnes) $PM_{2.5}$ (tonnes)	0.025 0.0215 0.014	Measurements (OLF[1]) Use the same distribution as for combustion of heavy fuel oil in industry (EPA 2002)
PAH (kg) Benzo(a)pyrene, benzo(b)fluoranthene benzo(k)fluoranthene indeno(1,2,3-cd)pyrene,	0.012 .. 0.00024	(OLF 1991) , Norwegian Oil and Gas (2021) Use the same distribution as for combustion of heavy fuel oil in industry (EPA 1998), as estimated by Finstad, Haakonsen et al. (2001)
Dioxins (mg) PCB (mg)	0.01 220	 Langøren and Malvik (2010), Norwegian Oil and Gas (2021)

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

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 2011) 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

The emissions calculated by Statistics Norway for 1990-2002 were compared with the emission data that the field operators reported to the Norwegian Environment Agency. From 2003, Statistics Norway estimates 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 annual reports from the operators are quality checked by NEA. This includes for instance crosschecking of reported CO_2 emission data against ETS-reports and crosschecking of reported fugitive emissions (methane and NMVOC) against data reported in Footprint by the operators. Annual emissions from loading of crude oil onto shuttle tankers on the Norwegian continental shelf are reported by the VOC Industrial cooperation. The VOC Industrial cooperation reports is available in Norwegian.

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.

4. INDUSTRIAL PROCESSES AND PRODUCT USE (NFR sector 2)

4.1 Overview

This chapter provides descriptions of the methodologies employed to calculate emissions of long-range transboundary air pollutants from industrial processes and product use. 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. If not otherwise specified, the emissions of particulate matter do not include the condensable component.

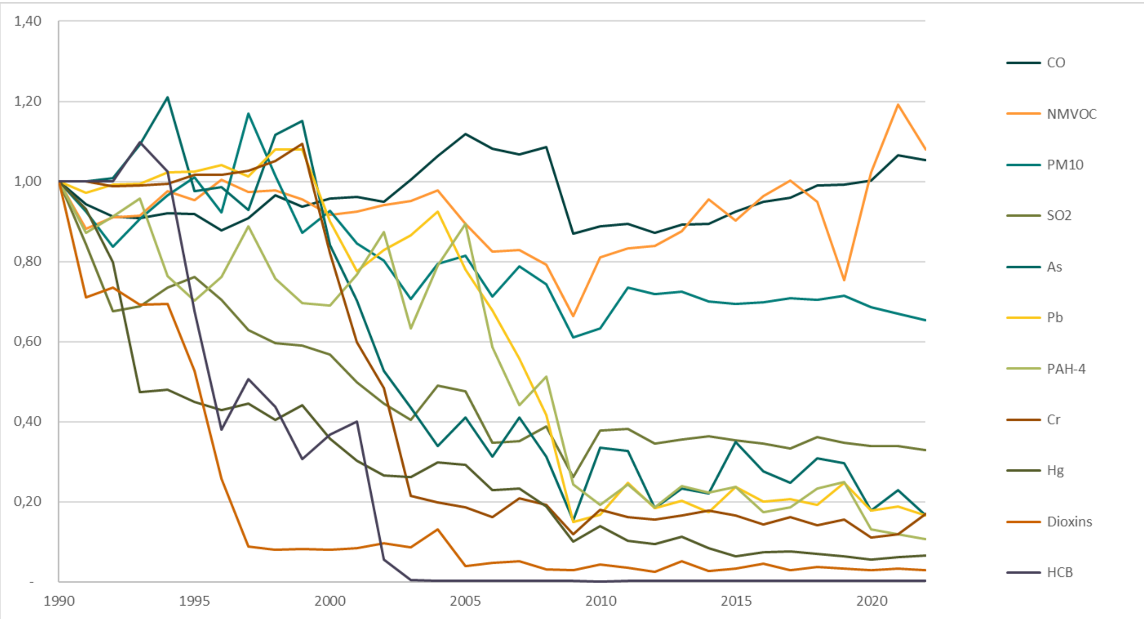


Figure 4.1. Trends for the emissions for most of long-range transboundary air pollutants from IPPU, relative to 1990. Index 1990=1.

Figure 4.1 shows the emission trends for the most important long-range transboundary air pollutants from IPPU, relative to 1990. Except for CO and NMVOC, the emissions of all pollutants have decreased since 1990. Emissions from As, Cr, HCB, Hg, Pb, Dioxins and PAH-4 have indeed decreased by more than 80 percent since 1990. More detailed information is given in Chapter 1.

4.2 Mineral products

NFR 2A

Last update: 25.02.19

The sector category Mineral products in the Norwegian inventory includes emissions from different products. SO_2, NO_X, NH_3, particles, BC, heavy metals dioxins, PAHs benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) and HCB are components that are emitted during the production of mineral products and included in the inventory.

4.2.1 Cement production

NFR 2A1

Last update: 02.02.24

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 Agency distributes 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 EEA (2023). PM_{10} and $PM_{2.5}$ are assumed to be 90 and 50 per cent of TSP, respectively.

- *BC*

Emissions have been estimated from a share of PM_{10} emissions given by EEA (2023). As a share of $PM_{2.5}$, BC emission factor is 3.0 per cent.

- *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.

HCB emissions are estimated using an old emission factor from the EEA of 11 µg/t cement and are reported under 2A1.

4.2.1.3 Activity data

The activity data is the production of clinker and this is reported annually to the Norwegian Environment Agency. These are reported in the NFR table and in Appendix F. The dip in activity level in 1991 was due to re-building of one of the cement producing plants and it had no production that year.

4.2.1.4 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.

4.2.1.5 Source specific QA/QC

The emissions are reported according to their permits to the Norwegian Environment Agency (NEA). The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs (greenhouse gases), so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.2.2 Lime production

NFR 2A2
Last update: 02.02.24

4.2.2.1 Description

Emissions of particles, black carbon and HCB from lime production are included in the Norwegian inventory.

4.2.2.2 Method

- *Particles*

One plant has reported emission figures for particulate matter 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. The plant has been contacted concerning the dips in 1999, 2008 and 2013. It is challenging to examine the dips in 1999 and 2008 as data older than 10 years is not easily available. The plant informed that the emissions are normally based on continuous measurements from a filter, but for 2013 the reported emissions were estimated by a third party. In the inventory, a particle size distribution suggested by EEA (2023). PM_{10} and $PM_{2.5}$ are assumed to be 38.9 and 7.8 per cent of TSP, respectively.

- *BC*

For the same plant that reports particles, BC emissions have been estimated by assuming a factor of 0.46 per cent of TSP emissions.

- *HCB*

HCB may unintentionally be formed in the production and extraction of lime in the thermic process. One plant has reported emissions in 2010. Emissions for the rest of the timeseries are estimated based on lime production data. Emissions for two other plants that do not report emissions are also estimated based on lime production. The emission factor used is 0.008 mg HCB per tonne lime from Japan (Toda 2006). It is also assumed that, for this category, the reported figures include emissions from fuel combustion, therefore emissions from combustion are not calculated.

4.2.2.3 Activity data

The activity data is the production of lime and this is reported annually to the Norwegian Environment Agency. These are reported in the NFR table and in Appendix F.

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 EEA (2023).

4.2.2.5 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.2.3 Glass and glass fibre production

NFR 2A3

Last update: 02.02.24

4.2.3.1 Description

Five plants producing glass, glass wool or glass fibre are included in the emission inventory, with figures based on emission reports to the Norwegian Environment Agency. PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) and dioxin emissions are neither calculated nor measured. 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.

4.2.3.2 Method

- *NO_X*

The two glass wool producing plants and the one producing glass fibre annually report emission figures for NO_X to the Norwegian Environment Agency. The emission figures are based on calculations using emission factors and use of raw materials.

- *NH_3*

The two glass wool 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 wool have reported emission figures to the Norwegian Environment Agency since 1990. The glass fibre producing plant has reported emissions from 1996; for the period 1990-1995, the 1996 figure is used in the inventory. One glass-producer with particle emissions reported figures from 1995. Emission figures from 1990 to 1994 were assumed to be the same as the reported 1995 figure. This plant has been closed down in 1999. The size distribution from EEA (2023) is used for particle size distribution, that is $PM_{2.5}$ is 80 per cent of TSP and PM_{10} is 90 per cent of TSP.

- *BC*

Emissions have been estimated from a share of $PM_{2.5}$ emissions given by EEA (2023), that is 0.062 per cent of $PM_{2.5}$ emissions.

- *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. The emissions of other heavy metals are reported under Energy.

4.2.3.3 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.

4.2.3.4 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.2.4 Mining and extraction of stones and minerals

NFR 2A5A

Last update: 07.01.22

4.2.4.1 Description

Mining and extraction of stones and minerals are done by several plants. Particles are emitted during these processes. Particles from 2A5C is reported in the NFR-table as IE and these emissions are included for example in 2A1.

4.2.4.2 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 fiber to clean their particle emissions. It is assumed by the Norwegian Environment Agency that the particles emitted are larger than PM_{10}. Thus, BC has not been considered for this category.

The Norwegian inventory uses the size distribution recommended by TNO (Institute of environmental and energy technology 2002) for sandpits and rock-crushing plants (Table 4.2). 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.

4.2.4.3 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.

4.2.4.4 Source specific QA/QC

The plants emissions are compared to the corresponding emissions in previous years. If the change in emissions between the years are large, NEA are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.2.5 Construction and demolition

NFR 2A5B

Last update: 29.01.24

4.2.5.1 Description

Construction and building include a lot of different activities that will generate particle emissions. Building of roads, railways, tunnels and demolition of buildings is also a source of particle emissions, but presently Statistics Norway do not have activity data for these sources available, and therefore such emissions are not included in the inventory. Statistics Norway started looking for relevant activity data for these sources in 2020.

4.2.5.2 Method

- *Particles*

The tier 1 default approach from EEA (2023) has been used to calculate emissions from construction and demolition. The method is expressed by the following equation:

$$EM_{PM10} = EFPM_{10} \cdot Aaffected \cdot d \cdot (1 - CE) \cdot (24/PE) \cdot (s/9\%)$$

Where: EM_{PM10} is the PM_{10} emission, $EFPM_{10}$ is the emission factors, Aaffected is the area affected by construction activity, d is the duration of construction, CE is the efficiency of emission control measures, PE is the Thornthwaite precipitation-evaporation index (correction for soil moisture) and s is the soil silt content.

4.2.5.3 Emission factors

The emission factors used are shown in Table 4.1.

Table 4.1. Factors for calculating Particle emissions for building and construction.

Factor	Houses	Apartments	Non-residential	Unit
EF TSP	0.29	1	3.3	kg PM10/m2
EF PM_{10}	0.086	0.3	1	kg PM10/m2
EF $PM_{2.5}$	0.0086	0.03	0.1	kg PM10/m2
d	0.5	0.75	0.83	year
CE	0	0	0.5	
PE	128	128	128	Humid
s	20	20	20	%
1-control efficiency	1	1	0.5	

Source: EEA (2023)

Statistics Norway assumes that the climatic conditions in Norway are comparable with Finland and the value for the PE-index is collected from the Finnish IIR. The value for soil silt is collected from the German IIR (which is also used in the Finnish IIR) due to the lack of national information.

Statistics Norway assumes that none of the processes used in building and construction will lead to BC emissions. Hence, BC has not been considered for this activity.

4.2.5.4 Activity data

The activity data used is the annual area of completed buildings from the building statistics at Statistics Norway. The activity data is divided into three subgroups; residential houses (detached single family, detached two family and single family terraced), residential apartments (all types) and non-residential construction (all construction except residential construction and road construction). The annual area in the three groups is assumed to be Aaffected. The total annual area of completed buildings are reported in the NFR table and in Appendix F.

4.2.5.5 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.

4.2.5.6 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between the years are large, the building statistics are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.2.6 Ceramics

NFR 2A6

Last update: 07.05.20

4.2.6.1 Description

One plant producing bricks reports emission of particulate matter from limestone and dolomite use to the Norwegian Environment Agency. The plant was closed down in 2014.

4.2.6.2 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. The same particle size distribution is used as for production of cement as given in TNO (Institute of environmental and energy technology 2002). PM10 and PM2.5 are assumed to be 85 and 30 per cent of TSP, respectively.

- *BC*

Emissions has been estimated from a share of $PM_{2.5}$ emissions. Values for bricks production are given by IIASA in Kupiainen and Klimont (2004). As a share of $PM_{2.5}$, emission factor is 37.5 per cent.

4.2.6.3 Uncertainties

Uncertainty estimates are given in Appendix C.

4.2.6.4 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.2.7 Non-metallurgical Magnesia Production

NFR 2A6

Last update: 07.01.22

4.2.7.1 Description

One plant whose main activity is producing magnesium oxide and calcium oxide from limestone and dolomite is included in the emission inventory. The plant was established in 2005.

4.2.7.2 Method

- *Particles*

Emissions have been reported to the Norwegian Environment Agency for the years 2005-2008 and 2013 and onwards. Linear interpolation has been used for the intervening years. No information is found regarding the particle size distribution for particles emitted during production. In lack of other data we used the same distribution as for aluminium production PM_{10} and $PM_{2.5}$ are assumed to be 100 and 43 per cent of TSP, respectively.

- *BC*

Emissions has been estimated from a share of $PM_{2.5}$ emissions. Values for bricks production are given by IIASA in Kupiainen and Klimont (2004). As a share of $PM_{2.5}$, emission factor is 37.5 per cent.

- *SO_2*

Emissions have been reported to the Norwegian Environment Agency since 2006.

- *Dioxins*

Emissions have been reported to the Norwegian Environment Agency for the years 2011, 2013 and onwards.

- *PCB*

Emissions have been measured and reported to the Norwegian Environment Agency for 2010. An emission factor has been built from these emissions measurements to estimate emissions for the whole timeseries.

4.2.7.3 Activity data

The amount of limestone and dolomite used by the plant in their calculation is annually reported to the Norwegian Environment Agency.

4.2.7.4 Uncertainties

Uncertainty estimates are given in Appendix C.
The particle distribution used is not specified for the plants, and the particles emitted might therefore have another distribution than the one suggested.

4.2.7.5 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from this plant also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.2.8 Sandpit and rock-crushing plant

NFR 2A6

Last update: 02.02.24

4.2.8.1 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 Directorate of Mineral Management, and emission factors recommended by the 2023 EMEP Guidebook. 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.

4.2.8.2 Activity data

The production of sand and crushed stone is annually given by the Directorate of Mineral Management mineral statistics. These are reported in the NFR table and in Appendix F.

4.2.8.3 Emission factors

The emission factors used are shown in Table 4.2.

Table 4.2. Particle emission factors for sandpits and rock-crushing plants. Ratio X[1]/TSP

Component	g/tonne produced
TSP	102
PM_{10}	50
$PM_{2.5}$	5

[1] X is either $PM_{2.5}$, PM_{10} or TSP.

Source: EEA (2023)

All particles are assumed to be larger than $PM_{2.5}$. Thus, no emission of BC has been estimated.

4.2.8.4 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

4.2.8.5 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the Directorate of Mineral Management are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.2.9 Concrete pumice stone

NFR 2A6

Last update: 07.01.22

4.2.9.1 Description

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

4.2.9.2 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.

- *BC*

Emissions has been estimated from a share of $PM_{2.5}$ emissions. Values for bricks production are given by IIASA in Kupiainen and Klimont (2004). As a share of $PM_{2.5}$, emission factor is 37.5 per cent.

4.2.9.3 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.

4.2.9.4 Source specific QA/QC

The plants emissions in year t are compared to the plants emissions in year t-1. If the change in emissions between years are large, NEA are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.2.10 Rock wool production

NFR 2A6

Last update: 11.02.21

4.2.10.1 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 (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) are neither reported nor calculated since emissions of these components are minor or not occurring.

4.2.10.2 Method

- *NO_X*

Emission figures are reported to the Norwegian Environment Agency.

- *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.

- *BC*

Emissions have been estimated from a share of $PM_{2.5}$ emissions. Values for glass fiber production are given by IIASA in Kupiainen and Klimont (2004). As a share of $PM_{2.5}$, emission factor is 0.06 per cent.

- *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.

4.2.10.3 Activity data

Production volumes of rock wool are annually reported from the plants to the Norwegian Environmental Agency.

4.2.10.4 Emission factors

- *BC*

Emissions have been estimated from a share of $PM_{2.5}$ emissions. Value given by IIASA in Kupiainen and Klimont (2004) for glass production have been used. As a share of PM_{10}, emission factor is 0.25 per cent.

- *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 4.3. 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: Statistics Norway/Norwegian Environment Agency

4.2.10.5 Uncertainties

- *Activity data*

The activity data is assumed to be of good quality since this is production rates reported from each plant to the Norwegian Environment 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.

4.2.10.6 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.2.11 Production of mineral white (plaster)

NFR 2A6

Last update: 11.02.21

4.2.11.1 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.

4.2.11.2 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.

- *BC*

Emissions are estimated from a share of $PM_{2.5}$ emissions. As no share for BC was found in the literature, BC share has been set to be 50 per cent of $PM_{2.5}$. Indeed, the amount of $PM_{2.5}$ is assumed to be equally shared between BC and organic mass (OM).

- *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.

4.2.11.3 Activity data

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

4.2.11.4 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.

4.2.11.5 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.

4.2.11.6 Source specific QA/QC

The plants emissions are compared to the corresponding emissions in previous years. If the change in emissions between years are large, NEA are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.2.12 Construction and repairing of vessels - Sandblasting

NFR 2A6

Last update: 11.02.21

4.2.12.1 Description

Five plants constructing and repairing vessels are included in the inventory with their particle emissions. One of the plants was closed 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.

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.

4.2.12.2 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 no $PM_{2.5}$ and PM_{10} is considered for this category. Thus, no BC emissions have been estimated.

4.2.12.3 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.

4.2.12.4 Source specific QA/QC

The plants emissions are compared to the plants emissions in previous years. If the change in emissions between years are large, NEA are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.3 Chemical Industry

NFR 2B

Last update: 02.02.24

In the Norwegian emission inventory, there are 13 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.

4.3.1 Ammonia Production

NFR 2B1

Last update: 02.02.24

4.3.1.1 Description

In Norway, ammonia is produced by catalytic steam reforming of wet fuel gas (containing ethane, propane, and some butane). This is one of the steps during fertilizer production. Hydrogen is needed to produce ammonia, and wet fuel gas is the basis to produce hydrogen. The plant producing ammonia produces also nitric acid and complete fertilizers (NPK and calcium nitrate). The reported emissions cannot be split and are generally aggregated under 2B2. The exception is for CO from 2B1 where we have estimated emissions. The plant has informed that the process does not result in NH_3 emissions as the NH_3 is absorbed in an argon facility.

4.3.1.2 Method

- *NO_X*

During the production of ammonia there are some non-combustion emissions of NO_X. These emission figures are measured in accordance with standard NS 13284-1 and are included in the reported NO_X emission from nitric acid production and production of other fertilizers.

- *CO*

The emissions are estimated through the production of ammonia as activity data and the emission factor of 0.006 kg CO per tonne ammonia produced (from table 3.7 in the 2019 EMEP Guidebook).

4.3.1.3 Activity data

The ammonia production is reported in the NFR table and in Appendix F. The dip in activity level in 1999 (from 1998 to 1999 and 1999 to 2000) is likely to be a result of the plant upgrading production capacity and energy efficiency in 1999-2000. The jump in 2015 is due to an expansion in production capacity in which imported ammonia is replaced with domestic ammonia production.

4.3.1.4 Uncertainties

The uncertainties in the figures reported by the plant are believed to be limited. Uncertainty estimates are given in Appendix C.

4.3.1.5 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.3.2 Production of nitric acid

NFR 2B2

Last update: 30.05.23

4.3.2.1 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 fertilizer. 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 fertilizer also leads to emissions of particles that are reported under 2B10A.

4.3.2.2 Method

- *NO_X*

The two plants report the emissions of NO_X to the Norwegian Environment Agency. The reported emissions are based on measurements in accordance with standard NS 13284-1.

- *NH_3*

Emission figures for NH_3 are annually reported to the Norwegian Environment Agency. The reported emissions are based on measurements in accordance with standard NS 13284-1.

4.3.2.3 Activity data

The nitric acid production is reported in the NFR table and in Appendix F. The dip in activity data in 1992 is due to rebuilding of one of the production lines and the dip in 2009 reflects lower economic activity due to the economic recession.

4.3.2.4 Uncertainties

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

4.3.2.5 *Source specific QA/QC*

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.3.3 Silicon carbide

NFR 2B5

Last update: 30.05.23

4.3.3.1 *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 PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) may also be emitted during the production process. Sulphur originates from the petrol coke.

4.3.3.2 *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.

- *CO*

The emissions of CO are calculated by Statistics Norway from the consumption of petrol coke and an emission factor.

- *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 for the years 1990-2015, so the same profile as for aluminium production is used for these years (Table 4.4).

After 2015 reported figures for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene from the plants are used in the inventory.

Table 4.4. Distribution of PAH emissions from silicon carbide production. Ratio X[1]/PAH

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

[1] X is either PAH, PAH-6 or PAH-4.

Source: Finstad, Haakonsen et al. (2001)

Table 4.5. Distribution of PAH-4 emissions from silicon carbide production. Share of PAH-4. Used 1990-2015

Component	Distribution of PAH emissions (ratio)
benzo(a)pyrene	0.2
benzo(b)fluoranthene	0.45
benzo(k)fluoranthene	0.25
indeno(1,2,3-cd)pyrene	0.1

Source: Norwegian Environment Agency (2016): Expert judgement, Oslo, Norway

4.3.3.3 Activity data

The activity data reported in the NFR table and in Appendix F and used to calculate NMVOC emissions is the annual production of silicon carbide. 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. The dip in activity data in 2003 is because a plant producing calcium carbide closed down in 2002.

4.3.3.4 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 factors are based on measurements made once a year. The emission factors for the two plants in operation are 10.906 tonne NMVOC/kilotonne Sic and 10.84 tonne NMVOC/kilotonne Sic respectively. For previous years, an average of the emission factors in 2007 and 2008 are applied.

4.3.3.5 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.

4.3.3.6 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.3.4 Production of calcium carbide

NFR 2B5

Last update: 02.02.24

4.3.4.1 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) $CaO + C \text{ (petrol coke)} \rightarrow CaC_2 + CO$

(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.

4.3.4.2 Method

- *NO_X*

Emission figures for NO_X were annually reported to the Norwegian Environment Agency. The reported values are based on calculations using emission factors and use of reducing agents.

- *NMVOC*

Reported figures were annually reported to the Norwegian Environment Agency, based on calculations using emission factors and use of reducing agents.

- *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.

- *BC*

Emissions are estimated from a share of $PM_{2.5}$ emissions. Tier 1 emission factor for BC applicable for 'general' chemical industry is used, EEA (2023). BC=1.8 per cent of $PM_{2.5.}$

- *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. No emission figures for PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) or dioxins are available.

4.3.4.3 Activity data

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

4.3.4.4 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.

4.3.5 Production of titanium dioxide

NFR 2B6

Last update: 19.02.24

4.3.5.1 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 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.

The processes are described as the sulphate process in the 2023 EMEP Guidebook.

4.3.5.2 Method

- *SO_2*

The emission figures for SO_2 are based on measurements in accordance with standard NS EN 14791 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 measured 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 $PM_{2.5}$.

- *BC*

Emissions are estimated from a share of $PM_{2.5}$ emissions. Tier 1 emission factor for BC applicable for 'general' chemical industry is used, EEA (2023). BC=1.8 per cent of $PM_{2.5.}$

- *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. PCB emissions have been measured and reported since 2006. Emissions from 1990 to 2006 are based on reported emissions from 2006.

Emission figures for PAH are reported from the plant to the Norwegian Environment Agency. No PAH profile is available for this source for the years 1990-2015. The Norwegian Environment Agency suggests a distribution of the emissions where PAH-4 is 15 per cent of reported PAH emissions. Emissions of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene are estimated using the same PAH-profile as for aluminium production for the years 1990-2015. After 2015 the plant has reported figures for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene.

4.3.5.3 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 cannot preclude that the distribution is different from the one used in the inventory.

4.3.5.4 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.3.6 Production of methanol

NFR 2B10A

Last update: 16.02.24

4.3.6.1 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 reported under 2B10A.

4.3.6.2 Method

The plant reports emission figures for NMVOC and NO_X, to the Norwegian Environment Agency. The reported emissions are based on measurements. In addition, emissions from flaring of natural gas are estimated by multiplying the amount of gas flared with the emission factors shown in Table 4.6.

Table 4.6. Emission factors for flare

Component	Flare natural gas kg/1000 Sm^3
SO_2	0
CO	1.5
NO_X	[1]
Particles	0.0018
NMVOC	0.06
	mg/1000 Sm^3
Pb	0.25
Cd	1.7
Hg	1
Cu	16
Cr	21
As	3.8
Dioxins	0.00005
Benzo(a)pyrene	0.02
benzo(b)fluoranthene	0.04
benzo(k)fluoranthene	0.02
indeno(1,2,3-cd)pyrene	0.02

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

Source: Statistics Norway/Norwegian Environment Agency. PAH: EEA (2023).

BC emissions have been estimated using emission factors as for flaring of natural gas in 1B2c (Table 3.4).

4.3.6.3 Uncertainties

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

4.3.6.4 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.3.7 Production of fertilizer

NFR 2B10A

Last update: 30.01.23

4.3.7.1 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 fertilizer. The production of nitrogenous-based fertilizer leads to emissions of particles.

4.3.7.2 Method

- *Particles*

Both plants report emission figures to the Norwegian Environment Agency and have done so since 1990 and 1992. The reported emissions are based on measurements in accordance with standard NS 13284-1. 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. In lack of plant specific information regarding particle size distribution of the emitted particles, Statistics Norway uses the distribution given by EEA (2023) for production of ammonium phosphate where PM_{10} is 80 per cent of TSP and $PM_{2.5}$ is 60 per cent of TSP.

- *BC*

Emissions are estimated from a share of $PM_{2.5}$ emissions. Tier 1 emission factor for BC applicable for 'general' chemical industry is used, EEA (2023). BC=1.8 per cent of $PM_{2.5}$..

4.3.7.3 Uncertainty

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 EEA (2023) is used in lack of other data.

4.3.7.4 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.3.8 Production of sulphuric acid

NFR 2B10A

Last update: 05.02.15

4.3.8.1 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 plants report the emissions from the production to the Norwegian Environment Agency, but only one plant has 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).

4.3.8.2 Method

The plants report annually emission figures of SO_2 to the Norwegian Environment Agency. The reported figures are based on measurements.

4.3.8.3 Uncertainties

No source specific uncertainty is known.

4.3.8.4 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.

4.3.9 Production of plastic

NFR 2B10A

Last update: 07.01.22

4.3.9.1 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 2B10a.

4.3.9.2 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 due to 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.

- *BC*

Emissions are estimated from a share of $PM_{2.5}$ emissions. Tier 1 emission factor for BC applicable for 'general' chemical industry is used, EEA (2023). BC=1.8 per cent of $PM_{2.5.}$

- *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.

- *HCB*

The plant producing vinyl chloride reports HCB emission figures since 1996. Emissions from 1990 to 1995 are based on the 1996 reported emissions.

- *PCB*

PCB emissions have been reported since 2010. Emissions from 1990 to 2010 are based on the 2010 reported emissions.

4.3.9.3 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.

4.3.9.4 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.3.10 Production of explosives

NFR 2B10A
Last update: 11.02.21

4.3.10.1 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. Reported particles 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.

4.3.10.2 Method

- *NO_X*

Emission figures were annually reported to the Norwegian Environment Agency, and the figures were based on calculations.

4.3.10.3 Uncertainties

No source specific uncertainty is known.

4.3.10.4 Source specific QA/QC

Prior to the plant's closure the emissions where compared to the emissions in previous years. If the change in the emissions between years where large, NEA was contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.3.11 Chloralkali production

NFR 2B10A

Last update: 11.02.21

4.3.11.1 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.

4.3.11.2 Method

- *Hg*

Emission figures were reported to the Norwegian Environment Agency.

4.3.11.3 Uncertainties

No source specific uncertainty is known.

4.3.11.4 Source specific QA/QC

Prior to the plants change in production process, the emissions were compared to the emissions in previous years. If the change in the emissions between years where large, NEA was contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.3.12 Production of pigments

NFR 2B10A

Last update: 07.01.22

4.3.12.1 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.

4.3.12.2 Method

Emission figures are reported to the Norwegian Environment Agency.

4.3.12.3 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.

4.3.12.4 Source specific QA/QC

The plants emissions are compared to the corresponding emissions in previous years. If the change in emissions between years are large, NEA are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.3.13 Production of soap

NFR 2B10A

Last update: 09.02.24

4.3.13.1 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 $PM_{2.5}$. BC emissions are estimated from a share of $PM_{2.5}$ emissions. Tier 1 emission factor for BC applicable for 'general' chemical industry is used, EEA (2023). BC=1,8 per cent of $PM_{2.5.}$

4.3.13.2 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.

4.3.13.3 Source specific QA/QC

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

4.3.14 Paint and varnish production

NFR 2B10A

Last update: 09.02.24

4.3.14.1 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 $PM_{2.5}$. BC emissions are estimated from a share of $PM_{2.5}$ emissions. Tier 1 emission factor for BC applicable for 'general' chemical industry is used, EEA (2023). BC=1,8 per cent of $PM_{2.5.}$

4.3.14.2 Uncertainties

No source specific uncertainty is known.

4.3.14.3 Source specific QA/QC

The plants emissions are compared to the corresponding emissions in previous years. If the change in emissions between years are large, NEA are contacted for control. See section 1.6 for the description of the general QA/QC procedure QA/QC procedure.

4.4 Metal production

NFR 2C

Last update: 07.01.22

Metal production in Norway includes plants producing iron and steel, ferroalloys, aluminium, nickel and zinc and also magnesium until the spring of 2006. Production of anodes is also included in this chapter. Most of the figures in the national inventory are from the plants' annual reports to the Norwegian Environment Agency.

4.4.1 Production of iron and steel

NFR 2C1

Last update: 02.02.24

4.4.1.1 Description

Several plants are included in the time series for the production of iron and steel, but not all plants are currently in production. Currently, the emissions are from one steel producing plant that uses an electric arc furnace (EAF). The components included in the inventory are particles, black carbon, heavy metals and POPs. One plant producing titanium dioxide slag also produces pig iron as a by-product, but the emissions from this plant are registered under 2B6.

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 $PM_{2.5}$.

- *BC*

Emissions have been estimated as a share of $PM_{2.5}$ emissions. Measurements from one plant showed that 0.1 per cent of the dust was carbon and this is used in the inventory. As no information on the share of BC and OC was found in the literature for iron and steel production, BC share has been set to be 50 per cent of $PM_{2.5}$ using the default method described in Aasestad (2013). Indeed, the amount of $PM_{2.5}$ is assumed to be equally shared between BC and organic mass (OM). Hence, BC emissions represent 0.05 per cent of $PM_{2.5}$ emissions.

- *Heavy metals and POPs*

Heavy metal emissions are due to the metallurgical melting process and the content of heavy metals in the raw materials used. 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 been available since 1997. The reported numbers from 1997 have been used for all years from 1990 to 1996. After 2015, the plant has reported figures for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene.
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.

HCB emissions have been estimated using the emission factor from the EMEP inventory guidebook EEA (2023) and the crude steel production. Plants reported PCB emissions in 2010. Emissions for the other years have been estimated using the data reported in 2010.

4.4.1.3 Activity data

The production of steel is reported in the NFR table and in Appendix F.

4.4.1.4 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 cannot 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.

4.4.1.5 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: 02.02.24

4.4.2.1 Description

There are 12 plants producing ferroalloys in Norway. 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 the summer of 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 4.9, 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 cannot 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 $TSP=PM_{10}= PM_{2.5}$.

- *BC*

Emissions have been estimated as a share of $PM_{2.5}$ emissions. Measurements of particles composition from several plants were used to estimate the dust carbon content. This value was used to estimate BC. As no information on the share of BC and OC was found in the literature for ferroalloys production, the BC share has been set to be 50 per cent of the carbon contents of $PM_{2.5}$ using the default method described in Aasestad (2013). Indeed, the amount of $PM_{2.5}$ is assumed to be equally shared between BC and organic mass (OM). BC emissions represent 3.5 per cent of the PM2.5 emissions from ferro-manganese production and 0.23 per cent of the PM2.5 from ferro-silicon production (Aasestad 2013).

- *Heavy metals*

The Norwegian Environment Agency imposed in 1999 larger metallurgical plants to map their emissions of heavy metals. Most plants have therefore reported heavy metal emissions 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 emissions and production rate for the first year of reporting. These emission factors have been used together with 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 4.11).

[9] Eikeland (2002): Personal information, e-mail dated 29/05 2002. Elkem@elkem.no
[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.

- *PCB*

As for dioxins emissions, PCB emissions are only considered in the ferrosilicon production. Plants reported emissions in 2010 and reported data has been used to estimate emissions for the whole period.

- *PAHs (Benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene)*

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. No PAH profile is available for this source. The Norwegian Environment Agency suggests a distribution of the emissions where PAH-4 is 15 per cent of reported PAH emissions (Table 4.7).

The PAH emission figures are reported according to Norwegian standard (NS9815), but no PAH profile for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene is available. In lack of other data, the same profile as for aluminium production is used for the years 1990-2015. After 2015 the inventory is based on reported figures for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd) pyrene from eight plants.

Table 4.7. Distribution of PAH emissions from production of ferroalloys

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

Source: Finstad, Haakonsen et al. (2001)

Table 4.8 Distribution of PAH-4 emissions from production of ferroalloys. Share of PAH-4. 1990-2015

Component	Distribution of PAH emissions (ratio)
benzo(a)pyrene	0.2
benzo(b)fluoranthene	0.45
benzo(k)fluoranthene	0.25
indeno(1,2,3-cd)pyrene	0.1

Source: Norwegian Environmental Agency (2016): Expert judgement, Oslo, Norway

4.4.2.3 Activity data

The use of reducing agents is reported in the NFR table and in Appendix F. The dip in activity data in 2009 reflects lower economic activity due to the economic recession.

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 some plants. The emission factors in Table 4.9 are based on several measuring campaigns at some 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. One major ferroalloy producing company with four plants use emissions factors (kg NO_X/tonne metal produced) that are: 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 4.9. NO_X emission factors for production of ferrosilicon. Kg NO_X /tonne metal produced

	Normal operations	**Sprinkle - charging**	**Sprinkle-charging > 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*

There is no emission factor for NMVOC in the EMEP Guidebook (EEA 2023), but 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 4.10.

Table 4.10. Emission factors for production of ferroalloys. µg dioxin/tonne metal produced

	Normal operations	Sprinkle - charging	Sprinkle-charging > 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.*

For plants that have not reported dioxins emissions to the Norwegian Environment Agency, emissions are estimated through use of an emission factor for combustion of coke and coal in the industry (Table 4.11).

Table 4.11. 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, Troost et al. (1994) and Finstad, Haakonsen et al. (2002)

- *PAH*

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. g PAH /tonne metal produced

	Normal operations	Sprinkle - charging	Sprinkle-charging > 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 a 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*

PAH was first included in the Norwegian Inventory in 2000, and only two plants producing ferrosilicon and silicon metal reported emission figures to the Norwegian Environment Agency for the year 1999. In 2004, a specific emission factor for each plant was derived based on the plants' reported emission figures for 2000, 2001 and 2002 and production volumes. 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.),* 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: 12.02.24

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 94 per cent in 2022.

Production of aluminium leads to emissions of various components, such as SO_2, NO_X, heavy metals and persistent organic pollutants. The emissions 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 PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene).

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.

- *CO*

CO emissions are estimated by Statistics Norway from the level of production and the emission factor 120 kg CO/tonne aluminium from EEA (2023).

- *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 EEA (2023), PM_{10} is 83.3 per cent of TSP, and $PM_{2.5}$ is 67 per cent of TSP for pre-baked cell and 61 per cent of TSP for Soederberg anodes.

- *BC*

Emissions are estimated from a share of $PM_{2.5}$ emissions. Tier 1 emission factor for BC applicable for aluminium production is used, EEA (2023). BC=2.3 per cent of $PM_{2.5}$.

- *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.

- *HCB*

HCB emissions have not been estimated since there are no default emission factor for HCB in the EMEP 2023 Guidebook for primary aluminium.

- *PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno (1,2,3-cd)pyrene)*

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 of PAH-4 accounts for 5 -10 per cent of total PAH emissions reported from production of aluminium (Table 4.13). 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. In addition, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene have been measured at some plants for the last year. Based on these profiles it is believed that PAH-4 accounts for 10 per cent of total PAH emissions from production of aluminium from one plant, 7.5 per cent is used for the other. Emissions of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene have been measured in 2016 and in 2001. Based on these measurements a PAH-profile has been made by Hetland, the Norwegian Environment Agency *(pers. comm)*[12]. The PAH-4 profile used for aluminium production for the years 1990 – 2015 is shown in Table 4.14. After 2015 the inventory is based on reported figures for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene from three plants.

Table 4.13. Distribution of PAH emissions from production of primary aluminium. Ratio

Component	Distribution of PAH emissions (ratio)
PAH (Norwegian standard)	1
PAH-4 (CLRTAP)	0.05-0.1

Source: Statistics Norway/Norwegian Environmental Agency

Table 4.14. Distribution of PAH-4 emissions from production of primary aluminium. Share of PAH-4

Component	Distribution of PAH emissions (ratio)
benzo(a)pyrene	0.2
benzo(b)fluoranthene	0.45
benzo(k)fluoranthene	0.25
indeno(1,2,3-cd)pyrene	0.1

Source: Hetland (2016)

4.4.3.3 Activity data

The production of aluminium is reported in the NFR table and in Appendix F. The dip in activity data in 2009 reflects lower economic activity due to the economic recession.

[12] Pers. comm, email from Øyvind Hetland, 22. Nov. 2015, Norwegian Environment Agency.

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, Troost et al. (1994).

Table 4.15. Emission factor used to calculate dioxin emissions from aluminium production.

	Emission factor	Source
Coal and coke	1.6 µg/tonne	Bremmer, Troost 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 is not reported by the plants. Actual emissions are probably somewhat different from those estimated with the size distribution from EEA (2023).

4.4.3.6 Source specific QA/QC

- *PAH*

In 2014, the Norwegian Environment Agency had audits at all aluminium plants. For the four plants that have emissions of PAH, their systems for monitoring emissions of PAH were checked.

- *Heavy metals*

First requirement for reporting of heavy metals was given in 1999, and the reported figures were 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. Historical reported data were recalculated based on the new calculation method. Recalculation of historical data is normally based on production rate data, but due to very low emissions and relatively 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: 09.02.24

4.4.4.1 Description

One open mill in Norway is handling secondary aluminium production. Heavy metals and persistent organic pollutants (dioxins and PAHs, (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene)) 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 70 per cent of TSP and $PM_{2.5}$ is 27.5 per cent of TSP in line with EEA (2023).

- *BC*

BC has been estimated as a fraction of $PM_{2.5}$ emissions. The share of 2.3 per cent of $PM_{2.5}$ from EEA (2023) has been used.

- *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 cannot 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 before 1997.

- *PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene)*

No PAH profile is available for this source. The Norwegian Environment Agency suggests a distribution of the emissions where PAH-4 is 15 per cent of reported PAH emissions. Since no PAH profile is available, emissions of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene are assumed to be 25 per cent each of PAH-4 This assumption is used for the years 1990 - 2015. After 2015 one plant has reported figures for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene.

HCB emissions have been reported since 2010. For the period 1990-2009, aluminium production has been used with an emission factor from Japan (Toda 2006) to estimate HCB emissions. The emission factor is 1.7 mg/tonne secondary aluminium. PCB emissions have been reported from 2006 to 2008 and in 2010. Data reported have been used to build an emission factor and estimate emissions from 1990.

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 was 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

The plants emissions are compared to the plants emissions in previous years. If the change in emissions between years are large, NEA are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.4.5 Production of magnesium

NFR 2C4

Last update: 25.02.19

4.4.5.1 Description

There has been one magnesium producing plant in Norway. 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. The plant closed down the production of primary magnesium in 2002, but the production of cast magnesium continued. During 2006, the production of remelting Mg also stopped.

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 (Institute of environmental and energy technology 2002).

- *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 and HCB are emitted. Emission figures for dioxins were reported to the Norwegian Environment Agency from 1990 while emissions from HCB have been reported from 1992. For 1990 and 1991, 1992 figures have been considered. As no reports were available in 2004 and 2006, emissions have been estimated using 2003 and 2005 figures. Since the plant is closed, information concerning emission factors has not been prioritised.

4.4.5.3 Activity data

The production of magnesium is reported in the NFR table and in Appendix F.

4.4.5.4 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 earlier years. This is uncertain and only an estimate since it does not consider annually changes in raw materials nor possible cleaning devices.

4.4.5.5 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 Production of zinc

NFR 2C6

Last update: 31.01.24

4.4.6.1 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 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. Emissions in 1990 and 1991 are assumed to be the same as reported figures in 1992. For As, emissions for the years 2003 to 2014 are interpolated from reported emissions in 2002 and 2015.

PCB emissions have been estimated using the emission factor given by EEA (2023). This emission factor, which amounts to 2.0 µg/tonne of zinc, is used for the whole period.

4.4.6.3 Activity data
The production of zinc is reported in the NFR table and in Appendix F.

4.4.6.4 Source specific QA/QC
The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.4.7 Production of nickel
NFR 2C7B

Last update: 09.02.24

4.4.7.1 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.

4.4.7.2 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 using emission factors and use of energy.

- *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.

4.4.7.3 Activity data

The production of nickel is reported in the NFR table and in Appendix F.

4.4.7.4 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 cannot preclude that the distribution might be different than the one suggested. The particle size distribution can therefore only be seen as an estimate.

4.4.7.5 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.4.8 Manufacture of anodes

NFR 2C7C

Last update: 07.05.20

4.4.8.1 Description

Four plants in Norway produce or have produced prebaked anodes and 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, particles, BC, PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) and heavy metals.

4.4.8.2 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.

- *BC*

Emissions have been estimated as a share of $PM_{2.5}$ emissions. Measurements of the composition of the particulate matter at one plant showed that 8 per cent of the particulate matter was carbon. As no information on the share of BC and OC was found in the literature for anode production, BC share has been set to be 50 per cent of $PM_{2.5}$ using the default method described in Aasestad (2013). Indeed, the amount of $PM_{2.5}$ is assumed to be equally shared between BC and organic mass (OM). BC emission have therefore been set to 4 per cent of $PM_{2.5}$ emissions.

- *PAHs (Benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene)*

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-4 account for 5 per cent of the total PAH emissions (Table 4.16). Emissions of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene are estimated using the same PAH-profile as for aluminium production for the years 1990 - 2015, see Table 4.14. After 2015 two plants have reported figures for benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene.

Table 4.16. Share of PAH-4 emissions of total PAH emissions from production of anodes.

Component	Share of PAH emissions
PAH-4 (CLRTAP)	0.05

Source: Norwegian pollution control authority (SFT 1999)

- *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.

4.4.8.3 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.

4.4.8.4 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.5 Solvents and product use

NFR 2D, 2G

Last update: 02.01.18

Within solvents and product use, Norway includes emissions from solvent losses, creosote-treated materials, road paving with asphalt, mercury-containing products, tobacco, and use of fireworks. 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 PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene). Dioxins are also emitted during road paving with asphalt (2D3B). Emissions of mercury from mercury-containing products as well as emissions from combustion of tobacco and the use of fireworks are also included in the Norwegian inventory.

4.5.1 Solvent losses (NMVOC)

NFR 2D3A, 2D3D, 2D3E, 2D3F, 2D3G, 2D3H, 2D3I.

Last update: 01.03.21

4.5.1.1 Method

The general model 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). Activity data are reported in the NFR table and in Appendix F.

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 estimated 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, Danielsson 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.

2D3a Domestic solvent use 1990-2004

To calculate emissions of NMVOC for domestic solvent use in the period 1990-2004 the tier 1 method given in GB (2019) is used.

$$E_{pollutant} = AR_{production} \times EF_{pollutant}$$

Where AR = population
EF = 2.02 kg/capita

2D3h Printing 1990-2004

The emission of NMVOC from printing is based on activity data (Norwegian Product Register) from 2005. From 1990 to 2004 emissions are estimated from annual change in the Index of industrial production (Statistics Norway). This is under the assumption that emissions are correlated to activity in the industry “printing, reproduction”.

- *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 pharmaceuticals and cosmetics (SFT 2005). 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

[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."

Netherlands (IVAM 2005), with some supplements from the previous Norwegian solvent balance (the previous NMVOC emission model).

4.5.1.2 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; (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.

Variation in the activity data from the Product Register will in particular affect the emissions of NMVOC. This has to do with the fact that different solvents have different NMVOC content. For example, we can see an extraordinarily high emission in 2D3g in 2008. This is a result of increased imports of chemicals with a high NMVOC content. Similar effect can be seen in 2D3i from 2005 and onwards, as there in this source has been imported products with a lower content of NMVOC. Such variations in the solvent composition will thus not only result in large variations in emissions of NMVOC, but also in the IEF values. The IEFs are particularly sensitive to variations in solvent imports as they are calculated as the ratio between solvent use and NMVOC emissions.

The activity data for asphalt roofing is considered as confidential and the emissions from this source have been assessed as insignificant.

- *Allocation*

The data received from the Product register covers produced, imported and exported chemicals. The chemicals are allocated by CAS-nr, UCN-code and industrial sector. This includes water-borne wood preservatives. A detailed source allocation of CAS-nr, product type and NACE, based on the NFR sources are given in Holmengen and Kittelsen (2009) (A6: NFR source allocation).

- *Cosmetics*

The side model for cosmetics is updated each year with data on sales 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.

4.5.1.3 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, Danielsson 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. 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 0 kg/tonne solvent 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 of 0.95 kg/tonne solvent. 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.

4.5.1.4 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, Danielsson 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 4.17 and Table 4.18.

Table 4.17 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

Source: Holmengen and Kittilsen (2009)

Table 4.18. 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)

Source: Holmengen and Kittilsen (2009)

4.5.1.5 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.

4.5.2 Road paving with asphalt

NFR 2D3B

Last update: 02.02.24

Road paving with asphalt

4.5.2.1 Method

The emissions from road paving are being calculated in accordance with a Tier 1 approach for NMVOC, TSP, PM_{10} and $PM_{2.5}$. Emissions of BC and dioxins from production of asphalt are also included.

$$E_{pollutant} = AR_{production} * EF_{pollutatnt}$$

Where:

E pollutant = the emission of the specified pollutant

AR production = the activity rate for the road paving with asphalt

EF pollutant = the emission factor for this pollutant

4.5.2.1.1 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).

4.5.2.2 Activity data

The activity data used is the annual weight of asphalt used for road paving in Norway. EBA, *pers. comm*[14]).

4.5.2.3 Emission factors

Emissions of NMVOC, TSP, PM_{10} and $PM_{2.5}$ from road paving with asphalt are estimated using Tier 1 emission factors from the 2023 EEA Guidebook.

Table 4.19. Emission factor for road paving with asphalt. g/tonne

NMVOC	16
TSP	14 000
PM_{10}	3 000
$PM_{2.5}$	400

Source: EEA (2023)

[14] EBA (2014): Expert judgement by Contractors Association - Building and Construction (EBA), Oslo, Norway

- *BC*

Emissions are estimated from a share of $PM_{2.5}$ emissions. As no share for BC was found in the literature, BC share has been set to be 50 per cent of $PM_{2.5}$. Indeed, the amount of $PM_{2.5}$ is assumed to be equally shared between BC and organic mass (OM).

- *Dioxins*

Two emission factors are found in the literature. According to SFT (2001), the Oslo and Paris Convention (OSPAR) 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 4.20).

Table 4.20. Dioxin emission factor for asphalt production. µg I-TEQ/tonne produced asphalt

Source	Emission factor
SFT (2001)	0.047
Fyns Amt (2000)	0.0022
Emission factor chosen	0.025

4.5.2.4 Uncertainties

The activity data used are uncertain. The emission factors used are also uncertain. The annual emissions are low however and will not have any impact on the total level of these emissions.

4.5.2.5 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the respondent is contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.5.3 Leather preparing

NFR 2D3G

Last update: 07.01.22

4.5.3.1 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 emissions of NH_3 reported by the plant is equal to the consumption of NH_3. The plant was closed down in 2014.

4.5.3.2 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.

4.5.3.3 Source specific QA/QC

The plants emissions are compared to the corresponding emissions in previous years. If the change in the emissions between years are large, NEA are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.5.4 Creosote-treated materials

NFR 2D3I

Last update: 07.01.22

4.5.4.1 Description

Creosote is mainly used in quay materials and conductor 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 (Ministry of the Environment 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.

4.5.4.2 Method

Emissions of PAHs benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) 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.

4.5.4.3 Activity data

Data on imported amounts of creosote oil are taken from Statistics Norway's statistics on external trade. [15]

4.5.4.4 Emission factors

The emission factor used is taken from Finstad, Haakonsen et al. (2001). It is assumed that imported creosote oil contains on average 55 per cent PAH and that one per cent will evaporate during the lifetime of the creosote-treated materials. It is assumed that PAH-4 accounts for 0,018 per cent of the total PAH emissions. Emissions of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene are estimated using the a PAH-profile for creosote oil, Finstad at al. (2001), see Table 4.21.

[15] https://www.ssb.no/en/utenriksokonomi/statistikker/muh/aar

Table 4.21. Distribution of PAH-4 emissions from creosote oil. Share of PAH-4

Component	Distribution of PAH emissions (ratio)
benzo(a)pyrene	..
benzo(b)fluoranthene	0.50
benzo(k)fluoranthene	0.50
indeno(1,2,3-cd)pyrene	..

Source: Finstad et al (2001)

4.5.4.5 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.

4.5.4.6 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the foreign trade statistics are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.5.5 Mercury-containing products

NFR 2G

Last update: 11.02.21

4.5.5.1 Method

Breakage of mercury-containing thermometers, fluorescent tubes, economy bulbs, and various measuring and analytical instruments lead 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 lifetimes, 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 and economy bulbs, 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.

4.5.5.2 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 lifetimes. It is however impossible to predict the annual breakage and the mercury content in each of them.

4.5.5.3 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the foreign trade statistics are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.5.6 Tobacco

NFR 2G

Last update: 02.02.24

4.5.6.1 Method

- *NO_X, NMVOC, CO, NH_3, particles, BC, heavy metals and POPs*

The emission components included from the combustion of tobacco are NO_X, NMVOC, CO, NH_3, 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.

4.5.6.2 Activity data

The total consumption of tobacco in Norway is given by the net import of tobacco from Statistics Norway's external trade statistics and are reported in Appendix F. Tobacco bought tax free abroad and tobacco smuggled are not included in the inventory.

4.5.6.3 Emission factors

Table 4.22 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 Norwegian Directorate of Health (1990).

Table 4.22. Emission factors used for tobacco combustion

	Tobacco (unit/kg tobacco)	Source
NO_X (kg)	0.0034652	Statistics Norway, Norwegian Directorate of Health (1990)
NMVOC (kg)	0.0048374	Statistics Norway, Norwegian Directorate of Health (1990)
CO (kg)	0.1215475	Statistics Norway, Norwegian Directorate of Health (1990)
NH_3 (kg)	0.00415	EEA (2023)
TSP (kg)	0.04	Institute of environmental and energy technology (2002)
PM_{10} (kg)	0.04	Institute of environmental and energy technology (2002)
$PM_{2.5}$ (kg)	0.04	Institute of environmental and energy technology (2002)
BC	0.5% of $PM_{2.5}$	IIASA (Kupiainen and Klimont 2004)
Pb (g)	0.00005	Finstad, Haakonsen et al. (2001)
Cd (g)	0.0001	Finstad, Haakonsen et al. (2001)
Hg (g)	0.00001	Finstad, Haakonsen et al. (2001)
As (g)	0.000159	Finstad and Rypdal (2003)
Cr (g)	0.000125	Finstad and Rypdal (2003)
Cu (g)	0.000354	Finstad and Rypdal (2003)
Benzo(a)pyrene (g)	0.000111	EEA (2023)
Benzo(b)fluoranthene (g)	0.000045	EEA (2023)
Indeno(1,2,3-cd)pyrene (g)	0.000045	EEA (2023)
Indeno(1,2,3-cd)pyrene (g)	0.000045	EEA (2023)
Dioxins (µg)	0.0013	Finstad, Haakonsen et al. (2002)

4.5.6.4 Uncertainties

The emissions are assumed to be emitted the same year as the products are imported.

4.5.6.5 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the foreign trade statistics are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.5.7 Use of fireworks

NFR 2G

Last update: 02.02.24

4.5.7.1 Method

The emission components included from the use of fireworks are SO_2, CO, NO_X, particles and heavy metals. Emission figures have been calculated by multiplying the annual use of fireworks with emission factors for each pollutant.

4.5.7.2 Activity data

The total use of fireworks in Norway is given by the net import of fireworks from Statistics Norway's external trade statistics. The use of fireworks is reported in Appendix F.

4.5.7.3 Emission factors

Table 4.23 gives emission factors used for the use of fireworks.

Table 4.23. Emission factors used for the use of fireworks

	Value (g/t fireworks)
SO_2	3020
CO	7150
NOx	260
TSP	109 830
PM_{10}	99 920
$PM_{2.5}$	51 940
As	1.33
Cd	1.48
Cr	15.6
Cu	444
Hg	0.057 [1]
Pb	784 [2]

[1)] Emissions of Hg from fireworks assumed banned in 2002 like in Denmark.

[2)] Emissions of Pb from fireworks assumed banned in 2006 like in Denmark.

Source: EEA (2023)

4.5.7.4 Uncertainties

The emissions are assumed to be emitted the same year as the products are imported.

4.5.7.5 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the foreign trade statistics are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.6 Other production

NFR 2H

Within other production, Norway includes emissions from pulp and paper, food and beverages industry and ore mines.

4.6.1 Pulp and paper

NFR 2H1

Last update: 02.02.24

4.6.1.1 Description

Pulp and paper production have 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 chemical 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. Emissions of NOx, NMVOC and CO are estimated.

4.6.1.2 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. Some plants lack data for the earliest years, and emissions for those years are 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 EEA (2023), $PM_{2.5}$ is 60 per cent of TSP and PM_{10} is 80 per cent of TSP.

- *NOx, NMVOC and CO*

Emissions of NOx, NMVOC and CO are estimated based on annual production levels and emission factors. Emissions of NOx and NMVOC due to burning of fossil fuel is included in 1A2d. One of the plants emitted CO-emissions, but this plant was closed down in 2013.

- *BC*

BC emissions have been estimated using a share of $PM_{2.5}$ from EEA (2023) as emission factor. BC=2.6 per cent of $PM_{2.5.}$

4.6.1.3 Activity data

For the estimates of NOx, NMVOC and CO, production levels of pulp by different processing steps as reported by the plants are used. The pulp production is found in Annex F.

4.6.1.4 Emission factors

For the estimates of NOx, NMVOC and CO, emission factors from the 2023 Guidebook are used.

Table 4.24. Emission factors for pulp and paper. kg/Mg air dried pulp

NO_x	1 (Kraft), 2 (Acid sulphite)
NMVOC	2 (Kraft), 0.2 (Acid sulphite), 0.05 (neutral sulphite semi)
CO	5.5 (Kraft)

Source: EEA (2023)

4.6.1.5 Uncertainties

The particle size distribution used is not plant specific and might therefore be different from the one suggested by TNO.

4.6.1.6 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.6.2 Food and beverages industry

NFR 2H2

Last update: 02.02.24

4.6.2.1 Description

This source category includes NMVOC emissions from production of bread and beer. Emissions of NMVOC from fish and spirit manufacture are considered insignificant and are not included in the inventory.

4.6.2.2 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.

4.6.2.3 Activity data

Production volumes of bread and beverages are annually reported in the PRODCOM statistics at Statistics Norway and these are reported in Appendix F.

4.6.2.4 Emission factors

The emission factors are taken from EEA (2023).

Table 4.25. NMVOC emission factors from production of bread and beverage

	Emission factor	Unit
Production of bread	0.0045	tonnes/tonnes produced
Production of beverage	0.35	kg/1000 litres

Source: EEA (2023)

4.6.2.5 Uncertainties

The emission factors used are recommended by EEA (2023) and are not specific for Norwegian conditions.

4.6.2.6 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the PRODCOM statistics are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.6.3 Ore mines

NFR 2H3

Last update: 11.02.21

4.6.3.1 Description

Several 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. 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.

4.6.3.2 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. Emissions for earlier years are assumed to be the same as in the first year of reporting. The size distribution used in the Norwegian inventory is according to TNO (Institute of environmental and energy technology 2002) (Table 4.26).

Table 4.26. Particle size distribution for particles emitted from ore mining. Ratio X1/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 only included 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 to be the same as the reported figure in 1994.

4.6.3.3 Uncertainties

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.

4.6.3.4 Source specific QA/QC

The plants emissions in year t are compared to the emissions in year t-1. If the change in the emissions between years are large, NEA are contacted for control. See section 1.6 for the description of the general QA/QC procedure.

4.7 Wood processing

NFR 2I

Last update: 02.02.24

4.7.1 Description

This source category includes TSP emissions from four plants from wood processing.

4.7.2 Method

The emissions are calculated based on production volumes and emission factors.

4.7.3 Activity data

The production volumes of wood processing products are annually reported to the Norwegian Environment Agency. These are reported in the NFR table and in Appendix F.

4.7.4 Emission factors

The emission factor is taken from 2023 EEA Guidebook.

Table 4.27. TSP emission factor for wood processing

	Emission factor	Unit
Wood processing	1	Kg/Mg wood product

Source: EEA (2023)

4.7.5 Uncertainties

The emission factor is not specific for Norwegian conditions.

4.7.6 Source specific QA/QC

The emissions are reported according to their permits to NEA. The case handler assesses the reported emissions and activity data and contacts the plants if needed. Emissions from these plants also include GHGs, so the inventory team at NEA undertakes QA/QC procedures that also are relevant for other components. See section 1.6 for the description of the general QA/QC procedure.

4.8 Consumption of POPs and heavy metals - Hg, PCBs

NFR 2K

Last update: 18.02.21

4.8.1 Description

Hg

Norway reports Hg emissions from mercury-containing thermometers and fluorescent tubes under NFR 2G. The sale of these products decreased strongly since the mid-1990s, and the mercury content in these products has been reduced. In 1998, a prohibition against the production, import and export of mercury-containing products entered into force, except for some thermometers for professional use, which were prohibited in 2001. Using an EF per capita approach to calculate these emissions will not properly reflect the situation in Norway and the emissions are therefore reported as NE in NFR 2K.

PCB

Norway has no data for PCB emissions from products. Due to the requirements of collecting waste containing PCB, the emissions are considered to be insignificant. Building materials containing PCB, for example transformers and other electric equipment are treated as hazardous waste. Since it is not allowed to use products with PCB, it is not correct to calculate emissions based on population size. PCB is prohibited in products by Produktforskriften (product regulation). This is not available in English but can be found in Norwegian under the link: https://lovdata.no/dokument/LTI/forskrift/2011-11-17-1113. This includes transformers ("transformatorer"), power capacitor ("kraftkondensator") and small capacitors ("kondensatorer"). Capacitors produced between 1965 and 1979 are only allowed if it can be documented that they are free of PCB.

5. Agriculture

Last update: 26.02.2024

5.1 Overview

Agriculture is an important contributor to NH_3 emissions. Animal manure management, grazing animals and the use of fertilizer (manure, synthetic fertilizer, sewage sludge and other organic fertilizers applied to soils) generate emissions of NH_3. Another source of NH_3 is treatment of straw using NH_3 as a chemical. Animal manure management and the use of fertilizer also generates emissions of NO_X. Emissions of NMVOC from manure management and from cultivated crops are also included in the inventory. Non-combustion emissions of particles from manure management and agricultural soils are also calculated. Additionally, there are long-range transboundary air emissions arising from the burning of agricultural residues.

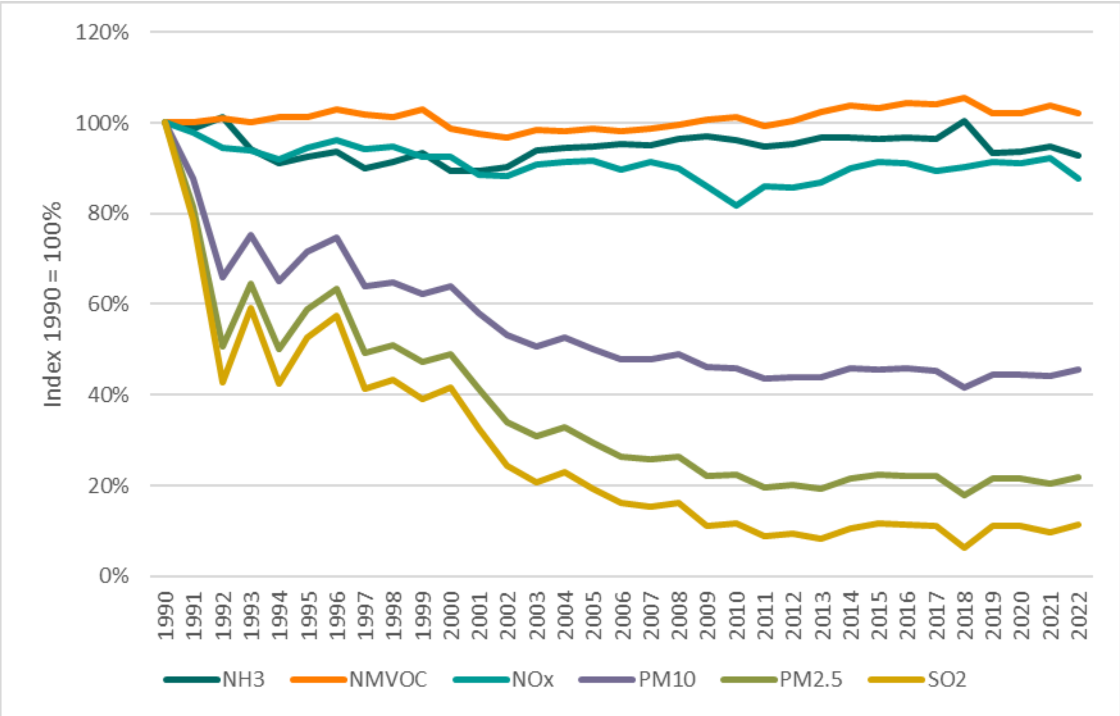


Figure 5.1 Trends for the emissions for most of the air pollutants from the agricultural sector, relative to 1990

Figure 5.1 shows the trends for most of the long-range transboundary air pollutants from the agricultural sources.

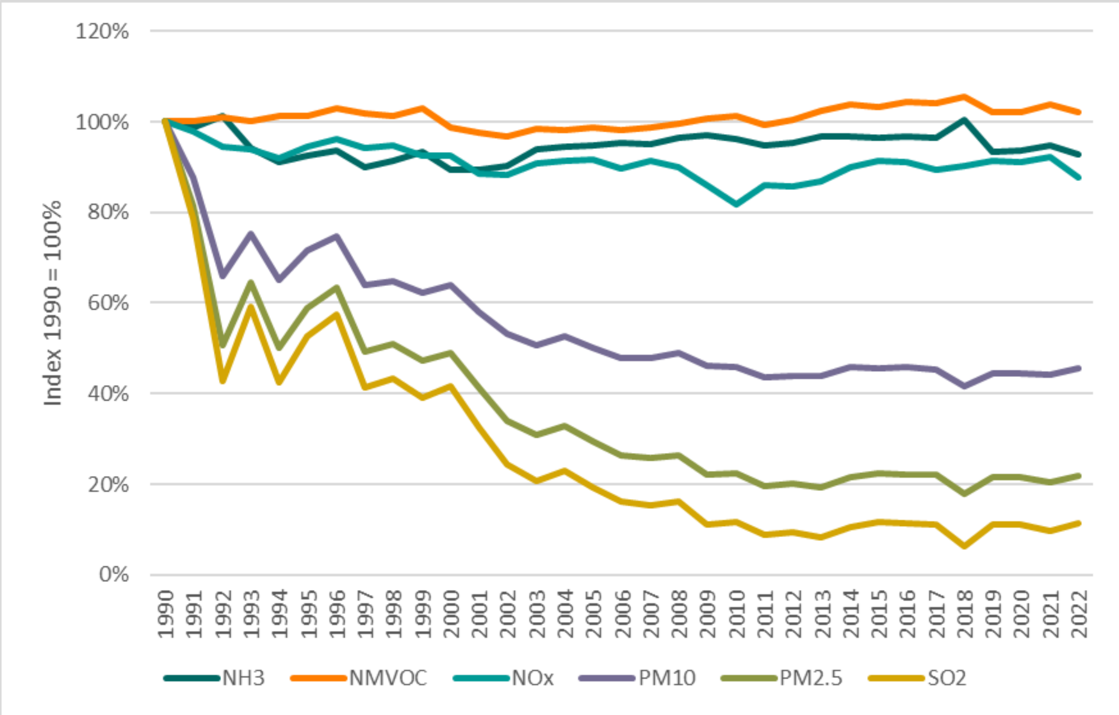


Figure 5.1 Trends for the emissions for most of the air pollutants from the agricultural sector, relative to 1990

While the trends for NH_3, NMVOC and NO_X have been quite stable since 1990, the emissions from PM10, PM2,5 and SO_x have had a considerable decline. The main reason for this decline is primarily due to reduced amount of straw burned since 1990.

The total emissions of NH_3 from agriculture are in 2022 about 7% lower than in 1990. Figure 5.2 and Figure 5.3 show the NH_3 trends for the different agriculture sources.

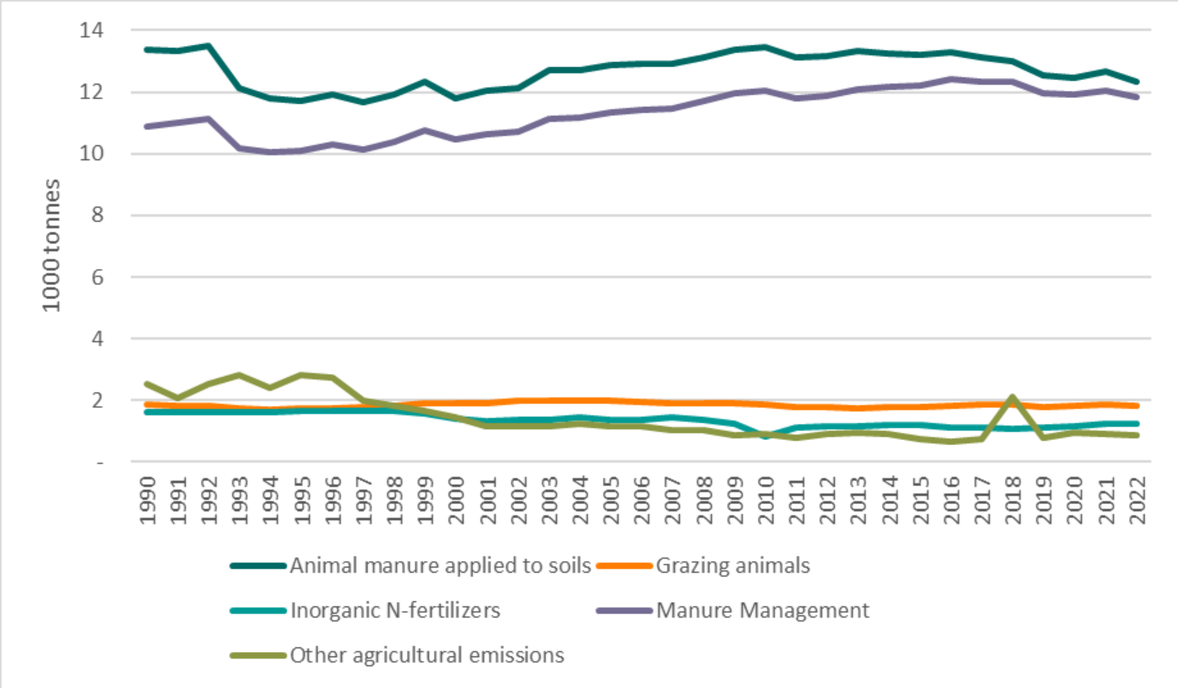


Figure 5.2 Trends for the NH_3 emissions for agricultural sources. 1000 tonnes NH_3. 1990-2022.

Source: Statistics Norway/ Norwegian Environment Agency

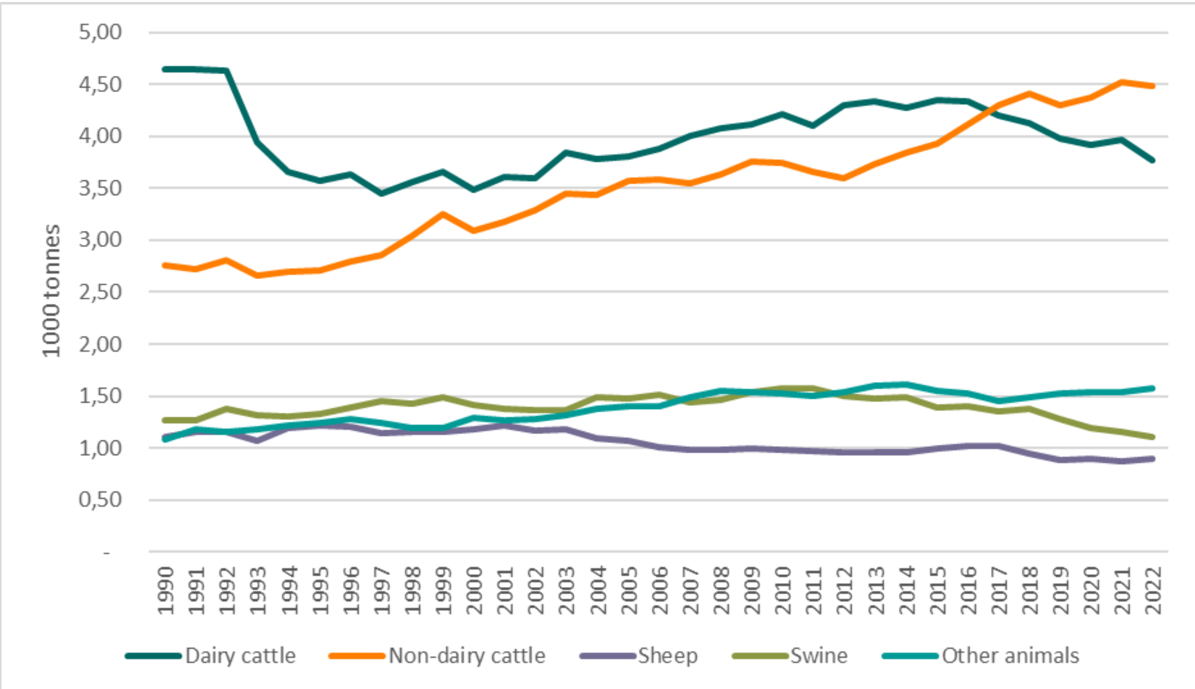


Figure 5.3 Trends for the NH_3 emissions from manure management. 1000 tonnes NH_3. 1990-2022

Source: Statistics Norway/ Norwegian Environment Agency

The increase of NH_3 emissions from manure management for cattle since second half of the 1990s is due to an increase in the number of animals. The strong increase in other agricultural emissions in 2018 can be explained by an increase in NH_3 treatment of straw because of an unusual hot and dry summer. The irregular emission trend from inorganic fertilizers around 2009 is due to a price change and is explained in more detail in chapter 5.5.2.2.

See chapter 2 for more information about trends.

5.2 Livestock population characterization

Last update: 31.01.2024

5.2.1 Data sources

The main sources of the livestock statistics are the register of production subsidies (sheep for breeding, goats, poultry for egg production and beef cows), statistics of approved carcasses (animals for slaughter and pig categories) and the Cow Recording System at TINE BA[16] (heifers for breeding and dairy cows). The animal numbers from production subsidies are corrected with the estimated coverage of animal populations before Statistics Norway receive the data. This means that the figures used in the calculations represent the total population. The number of dairy cows and heifers for breeding derive from the Cow Recording Systems (TINE BA Annually). Approximately 97 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 adjustment is based on the percentage of herds controlled by the cow recording system. The coverage in the data sources used is shown in Table 5.1.

[16] TINE BA is the sales and marketing organization for Norway's dairy cooperative and covers most of the milk production and the meat production induced by milk production.

Table 5.1 Coverage in data sources, percent

Animal categories	Statistics Norway, production subsidies	Statistics Norway, statistics of approved carcasses [4]	TINE	Other
Dairy cows		100[2]	98.4[1]	
Heifers for breeding			97.4	
Young cattle for slaughter		100	100[3]	
Beef cows	99.8	100[2]		
Sheep	99.8	100		
Goats	100			
Laying hens	100			
Chicks for breeding	100			
Chicken for slaughter		100		
Other poultry for breeding	96.5			
Other poultry for slaughter		100		
Sows		100		
Young pigs for breeding (gilts)		100		
Pigs for slaughter		100		
Horses	Unkown[5]			Unkown[5]
Fur-bearing animals	100			
Deer	100			
Reindeer				100[6]

[1] *Share of livestock herds.*

[2] *Data source only for slaughter weight*

[3] *Data source only for slaughter age*

[4] *Figure refers to share of slaughtered animals, excluding home slaughter. Animals dead from other causes also excluded*

[5] *Total number of horses used in the inventory is based on data from productions subsidies (roughly 50 per cent of total number) and an additional estimation of number of horses outside agriculture by NIBIO and nasjonalt hesteregister.*

[6] *Norwegian Agriculture Agency*

Source: Estimations by Statistics Norway and the Cow Recording System (dairy cows and heifers).

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 registered at the slaughterhouses.

In this 2024 submission a new methodology for calculating the number of pigs (animal years) is introduced. The basis is the number of slaughtered pigs per year and the other pig-categories; sows, young pigs for breeding (gilts) and weaners (piglets) are derived from that number based on how long an animal lives in the different phases (Bonesmo & Gjerlaug-

Enger 2022). The whole series was revised and led to 23 per cent lower animal number per year compared to former estimation.

The registers are updated annually. In addition to the animals included in these registers, an estimate of the number of other horses is obtained from the Norwegian Institute of Bioeconomy Research (NIBIO)[17]. The number of reindeer is obtained from the Norwegian Reindeer Husbandry Administration.

For the categories of animals living shorter than a year or two, generally animals for slaughter, lifetime is taken into account to get a yearly average for the number of animals.

5.2.2 Method for estimating number of cattle

For dairy cows, additional information from the Cow Recording System concerning annual milk production and proportion of concentrate in the diet is used (TINE BA Annually). The Cow Recording System also supplies annual information about slaughter age for heifers and bulls and data for estimating live weight of dairy cows and heifers for breeding, and the age of young cows at their first calving.

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 (TINE BA Annually), 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 in 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 for. Since animal populations are relatively stable, this error is considered much smaller compared to errors related to estimating animal years based on animal populations in the register of production subsidies which was previously used. The data sources used also ensure a better coherence between animal numbers, lifetime and weight. Estimated animal years for cattle are given in Table 5.2.

The number of milk cows calving their first time (=heifers for replacement) and their average age at time of calving is reported by the Cow Recording System (TINE BA Annually) on request from Statistics Norway. These data date back to 2004. For the years 1990-2003, average fraction (number of heifers)/(number of milk cows) for the years 2004-2011 is used to estimate number of heifers based on number of milk cows. Number of heifers for replacement in beef production is collected from annual reports from Animalia (Norwegian Meat and Poultry Research Center (www.animalia.no)). Figures exist from 2007. For previous years, the number is estimated with the same method as for heifers for milk production.

[17] Formerly named the Agricultural Economics Research Institute (NILF).

Table 5.2 Estimated animal years for cattle

	Heifers for replacement	Heifers for slaughter	Bulls for slaughter	Beef cows[1]	Dairy cows
1990	311 279	47 020	289 945	8 193	325 896
1995	299 284	47 103	284 237	20 334	310 346
2000	280 121	63 512	285 349	42 324	284 880
2005	255 862	57 619	263 170	54 841	255 663
2010	239 839	53 410	230 872	67 110	232 294
2013	239 386	47 294	220 401	70 969	225 163
2014	246 165	67 624	208 979	73 894	222 553
2015	240 419	64 814	206 328	77 408	222 276
2016	243 942	64 361	217 885	84 372	220 461
2017	247 715	43 501	250 630	88 332	215 849
2018	245 636	52 356	260 129	92 304	211 730
2019	240 049	47 230	238 845	94 001	199 417
2020	245 069	52 767	229 068	99 748	195 076
2021	247 748	56 773	229 199	106 082	196 934
2022	230 862	44 258	245 355	109 517	189 099

[1] *Counted animals*

Source: Cow Recording System at TINE BA (dairy cows), slaughter statistics and estimations by Statistics Norway

5.2.3 Method for estimating number of sheep

In the estimations, the sheep population is divided between sheep > one year and sheep < one year. Data from both the register of production subsidies and slaughter statistics is used in estimating the number of animals. In 2017 two changes appeared in the register data: The counting date changed from 1st of January to 1st of March, and the two categories' sheep > one year, and sheep < one year were merged into one category for adult sheep. To solve this, figures are split into the two categories sheep > and < one year based on data from the Norwegian Meat and Poultry Center, Animalia.

Sheep over one year is estimated as the number of sheep registered 1st of March deducted for the number of sheep slaughtered before May. The sheep slaughtered later in the year are counted as living the whole year.

Sheep under one year is estimated as number of sheep under one year registered 1st of March + number of lambs slaughtered June-December *143/365. Lambs slaughtered before June are assumed to be registered as sheep under one year the 1st of March. Practically all lambs slaughtered after June are born in the spring. An expert judgment suggests an average lifetime of 143 days for slaughtered lambs born in the spring (UMB, pers. comm[18]).

[18] UMB (2001): Expert judgement by Department of Animal Science, Ås: Norwegian University of Life Sciences.

5.2.4 Deviations from FAO statistics

There are some differences between the number of animals used in these calculations and the FAO statistics. The general reason that animal statistics used in the emission inventory differ from the statistics delivered to FAO is that the statistics are used for different purposes. Animal statistics used in the inventory has to be categorized so that the categories fit the recommended methodology and the various emission factors used in the emission estimations. The figures reported to the FAO are provided by the Norwegian Institute of Bioeconomy Research (NIBIO)[19.] NIBIO 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. Differences include:

- Different emphasis on the dates for counting.
- NIBIO does not register pigs under 8 weeks, whilst Statistics Norway (SN) does. For the number of animals for slaughter, SN uses the statistics of approved carcasses and estimates animal years (average population through the year) on basis of this, while NIBIO uses figures for registered animals at specific dates.
- For the number of dairy cows and heifers for replacement, Statistics Norway uses statistics from the Cow Recording System (TINE BA Annually)

5.2.5 Uncertainties

Activity data

The uncertainty in the data is considered to be within ±5 per cent and ±7 per cent for the number of pigs. 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.

5.2.6 Source specific QA/QC

In 2016, the method for estimating the number of sheep was revised. The revised data on animal populations form the basis for the emission calculations for all years.

5.3 Nitrogen in animal manure as basis for emission estimates

Last update: 26.02.2024

Access to nitrogen is vital for all plant growth; hence nitrogen is added to the soil from i.a. animal manure. This causes emissions to air of compounds containing nitrogen at various points. Of the nitrogen compounds emitted to air from animal manure, N_2O, NO_X and NH_3 are estimated.

[19] Former named the Agricultural Economics Research Institute (NILF).

According to the IPPC and LRTAP guidelines, process emissions of nitrogen compounds from use of animal manure are calculated from the following sources:

1. Manure management systems (N_2O, NO_X and NH_3)
2. Application of manure on soil (N_2O, NO_X and NH_3)
3. Droppings from animals on pastures (N_2O, NO_X and NH_3)
4. Leakage of nitrogen through manure management systems and soils (N_2O)
5. Deposition of nitrogen from emissions of NH_3 and NO_X (N_2O)

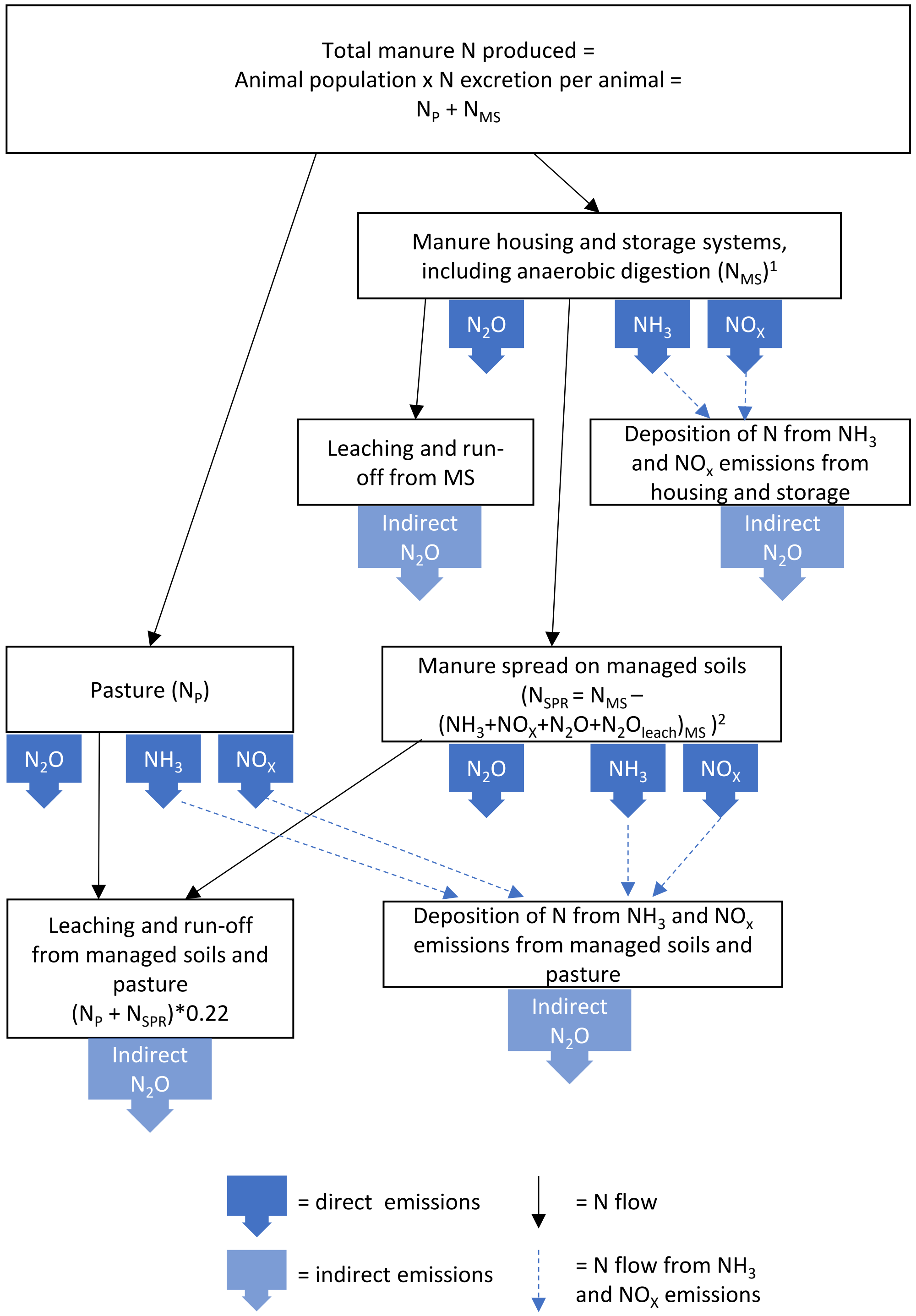
The nitrogen flow is continuously dependent on its surroundings (soil characteristics, temperature, moisture etc.) and the preceding supplies and losses of N. The Norwegian model for calculating nitrogen emissions to atmosphere from manure is described in Carbon Limits (2018); Carbon Limits (2020). The model is designed based on the EMEP/EEA 2023 Tier 2 technology-specific approach, which uses a mass-flow approach based on the flow of both total ammoniacal nitrogen (TAN) and total nitrogen through the manure management system until application to land (or deposition during grazing). The emission estimates of each of the sources therefore take into account emissions and losses of N forms from the preceding sources. Figure 5.4 gives an overview of the manure nitrogen flows in the Norwegian greenhouse gas inventory.

The following decides the amounts of N that are used as the basis for the respective emission calculations:

- The amount of N in manure systems is calculated as total N in manure adjusted for the N that is dropped on pastures.
- N_2O emitted during spreading is calculated from the amounts of N in manure spread to land. This means that N lost through leaching in manure storage and as N_2O, NH_3 and NO_X in manure housing and storage is deducted. However, N lost as N_2O, NH_3 and NO_X during spreading, as well as indirect emissions of N_2O due to atmospheric deposition, are not deducted.
- NH_3 emitted during and after spreading of manure is based on the amounts of TAN in manure spread to land minus N lost through leaching in manure storage and as N_2O, NH_3 and NO_X in manure housing and storage. NO_X emitted during and after spreading of manure also has the same basis. For NH_3 emissions, N lost as N_2O and NO_X during spreading, as well as indirect emissions of N_2O due to atmospheric deposition is not deducted. Similarly, for NO_X emissions, N lost as N_2O and NH_3 during spreading, as well as indirect emissions of N_2O due to atmospheric deposition is not deducted.
- Emissions of N_2O, NH_3 and NO_x from pasture are calculated independently of each other, and are based on the amounts of N (or TAN for NH_3 emissions) estimated in manure dropped during grazing.
- N_2O lost through leaching due to spreading is based on total N in manure spread to land minus N lost through leaching in manure storage and as N_2O, NH_3 and NO_X in manure housing and storage. N_2O lost through leaching due to grazing is based on total N excreted on pastures. N_2O lost through leaching during storage of manure is

based on the amounts of N estimated for the particular management systems that are susceptible to leaching. N lost through emissions of NH_3 from housing is not deducted.

- The nitrogen in NH_3 and NO_X volatilized during housing, storage, pasture and spreading of manure is the basis for the calculation of N_2O emissions from atmospheric deposition. How the amounts of N are estimated in the various emission estimates, is described in more details in the respective chapters below.



[1] For estimation of NH_3 and NO_X emissions from manure storage systems, emissions of NH_3 from housing are deducted from N excreted in housing. N_2O emissions (direct and indirect) are estimated directly from N excreted in housing.
[2] Emissions of N_2O, NH_3 and NO_X that have occured prior to spreading of manure on managed soils (during housing and storage) are deducted before emissions of N_2O, NH_3 and NO_X from application to soils are estimated.

Figure 5.4 Overview of manure nitrogen flows in the Norwegian greenhouse gas inventory

5.4 Emissions from manure management

NFR 3B

Last update: 31.01.2024

5.4.1 Description

Manure management in Norway is a source of emissions to air of NH_3, NO_X, NMVOC and PM.

5.4.2 NH_3 emissions from manure management

5.4.2.1 Description

The dominating pollutant emitted from manure management is NH_3 (NFR 3B). 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.

5.4.2.2 Method

In Norway, all animal excreta that are not deposited during grazing are managed as manure. The estimations are made in accordance with the IPCC tier 2 method (IPCC 2006), using Norwegian values for N in excreta from different animals according to Table 5.3. The rationale for the Norwegian values for N in excreta is given in Karlengen et al. (2012) ,for beef cow in Aspeholen Åby et al. (2018) and for pigs in Kjos (2023). The N-excretion factors for cattle, poultry and pigs have been scientifically investigated, while the remaining categories have been given by expert judgements (Karlengen et al. 2012). For reindeer, the factor for N excretion rate from 2019 refinement to the 2006 IPCC Guidelines is used (IPCC 2019). Based on typical Norwegian feedstock ratios, the excretion of nitrogen (N) was calculated by subtracting N in growth and products from assimilated N and P. Comparisons have also been made with emission factors used in other Nordic countries and IPCC default factors.

In 2021 the N-factors for cattle were evaluated due to recent studies and data available. And the conclusion was that the factors were still valid as referred to in Volden (2022).
The factors for cattle are based on equations using animal weight, production (milking cows), lifetime (young cattle) and protein content in the fodder as activity data.

The Nordic feed evaluation system (NorFor) was used to develop the nitrogen factors for cattle. Excretions of N in the manure were calculated as the difference between their intake, and the sum of what is excreted in milk, fetus and deposited in the animal itself. The procedure used for calculating the excretion of faeces and N consisted of two steps:

1. Simulations in "NorFor" were conducted to gain values for the faeces/manure characteristics covering a wide variation of feed characteristics (N content) and production intensities (milk yield/meat production).
2. The results from the simulations were used to develop regression equations between faeces/manure characteristics and parameters related to the diet (N content) and animal characteristics (milk yield, weight, age etc.).

Calculations of N-factors based on these equations have been made back to 1990 for cattle. For poultry and pigs, N-factors have been estimated for 2011 in Karlengen et al. (2012). The factors used until this update were estimated in 1988 (Sundstøl & Mroz 1988), and are regarded as still valid for 1990. A linear interpolation has been used for the years between 1990 and 2011. In 2023, new N-factors for pigs were estimated (Kjos 2023). For the remaining animal categories, the N in excreta is considered constant throughout the time series. The factors are shown in Table 5.3. The factors for total N are used in the estimations of N2O emissions, and ammonium N are used in the estimations of NH3 and NOX emissions.

Norwegian values are also used for the fraction of total excretion per animal categories for each management system (MS) and for pasture. The fractions are updated every year.

Table 5.3 N in excreta from different animals[1]. 2022. kg/animal/year unless otherwise informed in footnote

	Total N	**Ammonium N**
Dairy cattle	133.0	75.8
Suckling cows	93.0	52.6
Replacement heifers[2]	89.3	55.6
Heifers for slaughter[2]	65.6	26.3
Bull for slaughter[2]	74.5	45.4
Sows	22.9	15.3
Boars	18.3	12.2
Piglets	2.7	1.8
Fattening pigs[3]	2.3	1.5
Young pigs for breeding	15.0	10.0
Laying hens	0.7	0.3
Chickens reared for laying[3]	0.05	0.02
Broilers[3]	0.03	0.01
Turkeys for slaughter[3]	0.5	0.2
Ducks and geese for slaughter[3]	0.1	0.03
Turkeys, ducks and geese reared for laying	2.0	0.8
Horses	50.0	25.0
Dairy goats	16.9	10.1
Other goats	8.5	5.1
Sheep over 1 year old	11.6	6.4
Sheep under 1 year old	7.7	4.3
Mink	4.3	1.7
Foxes	9.0	3.6
Deer	12.0	5.4
Reindeer	5.4	2.4

[1] *Includes pasture.*

[2] *Factors for excreted nitrogen apply for the whole lifetime of animals, and nitrogen is calculated when animals are slaughtered/replaced.*
[3] *Per animal. For these categories, lifetime 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), Aspeholen Åby et al. (2018), Kjos (2023), IPCC (2019) and estimations by Statistics Norway 2022.

A model based on the stepwise approach proposed by the EEA (2023) is used for calculating the emissions of ammonia from manure management. The principle of the model is illustrated in Figure 5.5.

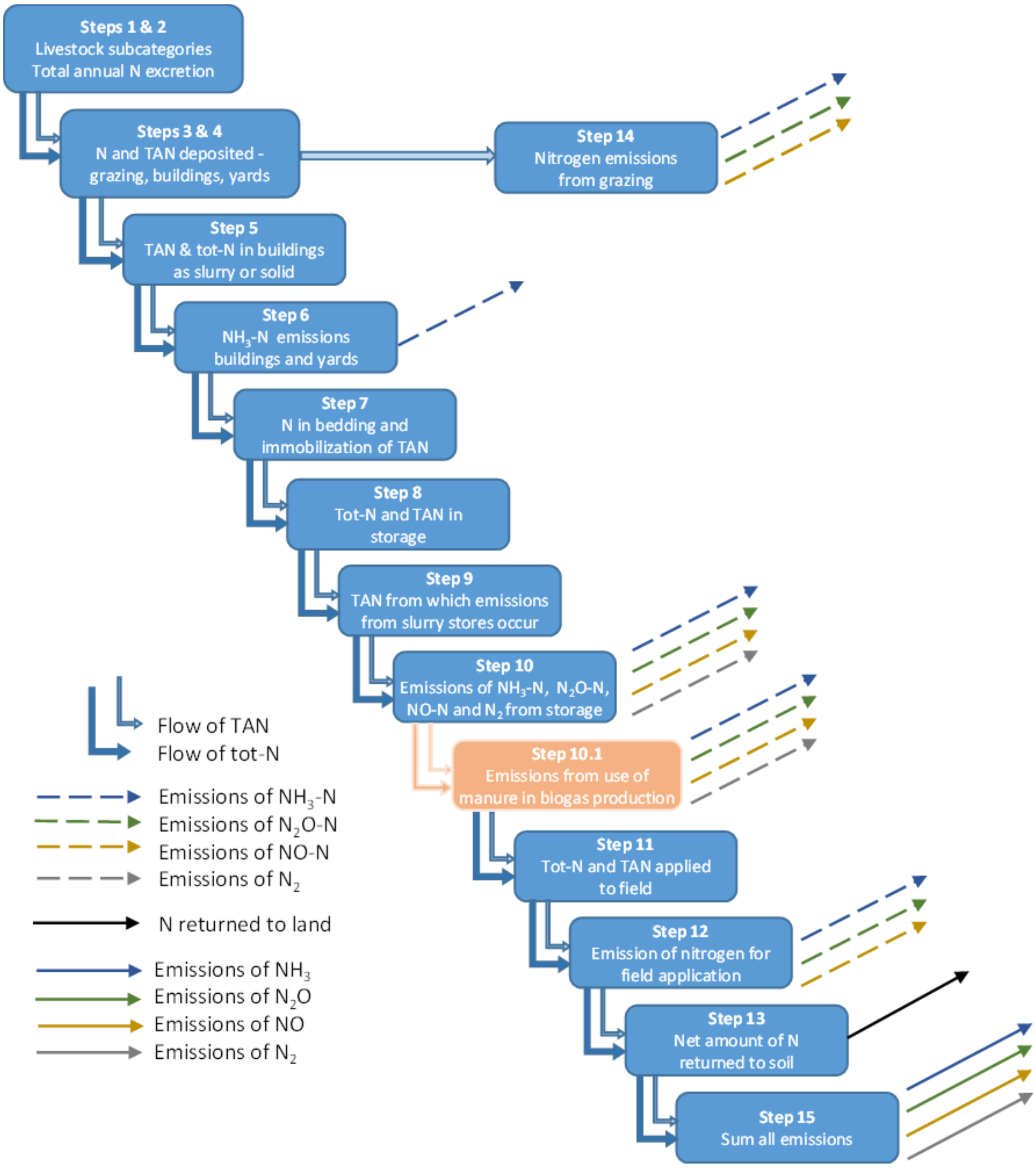


Figure 5.5 The principle of the Norwegian nitrogen model

Emissions of NH_3 are determined from buildings and yards and from manure storage systems. Total NH_3 emissions from manure management (housing and storage) are estimated by multiplying the amount of manure nitrogen (TAN) by the different emission factors for the housing and storage systems, taking into account the effect of any abatement measures and improved practices. The model also takes into account NH3 emissions from anaerobic digestion (AD), namely emissions from pre-storage of manure used for AD, emissions from the digester, separation and storage of digestate. The nitrogen in digestate produced from manure is then assumed to return to land, together with the nitrogen in untreated manure. The amount of ammonium nitrogen in the manure is estimated by the number of animals and ammonium nitrogen excretion factors for each type of animal (see Table 5.3). The Norwegian model for calculating nitrogen emissions from manure is described in more detail in Carbon Limits (2020).

5.4.2.3 Activity data

Emissions are estimated from the animal population. How the animal population is estimated is described in section 5.2.
Surveys for assessing use of manure management systems (MMS) have been carried out in 2000, 2003, 2013, 2018 and 2020. The surveys aim to determine the fraction of manure from each animal category that is deposited in pastures during grazing, which is summarized in Table 5.4, in addition to collecting data on the MMS used for manure deposited in buildings and yards (Table 5.5).

Table 5.4 Percent of total excretion per species processed by an MMS (i.e. deposited in housing) and deposited on pasture. 2020.

	% manure to pasture	% manure to MMS
Dairy cattle	16 %	84 %
Suckling cows	37 %	63 %
Young beef cattle	24 %	76 %
Swine	0 %	100 %
Laying hens	0 %	100 %
Broilers	0 %	100 %
Turkeys	0 %	100 %
Other poultry	0 %	100 %
Horses	26 %	74 %
Goats	30 %	70 %
Sheep	77 %	23 %
Fur animals	0 %	100 %
Deer	100 %	0 %
Reindeer	100 %	0 %

Source: Data for storage systems from Statistics Norway (Kolle & Oguz-Alper 2020) (Gundersen & Heldal 2015), data for pasture times from (TINE BA Annually) (Dairy cattle, goat), Statistics Norway's Sample Survey 2001 (Statistics Norway 2002b)

Data on storage systems for other years are not available. Separate estimations of the effects on emissions of the assumed changes in storage systems since 1990 show that these assumed changes do not impact significantly. For the intermediate years 2004-2012 between the surveys of 2003 and 2013, the distribution of management system has been estimated using a linear interpolation of changes between 2003 and 2013, between 2014 and 2018, and between 2019 and 2020 for each system, and was updated for the 2023 submission.

Currently, data for pasture times for dairy cattle and dairy goats are annually updated in the Cow Recording System, however pasture time for dairy cattle has not been updated since 2013. The 2018 manure surveys final figures gave updated pasture times for other cattle and sheep. For other grazing animals the sample survey of agriculture and forestry for 2001 at Statistics Norway is used.

Table 5.5 Fraction of total excretion per animal category for each management system used in the estimations of NH3 and NOx. 2022.

	In-house slurry pit [pit storage below animal confinements]	**Tank without cover [Liquid/ slurry]**	**Tank with cover [Liquid/ slurry]**	**Heaps [solid storage]**	**In-house deep litter [Cattle and swine deep bedding]**	**Dry lot**
Dairy cattle	0.67	0.01	0.32	0.00	0.00	0.00
Suckling cows	0.53	0.00	0.16	0.13	0.14	0.04
Young beef cattle	0.67	0.01	0.23	0.04	0.04	0.01
Swine	0.52	0.31	0.13	0.02	0.01	0.00
Laying hens	0.51	0.06	0.03	0.36	0.03	0.01
Broilers	0.16	0.02	0.01	0.74	0.04	0.04
Turkeys	0.16	0.02	0.01	0.74	0.04	0.04
Other poultry	0.16	0.02	0.01	0.74	0.04	0.04
Horses	0.20	0.01	0.00	0.58	0.07	0.14
Goats	0.82	0.01	0.00	0.04	0.10	0.02
Sheep	0.72	0.01	0.01	0.08	0.13	0.05
Fur animals[1]	0.00	0.00	0.00	1.00	0.00	0.00
Deer	NA	NA	NA	NA	NA	NA
Reindeer	NA	NA	NA	NA	NA	NA

[1] Based in expert opinion NIBIO

Source: Data for storage systems from Statistics Norway (2021)

In the manure surveys of 2000, 2013,2018 and Statistics Norway's agriculture full count in 2020, the manure of each management system is distributed by all combinations of the following productions[20]:

- Cattle
- Pigs
- Sheep
- Goats and horses
- Poultry

[20] The grouping of animals is different in the surveys. Cattle is one category in the 2000 survey and three categories in the 2013 and 2018 survey. Goats are grouped with sheep in the 2000 survey, but with horses in the 2013. In the 2018 survey, horses and goats were divided into two categories. Horses are grouped with other animals in the 2000 survey. Fur bearing animals are not included in the 2013 and 2018 survey but added to the horse/goat category. All manure from fur bearing animals is considered to be stored in heaps.

5.4.2.4 Emission factors

Emission factors vary with production and storage system; in the model there is no variation between regions for the manure management systems. The factors used are shown in Table 5.6. All emission factors in Table 5.6 are sourced from EEA (2023), since measurements of NH3 losses in animal housing and manure storage have so far not been carried out in Norway.

Table 5.6 NH_3 emissions factors for various storage systems and productions. Per cent losses of N of ammonium N.

	Housing		Storage	
	Slurry	**Solid manure**	**Slurry**	**Solid**
Dairy cattle	24%	8%	25 %	32 %
Suckling cows	24%	8%	25 %	32 %
Young beef cattle	24%	8%	25 %	32 %
Swine	27%	23%	11 %	29 %
Laying hens	41 %	20%	14 %	8 %
Broilers	21%	21%	30 %	30 %
Turkeys	35 %	35 %	24 %	24 %
Other poultry	57 %	57 %	24 %	24 %
Horses	22 %	22 %	35 %	35 %
Goats	22 %	22 %	28 %	28 %
Sheep	22 %	22 %	32 %	32 %
Fur animals	27 %	27 %	9 %	9 %
Deer	24%	24%	25 %	25 %
Reindeer	24%	24%	25 %	25 %

In addition to default (or unabated) emission factors, the model includes different options for reducing emissions through mitigation measures. For housing, the model integrates the impact of slatted floors in animal buildings, which results in a lower residence time of the manure in buildings, and therefore lower emissions of NH_3-N at this stage of the manure management system. For the proportion of animals kept in buildings with slatted floor, the EF given in Table 5.6 is halved, which correlates with the approach used by Rösemann et al. (2017).

For storage, the NH_3-N emissions reduction potential for each of the storage options for cattle and pig slurry is based on Bittman et al. (2014) and has been reviewed by Rivedal et al. (2019a), as outlined in Table 5.7.

Table 5.7 Ammonia reduction potential for abatement measures for cattle and pig slurry storage

	NH_3-N emissions reduction	**Comments**
Manure cellar for slurry, under slatted floor	30 %	Some crust is assumed to be formed under the slatted floors, however, supply of urine that will accumulate on top of the crust will lead to some NH3 emissions
Manure cellar for slurry, under solid floor	60 %	Covers a broad category from tight lids with water locks to covered but with open access for manure. Emission reduction associated applied to “Manure tank with floating cover” considered conservative
Open manure tank for slurry (unabated)	0 %	From EMEP/EEA Guidebook 2019
Manure tank with tight roof	80 %	From Bittman et al. (2014)
Manure tank with floating cover (plastic sheeting, LECA)	60 %	From Bittman et al. (2014)
Manure tank with floating cover (natural crust)	40 %	From Bittman et al. (2014)
Indoor built up/deep litter	0 %	No abatement assumed
Outdoors built up/deep litter	0 %	No abatement assumed
Solid manure, outdoor storage	0 %	No abatement assumed

The emission factors and abatement efficiencies are combined with activity data from the Statistics Norway survey of different storage systems (as described in the previous section), and emissions from storage of manure and animal housing are calculated. 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 5.3).

5.4.2.5 Uncertainties

Uncertainty estimates are provided in Appendix C.

5.4.2.5.1 Activity data

Emissions are estimated from the animal population. The data for the number of animals are considered to be known within ±5 per cent and for pigs ±7 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 been estimated for the revised nitrogen excretion factors from Karlengen et al. (2012), 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, the fact 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.

5.4.2.5.2 Emission factors

Ammonia emissions from agriculture are estimated based on national conditions. There are uncertainties in several parameters as fraction of manure left on pastures, amount of manure, conditions of storage, conditions of spreading and climate conditions. All emission factors for NH_3 which have been used for both housing and storage are sourced from EEA (2023). As stated in EEA (2023), uncertainties with regards to NH_3 EFs vary considerably. EEA (2023) concludes that the overall uncertainty for the United Kingdom NH_3 emissions inventory, as calculated using a Tier 3 approach, was ±21 % (Webb & Misselbrook 2004), while that for the Netherlands, also calculated using a Tier 3 approach, was ±25 % (Wever et al., 2018, cited in Bruggen et al., 2018).

5.4.3 NO_X emissions from manure management

5.4.3.1 Description

Emissions of NO_X from manure management for the different animal groups in Norway is included in the inventory.

5.4.3.2 Method

In Norway, all animal excreta that are not deposited during grazing are managed as manure. Norwegian values for N in excreta from different animals according to Table 5.3 are used. How these are estimated is described in section 5.4.2.2. Norwegian values are also used for the fraction of total excretion per animal categories for each management system (MS) and for pasture. The fractions are updated every year.

NO_X volatilized from manure storage is part of the estimations of indirect N_2O emissions from atmospheric deposition.

5.4.3.3 Activity data

Emissions are estimated from the animal population. How the animal population is estimated is described in section 5.2.

Surveys for assessing use of management systems have been carried out in 2000, 2003, 2013 and 2018. The distribution of manure systems used in the latest inventory is given in Table 5.5.

5.4.3.4 Emission factors

The emission factors used for NO_X emissions in manure management systems are shown in Table 5.8.

Table 5.8 NO_X and N_2 emission factors for manure management per manure management system.

	kg of N in NO or N_2 (kg TAN)$^{-1}$
NO_X Slurry storage	0.0001
N_2 Slurry storage	0.0030
NO_X Solid storage	0.01
N_2 Solid storage	0.30

Source: EEA (2023)

N excretions is estimated as ammonia-N (or TAN), which is the same N excretion factor that is used in the estimations of NH_3 from manure management systems.

For estimating N_2 from storage the amount is estimated as ammonia-N (TAN) and the default values for the EFs given in EEA (2023) (Table 5.7) are used.

5.4.4 NMVOC emissions from manure management

5.4.4.1 Description

Livestock production is a source of emissions of NMVOC during feeding with silage and manure management. The emissions come from feed, degradation of feed in the rumen and from undigested fat, and carbohydrate and protein decomposition in the rumen and in the manure.

5.4.4.2 Method

The emissions have been estimated using a Tier 2 approach (EEA 2023). The estimation includes NMVOC from silage storage and the feeding table if silage is used for feeding, since silage is a major source of NMVOC emissions. The estimation also includes emissions from housing of livestock, storage of manure, manure application and grazing animals.

5.4.4.3 Activity data

Emissions are estimated from the animal population. How the animal population is estimated is described in section 5.2. The data source of share of housing, storage, application, and grazing is the same source as the N-model documented in 5.4.2.

5.4.4.4 Emission factors

Emission factors are taken from EEA (2023), see Table 5.9.

Table 5.9 Default Tier 2 EF for NMVOC (EEA 2023)

	EF, with silage feeding	***EF, housing***	***EF, grazing***
Livestock	**NMVOC kg/kg VS excreted**	**NMVOC kg/kg VS excreted**	**NMVOC kg/kg VS excreted**
Dairy cows	0.0002002	0.0000353	0.0000069
Other cattle[1]	0.0002002	0.0000353	0.0000069
Sheep	0.01076	0.001614	0.00002349
Fattening pigs[2]		0.001703	
Sows		0.007042	
Goats	0.01076	0.001614	0.00002349
Horses	0.01076	0.001614	0.00002349
Laying hens (laying hens and parents)		0.005684	
Broilers (broilers and parents)		0.009147	
Turkeys		0.005684	
Other poultry (ducks, geese)[3]		0.005684	
Fur animals		0.005684	
Rabbits		0.001614	
Reindeer[4]		0.001614	0.00002349
Buffalo	0.01076	0.001614	0.00002349
Camels			
Mules and Asses	0.01076	0.001614	0.00002349

[1] Includes all other cattle

[2] Includes piglets from 8 kg to slaughtering

[3] Based on data for layers

[4] Assume 100% grazing

The share of silage in fodder is registered for dairy cows in the Cow recording system. For the other ruminants the share of silage in fodder intake is based on expert judgments (Table 5.10).

Table 5.10 Silage as share of total feed intake

Livestock	Silage fodder, average share of daily intake (%)
Dairy cows	
Growing cattle and mature non-dairy cattle	45[1]
	50[2]
Sheep	33[3]
Goats	40[4]
Horses	33[5]

[1] *Cow recording system (TINE BA Annually)*

[2] *Expert judgement Harald Volden, Norwegian University of Life Sciences. November 2016*
[3] *Expert judgement Finn Avdem, Nortura. July 2016*
[4] *Judgement by Statistics Norway. November 2016.*
[5] *Expert judgement Dag Austbø, Norwegian University of Life Sciences. June 2016*

5.4.5 PM emissions from manure management

5.4.5.1 Method

Tier 1 methodology from EEA (2023) is used.

5.4.5.2 Activity data

Emissions are estimated from the animal population. How the animal population is estimated is described in section 5.2.

5.4.5.3 Emission factors

Default Tier 1 emission factors are used, see Table 5.11.

Table 5.11 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing)

Livestock	EF,TSP kg AAP^{-1}. a^{-1}	EF, PM10 kg AAP^{-1}. a^{-1}	EF, PM2.5 kg AAP^{-1}. a^{-1}
Dairy cattle	1.38	0.63	0.41
Other cattle [1]	0.59	0.27	0.18
Calves	0.34	0.16	0.10
Finishing pigs	1.05	0.14	0.006
Weaners	0.27	0.05	0.002
Sows	0.62	0.17	0.01
Sheep	0.14	0.06	0.02
Goats	0.14	0.06	0.02
Horses	0.48	0.22	0.14
Laying hens (laying hens and parents)	0.19	0.04	0.003
Broilers (broilers and parents)	0.04	0.02	0.002
Other poultry (ducks, geese, turkeys)	0.11	0.11	0.02
Fur animals	0.018	0.008	0.004

[1] Non-dairy cattle (including young cattle, beef cattle and suckling cows)

Source: EEA (2023).

5.4.6 Source specific QA/QC

In 2014, a new manure survey for 2013 was carried out by Statistics Norway (Statistics Norway 2015), and in 2019 another one was carried out (Kolle & Oguz-Alper 2020). The results are implemented in the estimations of CH_4 and N_2O emissions from manure. 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.

In 2018, the model for calculating emissions of N_2O, NH_3 and NOx from manure was revised. As part of the revision of the nitrogen model undertaken in 2018, a review was undertaken of the Norwegian emissions factors compared to those used in other Nordic and Northern European countries. The review demonstrated that the Norwegian EFs compare well with those used in other Nordic and Northern European countries. In most cases the EFs used in the Norwegian model lie within the range of EFs used by the example countries, and in most cases are at the upper end of the range which demonstrates the conservative approach taken in the absence of country specific EFs.

In the 2023 submission new data from Statistics Norway's agricultural full count 2020 is implemented for manure management and spreading. Figures from Statistics Norway's census of agriculture 2020 provided new data on manure management systems (MMS) for the year 2020.

5.5 Crop production and agricultural soils

NFR 3D

Last update: 26.01.2023

5.5.1 Description

The use of synthetic fertilizers, animal excreta nitrogen, sewage sludge and other organic fertilizers applied to soils, and droppings on pastures result in emissions of NH_3. Agricultural activities are also a source of NO_X, NMVOC from crop plants and non-combustion emissions of particles.

5.5.2 NH_3 emissions from agricultural soils

5.5.2.1 Method

5.5.2.1.1 NH_3 emissions from use of inorganic N-fertilizers

NFR 3Da1

The calculations of NH_3 emissions from the use of synthetic fertilizer are based on the amounts of nitrogen supplied and emission factors for the percentage of nitrogen emitted as NH_3 during spreading, $frac_{GASF}$. The amount of nitrogen supplied is estimated based on data for total annual amount of fertilizer sold in Norway and its nitrogen content. Before 2013 these figures contained synthetic fertilizer applied in forest, so the figures are corrected for this amount in order to calculate the amount applied on agricultural fields. In the 2021 submission, new emission factors were introduced, and the method was updated due to new activity data.

5.5.2.1.2 NH_3 emissions from animal manure applied to soils

NFR 3Da2a

In Norway, all animal excreta that are not deposited during grazing are used as manure and applied to soils. NH_3 emissions from spreading of manure depend on several factors, e.g., climate and time of spreading of manure, type of cultivation and cultivation practices and characteristics of the soil.

Emissions of ammonia are calculated for spreading of manure on cultivated fields, meadows and cultivated pastures. The total amount of manure nitrogen that is spread is estimated by the number of animals and nitrogen excretion factors for each type of animal and is thereafter distributed on different spreading methods based on national data. The nitrogen basis for the estimated amounts of nitrogen that volatilizes as NH_3 during spreading takes into account the amount of nitrogen in the NH_3, NO_X, and N_2 that volatilizes during housing and storage, as well as the N lost as N_2O and leaching during storage. Nitrogen remaining in the digestate after biogas production from manure is also taken into account when estimating emissions from spreading of manure in line with EEA (2023). Total emissions from spreading are estimated by emission factors for each different spreading method used multiplied by the amount of manure nitrogen spread with the respective method. The Norwegian model for calculating nitrogen emissions from manure is described in more detail in Carbon Limits (2020).

5.5.2.1.3 NH_3 emissions from sewage sludge applied to soils

NFR 3Da2b

The default emission factor of 0,13 kg NH3/kg N from the EEA (2023) is used to calculate NH3 emissions from sewage sludge used as fertilizer.

5.5.2.1.4 NH_3 emissions from other organic fertilizers applied to soils

NFR 3Da2c

Emissions of NH_3 from other organic fertilizers applied to soils are estimated by multiplying estimated amounts of N in organic fertilizers with the default emission factor of 0.08 kg NH_3/kg N from the EEA (2023). The annual amount of nitrogen in other organic fertilizers applied in agriculture during the period 1990-2013 was assessed in 2014 (Aquateam COWI AS 2014). Other organic fertilizers comprise three main categories; biomanure and other biological residues from biogas plants, compost from composting plants and other commercial organic fertilizer products sold. This was a practically non-existent source of nitrogen before 2000. Since then, the emissions have varied over the years, but it is a minor emission source for all years. One reason for the inter-annual variations is changes in regulations for the usage of meat and bone meal as fertilizer on agriculture land. The activity data estimate from 2013 is still used since it is the latest available estimate. It is still expected to be representative and because of the minor size of this emission source, a new assessment has not been prioritized.

NFR 3Da3

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. The amount of animal manure dropped on pastures is given by estimations of total N in manure excreted from animals and data for pasture times (Table 5.4). It is assumed that the share of time the animals spend on pastures corresponds to the share of total N produced that is dropped during grazing. The emissions are calculated by the estimated amount of N deposited during grazing multiplied with specific emission factors by animal category (see table Table 5.14).

5.5.2.2 Activity data

5.5.2.2.1 NH_3 emissions from use of synthetic fertilizer

The Norwegian Food Safety Authority calculates a total value for annual consumption of synthetic fertilizers in Norway based on sales figures.

For the calculation of the emission of NH_3 we need a specification of the use of different types of synthetic fertilizer since the NH_3 emission factor vary between different types. 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 fertilizer types is the same as in 1994 for these years.
The calculation of emissions from use of nitrogen fertilizer is based on sales figures for each year. A strong price increase for nitrogen fertilizer caused a stock building in 2008 and corresponding lower sales in 2009. In addition, new fertilization standards may have brought about a reduction of the use of fertilizers. To correct for this, a transfer of fertilizer use has been made from 2008 to 2009.

From the 2021 submission the emissions of NH3 from inorganic fertilizer was calculated taking into account the incorporation into soil when spreading. The practice here for Norwegian potato, vegetable and grain productions was evaluated in a report performed by Norwegian Institute of Bioeconomy Research (NIBIO) (Rivedal et al. (2019a) and Rivedal et al. (2019b)).

5.5.2.2.2 Animal manure applied to soil and pasture

There are several sources of activity data on spreading of manure. The main sources are the manure surveys in 2000, 2013 and in 2018 by Statistics Norway (Kolle & Oguz-Alper 2020) and Statistics Norway et al. (2015) for 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 5.2. Data from the manure survey do only exist for 2000, 2013 and 2018, while the data from the sample surveys have been updated for several, but not all, years. The manner of spreading the manure also affects the NH_3 emission estimates.

Data for time on pasture and share of animals on pasture are collected from the 2018 manure survey in Statistics Norway, Sample Survey in Statistics Norway 2001 and from TINE BA (TINE BA is the sales and marketing organization 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 used to be updated annually, but since 2013 only goat figures are updated annually while the 2013 pasture data is still used for milking cows 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 5.12.

Table 5.12

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	Karlengen et al. (2012), Aspeholen Åby et al. (2018), Kjos (2023), IPCC (2019), 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), Statistics Norway et al. (2015) ,Statistic Norway et al. (2019) and Statistic Norway et al. (2022).
Area and amount where manure is spread, split on spring and autumn.	Gundersen and Rognstad (2001), Statistics Norway et al. (2015) and Statistic Norway et al. (2019)
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) and Statistics Norway et al. (2015), expert judgements, Statistics Norway's Sample Survey 2007
Spreading techniques	Gundersen and Rognstad (2001), Statistics Norway et al. (2015), expert judgements, Statistic Norway et al. (2019) and Statistic Norway et al. (2022).
Usage and time of harrowing and ploughing.	Statistics Norway (Sample Surveys of Agriculture), Gundersen and Rognstad (2001), Statistics Norway et al. (2015) Statistic Norway et al. (2019), Statistic Norway et al. (2022) and expert judgements.
Pasture times for different animal categories	TINE BA (Annually) (Dairy cattle, goats), Statistics Norway's Sample Survey 2001 (Statistics Norway 2002a) (non-dairy cattle, sheep), Kolle and Oguz-Alper (2020) and expert judgements.

5.5.2.3 Emission factors

5.5.2.3.1 Synthetic fertilizer

Different types of synthetic fertilizers 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 for the different types of fertilizers are shown in Table 5.13.

Table 5.13 Emission factors for NH_3 for different fertilizers. kg NH_3 per kg N

Fertiliser	Emission factor (kg NH_3 per kg N)
Urea	0.155
Ammonium sulphate	0.09
Ammonium nitrate	0.015
Liquid ammonia	0.019
Calcium and boron calcium nitrate	0.05
Calcium ammonium nitrate and other nitrate types	0.08
NPK (Nitrogen, phosphorus, potassium)	0.05
Magnesium fertiliser	0.05
Diammonphosphate	0.05
Other NP fertiliser	0.05
NK fertiliser	0.015

Source: EEA (2019)

5.5.2.3.2 Animal manure applied to soil and pasture

Emission factors for spreading of stored manure vary with spreading method (Gundersen & Rognstad 2001; Gundersen & Heldal 2015), water contents (Statistics Norway 2007), type and time of treatment of soil, time of year of spreading (Gundersen & Rognstad 2001; Gundersen & Heldal 2015; Statistics Norway 2007), cultivation and region, (Gundersen & Rognstad 2001; Gundersen & Heldal 2015;(Kolle & Oguz-Alper 2020). The basic factors used are shown in Table 5.14.

Table 5.14 Emission factors for animal manure applied to soil and pasture

Meadow			**Spring**	**Summer**	**Autumn**
				kg NH_3-N/kg TAN	
Spreading method	**Added water**				
Broadcast spreading	< 100%		0.4	0.7	0.7
	> 100%		0.24	0.35	0.35
Trailing hose	< 100%		0.3	0.5	0.4
	> 100%		0.18	0.25	0.2
Injection			0.15	0.30	0.05
Dry manure			0.7	0.9	0.7
Arable land		**Incorporation time**	**Spring**	**Summer**	**Autumn**
				kg NH_3-N/kg TAN	
Spreading method	**Added water**	Hours			
Broadcast spreading	< 100%	0-1	0.08	0.08	0.12
		1-4	0.20	0.20	0.30
		4-12	0.33	0.33	0.45
		12+	0.50	0.50	0.45
	> 100%	0-1	0.04	0.04	0.06
		1-4	0.10	0.10	0.15
		4-12	0.17	0.17	0.28
		12+	0.25	0.25	0.28
Trailing hose	< 100%	0-1	0.03	0.03	0.05
		1-4	0.12	0.12	0.17
		4-12	0.23	0.23	0.35
		12+	0.50	0.50	0.45
	> 100%	0-1	0.02	0.02	0.02
		1-4	0.06	0.06	0.09
		4-12	0.12	0.12	0.22
		12+	0.25	0.25	0.28
Dry manure			0.70	0.70	0.70

Source: The emission factors for spreading of manure to meadow are taken from Karlsson and Rodhe (2002). The emission factors for spreading of manure to cultivated land are based on Norwegian specific emission *factors (Morken et al. 2005) but have been amended proportionally based on EFs proposed by Rösemann et al. (2017).*

The factors in Table 5.14 are combined with data from the Sample survey of agriculture and forestry 2006 (Statistics Norway 2007) and a time series on mixture of water in manure. Emission factors for NH_3 emissions from spreading of manure are connected to activity data that is updated for the whole time series when new information is available, 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 5.15. These are the same as the emission factors recommended in EEA (2023).

Table 5.15 Ammonia emission factors from droppings from grazing animals on pasture. Per cent of TAN.

	NH_3 loss, % of TAN
Dairy cattle	14 %
Suckling cows	14 %
Young beef cattle	14 %
Swine	31 %
Horses	35 %
Goats	9 %
Sheep	9 %
Fur animals	9 %
Deer	14 %
Reindeer	14 %

Source: EEA (2023). For deer and reindeer EF for dairy cattle is used

5.5.3 NO_X emissions from agricultural soil

NFR 3Da1

5.5.3.1 Method

The sum of all nitrogen applied to soil has been multiplied with the default tier 1 emission factor to estimate the nitric oxide emission from crop production.

5.5.3.2 Activity data

Total N from the following sources is included:

- Synthetic fertilizers
- Animal manure spread
- Urine and dung deposited by grazing animals
- Sewage sludge
- Other organic fertilizers

5.5.3.2.1 Synthetic fertilizer

The Norwegian Food Safety Authority calculates a total value for annual consumption of synthetic fertilizers in Norway based on sales figures as referred to in 5.5.2.2.1.

5.5.3.2.2 Animal manure spread

In Norway, all animal excreta that are not deposited during grazing are used as manure and applied to soils. The total amount of N in manure used as fertilizer is equivalent to total N excreted from the animals deducted for the amount dropped during grazing and for the amount emitted during housing and storage, as well as losses occurring during use of manure in anaerobic digestion. How the amount of nitrogen in animal manure are calculated is described further in section 5.4.2.2.

5.5.3.2.3 Urine and dung deposited by grazing animals

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. The emissions are calculated by the estimated amount of N deposited during grazing multiplied with specific emission factors by animal category. Emissions factor used is showed in Table 5.16.

5.5.3.2.4 Sewage sludge applied to soils

Statistics Norway (wastewater statistics) annually gives values for the amount of sewage sludge, and the fraction of the sewage sludge that are 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.

5.5.3.2.5 Other organic fertilizers applied to soils

How the amount of nitrogen in other organic fertilizer are estimated is described further in section 5.5.2.1.4.

5.5.3.3 Emission factors

Tier 1 default emission factor for NO_X emissions from agricultural soils has been used, see Table 5.16.

Table 5.16 Tier 1 default emission factor for NO_X emissions from agricultural soils

Pollutant	Value	Unit
NO_2	0.04	kg NO_2 kg^{-1} fertilizer-N applied

Source: EEA (2023)

5.5.4 NMVOC emissions from cultivated crops

NFR 3De

As a result of tier 2 estimations for NMVOC from 3B, the 3Da emissions from spreading of animal manure and urine and dung deposited by grazing animals were also calculated. The methodology and activity data are explained in 5.4.4 but the emissions were reported as 3Da2a and 3Da3.

5.5.4.1 Method

The tier 1 methodology has been used, multiplying cultivated area in Norway with the default emission factor from EEA.

5.5.4.2 Activity data

The activity data used are fully cultivated area given by Statistics Norway.

5.5.4.3 Emission factors

The recommended average emission factor of 0.86 kg NMVOC per ha from EEA (2023) is used. There are great variations in NMVOC emissions, dependent on crop, temperatures, yield etc. The average factor is based on a 50-50 distribution between grass and cropland. In Norway, about two thirds of the agricultural land is grassland. This may indicate an underestimation, but lower average temperatures compared to the average for the whole EMEP area has the opposite effect.

5.5.5 Particle emissions from farm-level agricultural operations

NFR 3Dc

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.

5.5.5.1 Method

The tier 1 methodology described in EEA (2023) is used. The area of crop land in Norway is multiplied with tier 1 emission factors, which gives emissions per area unit.

5.5.5.2 Activity data

The area of crop land given by Statistics Norway (open fields and gardens) is used since these emissions are mainly from combine harvesting and soil cultivation. The emissions may therefore be slightly overestimated since parts of the cropland is not plowed or harrowed every year.

5.5.5.3 Emission factors

Table 5.17 Tier 1 emission factors for emissions of particles from farm-level agricultural operations. kg/ha

Pollutant	Value (kg ha-1)
PM10	1.56
PM2.5	0.06
TSP	1.56

Source: EEA (2023)

5.5.6 Use of pesticides

NFR 3Df

Hexachlorobenzene (HCB) was earlier used as a pesticide but is now forbidden. The use of this substance is not known in products in Norway today, but it can arise unintentionally and constitute a contamination in some products, among them pesticides. Pesticides can contain among other things pentachlorophenol, atrazine, simazine, picloram, pentachloronitrobenzene (PCNB, quintozene), chlorothalonil, endosulfan and chlopyralid (SYKE 2013). Emissions from the use of pesticides that can include a contamination of HCB are part of the emission inventory estimations. Information about the concentration of HCB in some of the above mentioned pesticides are shown in Table 5.18. This information is collected from Finland (SYKE 2013) and in the estimations it is supposed that half of the HCB remnants in the pesticides are emitted to air.

5.5.6.1 Activity data

The amounts sold of the substances that can contain contaminates of HCB have been given by the Norwegian Food Safety Authority and the Product Register in the Norwegian Environment Agency. The amount of the effective substance sold in Norway have been used as activity data for the period 1996 to 2008. Since 2008, no substances containing HCB have been sold in Norway. For the years 1990-1995 the value for 1996 is used due to lack of data.

5.5.6.2 Emission factors

Table 5.18 HCB-contamination in pesticides. mg/kg

Pesticide	
Clorothalonil	10
Clopyralid	2.5
Endosulfan	0.1
Simazine	1

Source: SYKE (2013)

5.5.7 Uncertainties

There are several types of activity data entering the calculation scheme:

Sales of nitrogen fertilizer: The data are based on sales figures for one year (The Norwegian Food Safety Authority). The uncertainty in the sales figures is within ±5 per cent (Rypdal & Zhang 2000). In addition, there is a possible additional error due to the fact that sales do not necessarily equal consumption in a particular year, due to storage.

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. This uncertainty was substantially reduced in 2013 when the nitrogen factors were assessed in a research project (Karlengen et al. 2012).
The uncertainty connected to the estimate of the amount of manure is higher than for the amount of synthetic fertilizer used.

Fate of manure: There is significant uncertainty connected to the allocation of manure between what is used as fertilizer and droppings on pastures.
Atmospheric deposition of agricultural NH3 emissions: The data are based on national figures for NH3 emission from agriculture. These are within ±30 per cent (Rypdal 1999).

5.5.7.1 Emission factors

NH_3
The uncertainty in the estimate of NH3 emissions from use of fertilizer is assessed to be about ±20 per cent (Rypdal & Zhang 2001). The uncertainty is higher for animal manure (±30 per cent (Rypdal & 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 & 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.

NO_X, NMVOC and PM
Default Tier 1 emission factors from EEA (2023) are used for estimation of emissions of NOX, NMVOC and PM from crop production and agricultural soils in the Norwegian inventory. The uncertainty is given in Table 5.19.

Table 5.19 Uncertainty estimates for Tier 1 default EFs.

Pollutant	Value (kg ha-1)	Unit	95% confidence interval Lower	Upper
NO_2	0.04	kg NO_2 kg^{-1} fertilizer-N applied	0.005	0.104
NMVOC	0.86	kg ha^{-1}	0.22	3.44
PM10	1.56	kg ha^{-1}	0.78	7.8
PM2.5	0.06	kg ha^{-1}	0.03	0.3
TSP	1.56	kg ha^{-1}	0.78	7.8

Source: EEA (2023).

5.5.8 Source specific QA/QC

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. These were compared to corresponding factors used in Sweden, Denmark and Finland, and with IPCC default factors as a verification of the Norwegian factors (Karlengen et al. 2012). Data from the manure surveys of 2013 (Statistics Norway et al. 2015) and 2018 (Kolle & Oguz-Alper 2020) and the Statistics Norway's agricultural full count 2020 was implemented in the estimations of NH_3 emissions from manure.

There was a strong price increase for nitrogen fertilizer, which caused a stock building in 2008 and corresponding lower purchases in 2009. The calculation of N2O emissions from use of nitrogen fertilizer is based on sales figures for each year. To correct for this, a transfer of fertilizer from 2008 to 2009 was made in the calculations.

An update of the manure distribution between different manure management systems has been made for the N2O emissions estimates based on the results of a survey conducted by Statistics Norway in 2013-2014 (Gundersen & Heldal 2015) and 2015-2018 (Kolle & Oguz-Alper 2020). Data from the manure survey of 2013 was implemented in the estimations of N2O and CH4 emissions from manure in the 2015 submission, and in the 2016 submission for NH3.

In 2018, the model for calculating emissions of N2O, NH3 and NOx from manure was revised. As part of the revision of the nitrogen model undertaken in 2018, a review was undertaken of the Norwegian emissions factors compared to those used in other Nordic and Northern European countries.

In the 2023 submission new data from Statistics Norway's agricultural full count 2020 was implemented for manure management and spreading. Updated figures from Statistics Norway census of agriculture 2020 gave new information about spreading practice and incorporation time.

5.6 Field burning of agricultural waste

NFR 3F

Last update: 26.02.24

5.6.1 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 benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene (PAH-4) and dioxins are included in the inventory.

5.6.2 Method

The emissions from the burning of crop residues are being calculated in accordance with a Tier 1 approach (EEA 2019):

$$E_{Pollutant} = AR_{residue\_burnt} * EF_{Pollutant}$$

Where:

$EF_{Pollutant}$ = emission (E) of pollutant

$AR_{residue\_burnt}$ = activity rate (AR), mass of residue burnt (dry matter)

$EF_{Pollutant}$ = emission factor (EF) for pollutant

5.6.3 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[21]. This reduced the fraction for 2011 from 7.5 to 4 per cent. For cereals a water content of 15 per cent is used (Statistics Norway). The activity data are consistent with the data used in the estimations of N2O from crop residues.

[21] Johan Kollerud, Norwegian Agricultural Agency, unpublished material 2012.

5.6.4 Emission factors

Table 5.20 Emission factors for agricultural residue burning

Components	Emission factors	Unit	Source
Precursors			
NO_X	2.3	kg/ tonnes crop residue (d.m.) burned	EEA (2023)
CO	66.7	kg/ tonnes crop residue (d.m.) burned	EEA (2023)
SO_2	0.5	kg/ tonnes crop residue (d.m.) burned	EEA (2023)
NMVOC	0.5	kg/ tonnes crop residue (d.m.) burned	EEA (2023)
NH_3	2.4	kg /tonnes crop residue (d.m.) burned	EEA (2023)
Heavy metals			
Pb	0.11	g/ tonnes crop residue (d.m.) burned	EEA (2023)
Hg	0.14	g/ tonnes crop residue (d.m.) burned	EEA (2023)
Cd	0.88	g/ tonnes crop residue (d.m.) burned	EEA (2023)
As	0.0064	g/ tonnes crop residue (d.m.) burned	EEA (2023)
Cr	0.08	g/tonnes crop residue (d.m.) burned	EEA (2023)
Cu	0.073	g/ tonnes crop residue (d.m.) burned	EEA (2023)
Particles			
TSP	5.8	kg/ tonnes crop residue (d.m.) burned	EEA (2023)
PM_{10}	5.7	kg/ tonnes crop residue (d.m.) burned	EEA (2023)
$PM_{2.5}$	5.4	kg/ tonnes crop residue (d.m.) burned	EEA (2023)
BC	13	% of $PM_{2.5}$	GAINS model (IIASA)
benzo(a)pyrene	0,39266	g/ tonnes crop residue (d.m.) burned	EEA (2023)
benzo(b)fluoranthene	1,09678	g/ tonnes crop residue (d.m.) burned	EEA (2023)
benzo(k)fluoranthene	0,46806	g/ tonnes crop residue (d.m.) burned	EEA (2023)
indeno(1,2,3_cd)pyrene	0,33582	g/ tonnes crop residue (d.m.) burned	EEA (2023)
Dioxins	0.5	iμg I-TEQ/tonnes crop residue (d.m.) burned	EEA (2023)
PCB	2.7	μg/tonnes crop residue (d.m.) burned	Black et al. (2012)

Heavy metals and POPs

For heavy metals default emission factors from the EEA emission inventory guidebook are used (EEA 2023). The emissions of benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene (PAH-4) are also from EEA (2023) and calculated based on emission factors from Jenkins et al. (1996).

5.6.5 Uncertainties

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

5.6.6 Source specific QA/QC

. In 2016, a project to split PAH-4 emissions on individual PAHs; benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cdhte) pyrene has been performed. 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. The amount of crop residues burned in Norway has been investigated by questionnaires in 2004 and 2012.

5.7 Other agricultural emissions

NFR 3I

Last update: 31.01.24

5.7.1 Description

Straw treated with NH_3 to be utilised as fodder is a source of NH_3 emissions in Norway. The interannual variation depend only on the amount of NH_3 used for this purpose. The amount of straw treated are influenced by the availability of grass as fodder. In 2018 there was a big increase in the NH_3 treatment of straw to compensate for the reduced production of hay due to the unusually dry and hot summer that year.

5.7.2 NH_3 emissions from treatment of straw

5.7.2.1 Method

Emissions of NH_3 from treatment of straw depend in the estimations only on the amount of NH_3 used. The amount of straw treated are influenced by the availability of grass as fodder. 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.

5.7.2.2 Activity data

The amount of NH_3 used per year is obtained from the Budget Committee for Agriculture[22]. The area of cultivated fields is annually updated from Statistics Norway's agriculture statistics.

5.7.2.3 Emission factor

It is estimated that 54 per cent of the NH_3 applied is not integrated with the straw, and is therefore emitted after the treatment (EEA 2023).

5.7.2.4 Uncertainties

Uncertainty in the estimate of emissions from NH3 treatment of straw is rather low (±5 per cent) (Rypdal & Zhang 2001).

5.7.2.5 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.

[22] NILF (2017): Totalkalkylen for jordbruket. http://www.nilf.no/statistikk/totalkalkylen/2017/BMposter/Totalkalkylen-Post220B-Halmbeh_middel_Ammoniakk

6. WASTE (NFR sector 5)

6.1 Overview

This sector includes solid waste disposal on land (5A), other biological treatment of waste (5B), waste incineration (5C), wastewater handling (5D), and other waste (5E).
Emissions from waste incineration included in sector 5C are emissions from flaring, except flaring from energy sectors (included in NFR 1 energy), and emissions from cremation and hospital waste (until 2005). The main emissions from Waste Incineration are included in the energy sector (1A) since most of incineration of municipal, industrial and medical waste in Norway is now done with energy recovery. The source sector 5E Other Waste 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.

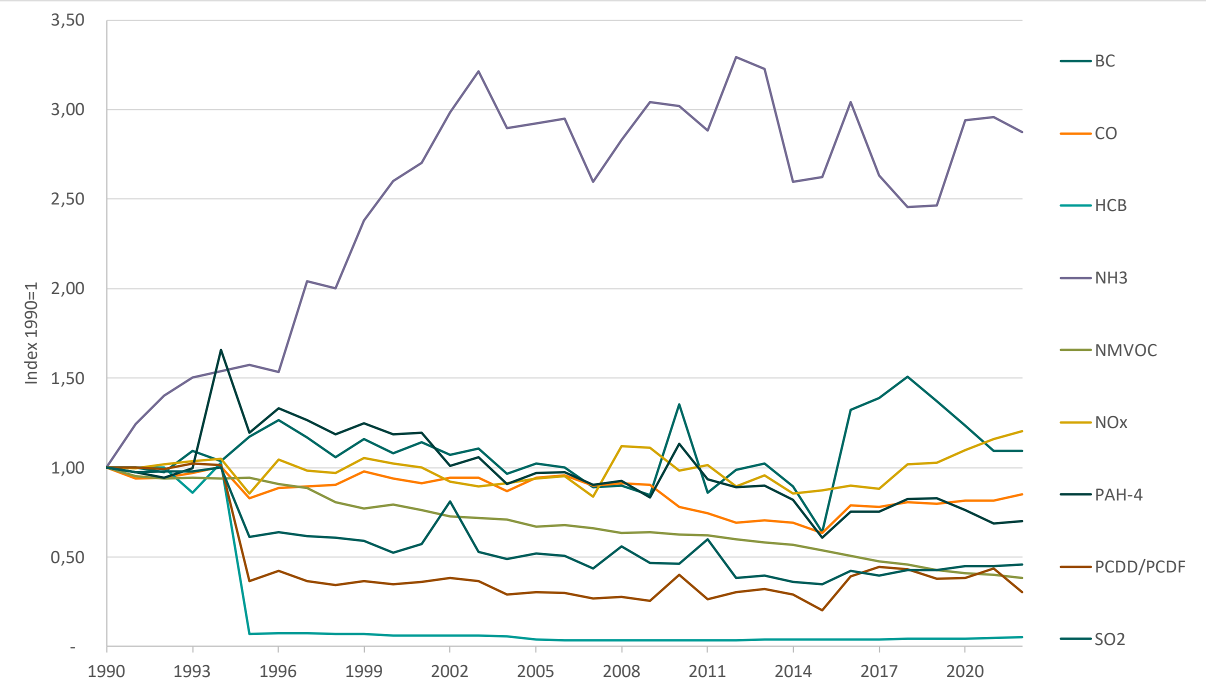


Figure 6.1. Trends for the emissions for most of long-range transboundary air pollutants from waste, relative to 1990

Source: Statistics Norway/ Norwegian Environment Agency
Figure 4.1 shows the emission trends for most of the long-range transboundary air pollutants from waste, relative to 1990. Except for NH3, BC and NOx, the emissions of all pollutants have decreased since 1990.
More detailed information is given in chapter 1.

6.2 Solid waste disposal on land

NFR 5A

Last update: 27.02.23

6.2.1 Description

This category is mainly a source of greenhouse gas emissions. Emissions of NMVOC and particulate matter are included in this inventory. Small quantities of CO and NH_3 may be released as well but are considered insignificant and are not estimated in this inventory.

6.2.2 Method

Emissions of NMVOC and particulate matter from solid waste disposal are being calculated in accordance with a Tier 1 approach EEA (2023) using equation:

$E_{Pollutant} = AR_{production} * EF_{Pollutant}$

Where:

EPollutant = emission (E) of pollutant

$AR_{production}$ = activity rate (AR), mass of landfilled waste

$EF_{Pollutant}$ = emission factor (EF) for pollutant

Emission factors for TSP, PM_{10} and $PM_{2.5}$ are shown in Table 6.1.

Table 6.1. Emission factors for biological treatment of waste. kg/tonnes

TSP	PM_{10}	$PM_{2.5}$
0.463	0.219	0.033

Source: EEA (2023)

No information is available in the guidebook concerning condensable component of PM emissions being included or not in the emission factors.

- *NMVOC*

Small quantities of NMVOC are also emitted. US Environmental Protection Agency (US EPA) evaluates that 98.7 % of the landfill gas is methane and 1.3 % are other VOCs such as perchlorethylene, pentane, butane, etc. (EEA 2009). NMVOC has therefore been estimated assuming being 1.3 % of the landfill gas. Landfill gas is estimated using IPPC methodology (IPCC 2006).

6.2.3 Activity data

The activity data is gathered from several different sources. The annual amount of waste deposited is taken from Statistics Norway's waste accounts between 1990 and 2020, while the amounts after 2020 are from the Norwegian Environment agency. The amount of methane formed by decomposition of biological waste in landfills is taken from Statistics Norway's estimation of methane at MSWD. The amount of methane used to calculate NMVOC is corrected by the amount collected for recovery.

As the activity data consists of different sources, they are not included in the NFR table. An overview of the activity data is given in Table 6.2.

Table 6.2. Activity data included in the calculation of emission in 5A. Tons.

	NMVOC: CH4 from MSWD	Particulate matter: Total amount of waste deposited
1990	82 470	2 194 000
1995	77 926	2 194 000
2000	65 391	2 168 000
2005	54 960	1 996 000
2010	51 645	3 048 000
2015	44 129	3 310 000
2016	41 557	4 151 000
2017	39 115	4 731 000
2018	37 610	4 937 000
2019	35 070	4 975 000
2020	33 707	5 031 000
2021	32 975	6 389 337
2022	31 255	5 704 797

Source: Statistics Norway

6.2.4 Uncertainties

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

6.2.5 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the origin of data is examined for control. This includes the Norwegian waste accounts and the calculation of methane at MSWD. See section 1.6 for the description of the general QA/QC procedure.

6.3 Compost production

NFR 5B

Last update: 03.03.21

6.3.1 Description

This category covers emissions from the biological treatment of waste: composting. Emissions of NH_3 and CO from home composting and emissions of NH_3 from industrial composting are included in the inventory. This source category is not considered to be significant in Norway in terms of long-range transboundary air pollutants. It can also be a source of NMVOC emissions which are not estimated in the Norwegian inventory.

6.3.2 Methodological issues

Emissions of NH_3 from composting of municipal waste have been calculated according to the Tier 2 default methodological guidance given by the 2023 Guidebook EEA (2023).

6.3.3 Activity data

All Norwegian waste treatment plants are obligated to statutory registration and reporting of all waste entering and leaving the plants. All waste streams are weighed, categorized with a waste type and a type of treatment. Data is available for all years since 1995 and for the year 1992.

Activity data for the year 1992 and since 1995 are collected from Statistics Norway's waste statistics. For the years 1990 and 1991, activity data for 1992 are used, while AD for 1993 and 1994 are estimated by linear interpolation of activity data from 1992 and 1995.

- *Home composting*

Emissions from home composting of garden waste and vegetable waste are also included in this inventory. The activity data for this category is available from Statistics Norway for the years 2009-2012. The amount of organic waste from households composted in the period 1990-2008 has been estimated assuming that 3 per cent of all households compost their garden and vegetable food waste (Lystad 2005). The average number of households with home composting in the period 2009-2012 are 2.6 per cent. This has been used for all years after 2012 to calculate the amount of waste that are home composted each year from the "Waste from households"

6.3.4 Emission factors

Emissions from composting, will depend on both the composition of waste composted, amount and type of supporting material (such as wood chips and peat) used, temperature, moisture content and aeration during the process.

Table 6.2 gives default factors for CO and NH_3 emissions from biological treatment for Tier 2 method used for the estimation of Norwegian emissions.

Table 6.2. Composting emission factors. kg/tons

	CO	NH_3
Compost production	NE	0.24
Home composting	0.56	0.66

Source: EEA (2023)

6.3.5 Uncertainties

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

6.3.6 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the origin of data (see chapter 6.4.3) is examined for control. See section 1.6 for the description of the general QA/QC procedure.

6.4 Waste incineration

NFR 1A1a, 1A2d and 5C

Last update: 27.02.23

6.4.1 Description

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. Since 2006, hospital wastes are incinerated in incinerators for municipal wastes and are included in the energy sector. Emissions from waste incineration are also included in this chapter, though waste incineration in district heating plants are reported under energy (NFR 1A1a), and therefore described in section 3.2.2. In 2022, there were 18 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. With one exception, 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 Norway, the open burning of private yard waste is under different restrictions according to the respective municipality. These restrictions involve what can be burned, but also the quantity, how, when and where. In some municipalities, a complete ban is imposed. There is no registration of private waste burning and activity data on this subject are difficult to estimate. Citizens are generally encouraged to compost their yard waste or to dispose of it through one of the many waste disposal/recycling sites. Emissions from open burning of waste are considered to be insignificant and have therefore not been included in the inventory.

PCB containing material are sent abroad, mostly to Sweden, to be destroyed. There is no incineration of PCB in Norway.

6.4.2 Method

Emissions from flaring of landfill gas are estimated by multiplying the amount of gas flared with the emission factors shown in Table 6.3. Emissions from flaring of biogas from industrial wastewater treatment plants are estimated. Emissions have been estimated by multiplying the amount of gas flared with the emission factors shown in Table 6.3.

A description of the method used for estimation of emissions from incineration of municipal waste is given in section 3.2.2.2.

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 have only been reported by two hospitals to the Norwegian Environment Agency for the year 1999. Country specific emission factors have been estimated 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 to 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, it is assumed that the emissions were higher. The emission standards for particulate matter from waste incineration changed from 100 to 30 mg/Nm^3. It was assumed that emissions of lead, cadmium, copper and chromium followed the same pattern as particulate matter. It is believed however, that arsenic and mercury have similar properties and it has thus been assumed 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/Nm^3 from 1994 to 1995. It is therefore assumed that emissions of arsenic before 1995 were twice as large as after 1995. Emissions of particulate matter were reported for all hospitals for the period 1990-1999. Since 2000, emissions from hospitals incinerators have been estimated based on EF and the amount of waste incinerated. Since 2006, all hospital waste has been incinerated at waste incineration plants.

6.4.3 Activity data

- *Municipal waste*

Most of the waste incinerated in Norway is used for district heating and is accordingly reported under energy. The amount of waste incinerated at facilities without utilisation of energy is reported under 5C1A. Both the amount of waste and emissions are reported directly to the Norwegian Environment Agency.

- *Landfill gas*

Information on the amount flared is given by the operators of landfills to the Norwegian Environment Agency. Emissions from landfill gas flared are included in 5C. Emissions from landfill gas used for district heating and used in other sectors are reported in the relevant subsectors under 1A1 and 1A4.

- *Biogas*

The amount of biogas flared at some industrial wastewater treatment plants are reported to the Norwegian Environment Agency for all years since 1991.

- *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 by some hospital incinerators.
The hospital incinerators have gradually been closed down, mainly due to new emission limits. Since 2006, no hospital incinerators have been in operation. Nowadays, hospital waste is incinerated in incinerators for municipal waste and emissions are included under 1A1a.

- *Cremation*

Incineration of human bodies is a common practice that is performed on an increasing part of the deceased. The number of cremated bodies is gathered by the Norsk forening for gravplasskultur and they publish a cremation statistic each year.

6.4.4 Emission factors

Table 6.3 presents emissions factors for the waste incineration sector.

Table 6.3. Emission factors for flare of landfill gas, cremation and hospital waste incineration

Component	Flare landfill gas and biogas kg/tonnes	Cremation Tonnes/body	Cremation Tonnes/body CS EF[1] 2007->	Hospital waste Tonnes/tonnes
SO_2	0.02	0.000113		0.0014
CO	0.04	0.00014		0.0028
NO_X	0.17	0.000825		0.0014
Particles PM_{10}	0.14	0.0000347	3.15504E-06	0.0005
TSP		0.00003856	3.506E-06	0.0005
$PM_{2.5}$		0.000031	2.81862E-06	0.0005
BC	7% of $PM_{2.5}$	50 % of $PM_{2.5}$	50 % of $PM_{2.5}$	18% of TSP
OC		36 % of $PM_{2.5}$	36 % of $PM_{2.5}$	
NMVOC	0	0.000013		0.0007
	g/tonne	kg/body		mg/tonne
Pb	NA	0.00003003	2.73042E-06	Plant-specific emission factors
Cd	NA	0.00000503	4.57344E-07	Plant-specific emission factors
Hg	NA	0.00149	5.59943E-05	Reported
Cu	NA	0.00001243	1.13018E-06	2594.6*
Cr	NA	0.00001356	1.23292E-06	1272.4*
As	NA	0.00001361	1.23747E-06	4705.6
Dioxins	NA	2.7E-11**		0.29685***
PCB	NA	4.1E-07		0.39*
HCB	NA	1.5E-07		2.6*
benzo(a)pyrene	NA	1.32E-08		0.004179
benzo(b)fluoranthene		7.21E-09		0.035821
benzo(k)fluoranthene	NA	6.44E-09		..
indeno(1,2,3_cd)pyrene	NA	6.99E-09		..

NA=Not Applicable.

[1] Country specific emission factor based on measurements of Hg and TSP for the years 2013-2015. EFs for all HM are reduced as much as TSP (91 %). The new emission factors are used for all years since 2007.

Country specific emission factor used for the years after 1995. Emission factors for the years 1990 to 1994 can be given on request.

** Emissions factor is given in kg I-TEQ/body

*** Emissions factor is given in mg I-TEQ/tonne

Source: EEA (2023), Kupiainen and Klimont (2004) and Danish IIR (Aarhus University, 2016)

No information is available in the guidebook concerning condensable component of PM emissions being included or not in the emission factors.

BC emissions have been estimated using shares of $PM_{2.5}$ as emission factors. Shares given by IIASA (Kupiainen & Klimont 2004) have been used. For cremation, as no share for BC was found in the literature, BC share has been set to be 50 per cent of $PM_{2.5}$. Indeed, the amount of $PM_{2.5}$ is assumed to be equally shared between BC and organic mass (OM).

6.4.5 Uncertainties

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

6.4.5.1 Activity data

No data on amounts of hospital waste have been reported since 1999. The amount of hospital waste for the subsequent years may vary from the data reported in 1998 and 1999. Since 2006, no hospital incinerators have been in operation.

6.4.5.2 Emission factors

The composition of the hospital waste could be different from the waste the emission factors are based on. In that case, the calculated emissions will be incorrect. Combustion engineering and processes also influence the emissions. These uncertainties have not been calculated.

6.4.6 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years is large, the origin of data (see chapter 6.4.3) is examined for control. See section 1.6 for the description of the general QA/QC procedure.

6.5 Wastewater handling

NFR 5D

Last update: 03.03.21

6.5.1 Description

This category covers emissions from the biological treatment of wastewater and latrines.
This source category is not considered to be significant on the Norwegian level in terms of long-range transboundary air pollutants.

Emissions of NMVOC are estimated in the Norwegian inventory. Emission factors for all other pollutants are not available and may be assumed negligible in most cases.

6.5.2 Method

The emissions of NMVOC from wastewater treatment are being calculated in accordance with a Tier 1 approach EEA (2023) using equation:

$E_{Pollutant} = AR_{production} * EF_{Pollutant}$

Where:

EPollutant	= emission (E) of pollutant
$AR_{production}$	= activity rate (AR), amount of wastewater
$EF_{Pollutant}$	= emission factor (EF) for pollutant

The emission factors for NMVOC is given in EEA (2023). The emission factors used is 15 mg NMVOC/m^3 wastewater.

6.5.3 Activity data

6.5.3.1 Domestic wastewater

Total amount of wastewater handled by all wastewater treatment plants in the country is taken from Statistics Norway's municipal water supply for the years after 2009. For the years from 1990 to 2008, the amount of wastewater is estimated based on the part of the population connected to treatment plants, using equation:

Wastewater = Population x NR_{PEOPLE} x EF

Where:

NR_{PEOPLE} = share of people connected to treatment plants

EF = emission factor (average household consumption per person per year)

Norwegian population data are extracted from Statistics Norway's population statistics. Data for the number of people in Norway connected to wastewater treatment plants are extracted from Statistics Norway's wastewater statistics. Data for the average household consumption per person per year (2002-2008) are extracted from Statistics Norway's statistics on municipal water supply. Varies between 70-76 m^3 water/inhabitant/year. The number for 2001 have been used for all years 1990-2001.

6.5.3.2 Industrial wastewater

The amount water released into recipient by the industry is reported to the Norwegian Environment Agency (pulp and paper industry, chemical industry and food processing industries).

6.5.4 Uncertainties

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

6.5.5 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If there is a large between-year change in the activity data, the origin of the data is investigated for control. Large changes in domestic wastewater are looked into in the statistics of municipal water supply, while the NEA is contacted regarding questions for the industrial wastewater. Statistics Norway is contacted for control. See section 1.6 for the description of the general QA/QC procedure.

6.6 Other emission sources from the waste sector

NFR 5E

Last update: 03.03.21

6.6.1 Description

This category is a catch all for the waste sector. In the Norwegian inventory, emissions from sewage sludge applied on fields other than agricultural soils, accidental car fires, house fires and emissions from recovering processes in the waste trade are included in this category.

6.6.2 Method

6.6.2.1 Sewage sludge applied on fields

- *NH_3*

Emissions of NH_3 are calculated for sewage sludge applied on fields other than agricultural soils.
To calculate NH_3 emissions from sewage sludge, the fraction of N in manure lost as NH_3 is used ($frac_{GASM}$). The loss equals to total N in sewage sludge multiplied by $frac_{GASM}$. See section 5.5.2.1.3.

6.6.2.2 Car and house fires

- *Particles, heavy metals and POPs*

Emissions of particles, heavy metals, PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene) and dioxins are calculated for car fires and house fires. In addition, SO_2, NOx, NMVOC and CO are calculated for car fires. Emissions are estimated 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.

6.6.2.3 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 (As, Cd, Cr, Cu, Hg, Pb), and PAHs (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene). The emission figures are reported annually by the actual plants to the Norwegian Environment Agency.

6.6.3 Activity data

6.6.3.1 Sewage sludge applied on fields

Statistics Norway's wastewater statistics annually gives values for the amount of sewage sludge and the fraction of the sewage sludge that is applied on fields.

6.6.3.2 Car and house fires

Data on the number of car and house fires are provided annually by the Directorate for Civil Protection (DSB) . These figures only include fires reported to the fire service.

6.6.4 Emission factors

6.6.4.1 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.

6.6.4.2 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 dioxins emissions from car fires is found in Hansen (2000). Emissions factors for heavy metal and PAHs from car fires is found in the Danish IIR (Aarhus University 2016). Emission factors for mercury from car fires is found in the French IIR (CITEPA 2016). No data are available for HCB and PCBs. NH3 is assumed not to be emitted. It is difficult to estimate the amount of material burned in a car fire. It is assumed that the average weight of a car is 1 383 kg, average weight loss is assumed to be 18.2 per cent or 252 kg (CITEPA 2023). Emissions from vehicle fires are calculated by multiplying the mass of vehicle fires with selected emission factors. Emission factors are not available for different vehicle types, whereas it is assumed that all the different vehicle types lead to similar emissions.

6.6.4.3 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. Emissions factors for PAHs is found in Danish IIR (Aarhus University 2016). The scaled emission factors used for the different building types are given in Table 6.4.

Table 6.4. Emission factors used for car fires and house fires, unit/fire

	Car	Detached house	Undetached house	Apartment building	Industrial building
SO_2 (tonnes)	0.0013	NE	NE	NE	NE
NO_x (tonnes)	0.0005	NE	NE	NE	NE
NMVOC (tonnes)	0.0021	NE	NE	NE	NE
CO (tonnes)	0.016	NE	NE	NE	NE
TSP (tonnes)	0.0023	0.14382	0.06162	0.04378	0.02723
PM_{10} (tonnes)	0.0023	0.14382	0.06162	0.04378	0.02723
$PM_{2.5}$ (tonnes)	0.0023	0.14382	0.06162	0.04378	0.02723
BC	NE	9 % of $PM_{2.5}$	9 % of $PM_{2.5}$	9 % of $PM_{2.5}$	9 % of $PM_{2.5}$
Pb (kg)	0.206	0.00042	0.00018	0.00013	8E-05
Cd (kg)	0.0004	0.00085	0.00036	0.00026	0.00016
Hg (kg)	0.0001	0.000087	0.000037	0.000026	0.000016
As (kg)	6.5E-05	0.00135	0.00058	0.00041	0.00025
Cr (kg)	0.00096	0.00129	0.00055	0.00039	0.00024
Cu (kg)	0.0067	0.00299	0.00128	0.00091	0.00057
benzo(a)pyrene (kg)	0.0037	0.008	0.0064	0.0037	0.0096
benzo(b)fluoranthene (kg)	0.0041	0.0126	0.0101	0.0059	0.0152
benzo(k)fluoranthene (kg)	0.0041	0.0044	0.0036	0.0021	0.0054
indeno(1,2,3_cd)pyrene (kg)	0.0059	0.0086	0.0069	0.004	0.0104
Dioxins (mg)	0.048	1.43817	0.61621	0.43779	0.27234

Source: Statistics Norway, EEA (2023), Danish IIR (Aarhus University 2016) and French IIR (CITEPA 2023).

No information is available in the guidebook concerning condensable component of PM emissions being included or not in the emission factors.

6.6.5 Uncertainties

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

6.6.6 Source specific QA/QC

The activity data and the emissions are compared to the activity data and the emissions in previous years. If the change in the activity data between years are large, the origin of data (see chapter 6.6.3) is examined for control. See section 1.6 for the description of the general QA/QC procedure.

7. Other and Natural emissions

There is no long-range transboundary air pollution reported for Norway as Other or Natural emissions.

8. Recalculations and Improvements

8.1 Recalculations

8.1.1 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 utilizing new or improved information where this has become available. The entire time series, at present 1990-2022, is recalculated when the method for a certain source category is revised. The figures in the inventory are therefore consistent through the whole time series as far as possible.

The most important recalculations in the 2024 submission:

- 1A3bvii Automobile road abrasion - The model calculating road abrasion in Norway has been reviewed and is updated. This work will continue in 2024 and further changes are expected. The emissions are recalculated from 1990-2021 and resulting in increased emissions of particles, Cd and PAH.
- 1A1B, 1A1C, 1B2A, 1B2B and 1B2C - During 2023, there has been a recalculation of emissions of NMVOC from land-based companies associated with the oil industry. The emissions have been revised throughout the entire time series, back to 1990 resulting in reduced emissions of NMVOC.
- 3B and 3D – Revised method for calculating the animal population of pigs resulted in a decrease in emissions of NOx and NH3, in the period 1990 - 2021.

In combination with some minor changes from other sources, the recalculations have caused several changes in the emission figures, see Table 8.4, Table 8.5 and Table 8.6.

8.1.2 Specific description of the recalculations

8.1.2.1 Energy

There will always be some changes in the energy figures for the last year in the previous submission, 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. The final figures for energy use are now 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.

1A1

There has been a recalculation of emissions of NMVOC from 1A1a public electricity and heat production and 1A1b Petroleum refining. This has resulted in reduced emissions of NMVOC throughout the entire time series.

1A2, 1A3, 1A4

Revised activity data, affecting most components. The input statistic “Energy Use in Manufacturing Industries” went through quality control, resulting in revised activity data for many industries. Figures for total energy use were not changed, however the distribution of the total energy use to different industries was adjusted. Due to these changes many NFR sources were recalculated in the period 2010-2020. The affected sources are: 1A2a Iron and steel, 1A2b Non-ferrous metals, 1A2c Chemicals, 1A2d Pulp and paper, 1A2f Non-metallic minerals, 1A2gvii Mobile Combustion in manufacturing industries and construction, 1A2gviii Stationary combustion in manufacturing industries and construction, 1A3b Road transport, 1A4ai Stationary combustion, 1A4bi Stationary combustion, 1A4ci Stationary combustion.

1A3a Civil aviation/1A5B Military
Activity data from respondents on jet kerosene has been updated and resulted in changes in domestic and international activity and emissions for the years 2018-2021. All biofuels are allocated in domestic aviation.

1A3b Road transport
Road transport is affected by the revision of activity data in the energy balance, and the emissions are recalculated for the years 2010-2021. The model for estimating BC emissions has changed and is now using the Handbook on Emission Factors for road transport (HBEFA). The emissions are recalculated from 1990-2021.

The $PM_{2.5}$ emissions from diesel are recalculated from 1990-2021 resulting in higher emissions. The emissions were previously assumed to be 95 per cent of PM_{10}, but the amount is now changed to 100 per cent.

1A3bvii Automobile road abrasion
The model calculating road abrasion in Norway has been reviewed and is updated. This work will continue in 2024 and further changes are expected. The review revealed a large underestimation of PM_{10} emissions, also concerning TSP, PM2.5, BC, Cd and PAH derived from PM_{10}. The emissions are recalculated from 1990-2021, increasing PM_{10} emissions by 640-885 per cent.

1A3c Railways
The activity data has changed due to corrections in the energy balance and 2018 is recalculated.

A review on the PM and BC factors revealed that the factors were outdated, and they were updated according to the EMEP/EEA guidebook 2023 (EEA 2023). The emissions are recalculated from 1990-2021.

1A4b-ii Offroad – household and gardening (mobile)
Mobile combustion in households is affected by the revision of activity data in the energy balance, and the emissions are recalculated for the years 2010-2021.
The BC factors were updated according to the EMEP/EEA guidebook 2023 (EEA 2023), and the emissions are recalculated from 1990-2021.

1B2

There has been a recalculation of emissions of NMVOC from 1B2ai Fugitive emissions oil: Exploration, production, transport, 1B2aiv Fugitive emissions oil: Refining / storage, 1B2b Fugitive emissions from natural gas and 1B2c Venting and Flaring. For 1B2aiv and 1B2C the emissions of NMVOC have increased. For 1B2ai and 1B2b the recalculations have led to decreased emissions of NMVOC.

8.1.2.2 Industrial processes and product use

2A5B Construction and demolition
Recalculation due to updated method. The calculation was updated to the Tier 1 method from the EMEP/EEA 2023 Guidebook, resulting in increased emissions of particles in the hole time series, especially for PM10 and TSP.

2B5 Silicon carbide
Recalculation of NMVOC emissions due to an updated EF for the period 1990 - 2021. The change resulted in lower emissions of NMVOC for most years and a small increase in two of the years.

2B10A Methanol production
Recalculation of NMVOC emissions from one plant due to an updated EF for the period 1997 - 2021. The change resulted in lower emissions of NMVOC for all years except 2021 which had a small increase.

2C6 Zinc Production.
The SO_2 emissions in 2021 have been updated. The time series for arsenic in the period 2003-2014 have been estimated. Data was previously missing in this period.

2C7IC Anodes.
The NOx emissions in 2021 have been updated for one plant. The time series for mercury in the period 1990-2000 have been estimated. Data was previously missing in this period.

2D3 Solvent use
There has been a recalculation of the NMVOC emissions in 2021 in 2D3 due to updated activity data. The recalculation led to a decrease in the emissions in 2D3a and 2D3h by 14 and 17 per cent respectively. The emissions in 2D3d, 2D3e, 2D3f, 2D3g and 2D3i increased

by 60, 36, 16, 3 and 26 per cent respectively. The total impact of the recalculation was an increase of 9280 tons NMVOC.

2D3I Other solvent use
Recalculation in the period 1990-2004 due to correction of error.

8.1.2.3 Agriculture

Animal population:
In previous submissions, the number of pigs in category sows, boars, piglets, fattening pigs and young pigs for breeding were based on data from production subsidies. In the 2024 submission the animal count for pigs is now based on slaughter data, where the number of slaughtered pigs (fattening pigs) per year is the basis for the number of pigs in other pig categories. Number of days animals are in each production stage is the main variable used to derive animal numbers. This methodology is a result of a project from NIBIO and the swine production corporation Norsvin SA[23] (Bonesmo and Gjerlaug-Enger 2022). Activity data is provided by Norsvin SA. Implementing this method led to 24 percent lower animal numbers on average per year compared to previous submissions. The fall in the number of pigs can be explained by a former overestimation. The new animal year number now considers days with empty stables, which is standard practice in Norwegian pig production.

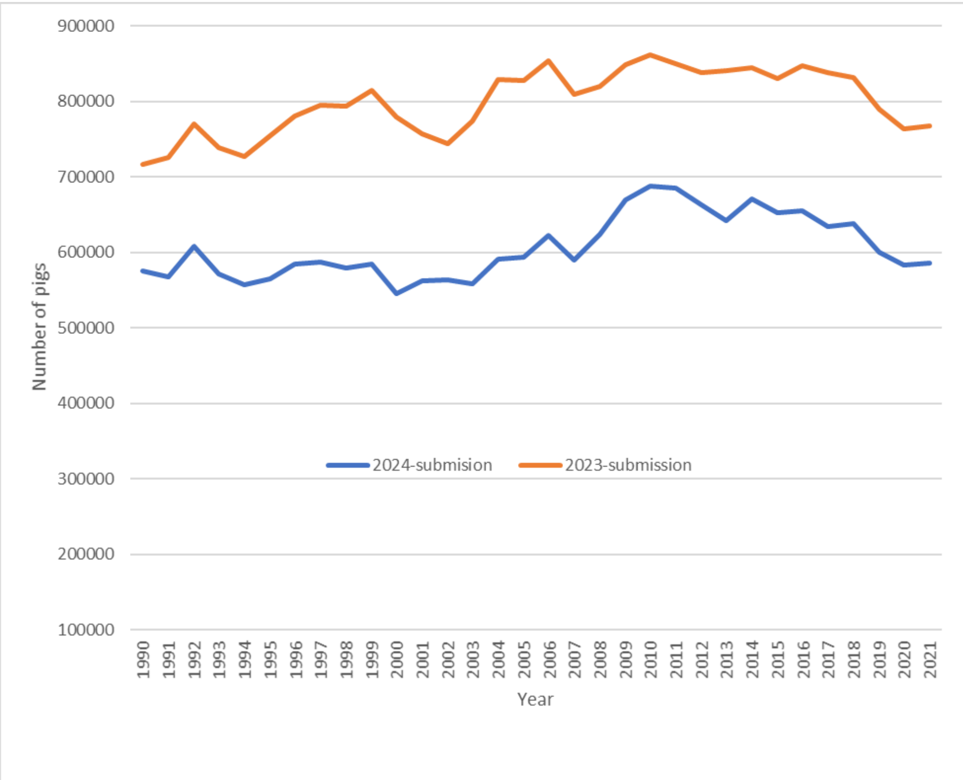


Figure 8.1 Recalculation of animal numbers for pigs 1990-2021

[23] Norsvin SA is the research and sales organization of swine genetics in Norway.

This recalculation led to a decrease of emissions in 3B from manure management and for 3Da2 from animal manure applied to soils.

3B NH_3,NO_x ,NMVOC and particles from manure management

Updated N-factors for both heifer for slaughter (Volden 2022), all pig categories (Kjos 2023) and for reindeer (IPCC 2019) led to changes in nitrogen basis for NH_3 and NO_x emissions. The largest contributor to changed emissions was updated population numbers for pigs.
NH3 and NOx emissions from pigs in 3B was as on average 2 per cent lower in the 2024 submission compared to the 2023 submission. The NMVOC emissions were lower from 1990 to 2008 but were higher from 2008 to 2021. This is due to the calculation which divides to animal groups and sow- numbers in new calculation being higher from 2008.
For 3B in total the NH_3 emissions were 1 per cent lower and the NOx emissions were 0,4 per cent lower compared to former estimates. NMVOC in 3B was 6 per cent lower on average compared to the 2023 submission. For particles TSP emissions were 4 per cent lower, PM_{10} were 1 per cent lower and $PM_{2.5}$ were almost unchanged compared to former estimates.

3D NH_3,NO_x ,NMVOC and particles from crop production and agricultural soils.

For NH3 and NOx emissions from animal manure applied to soils and grazing the updated calculation showed 1 per cent lower emissions on average compared to former submission. For NMVOC the result was 6 per cent lower emissions.

8.1.2.4 Waste

5A Solid waste disposal on land

The emissions of NMVOC are recalculated in the period 2017-2021 due to updated information on recovered amounts of landfill gas, leading to a minor decrease in all years.

5B1 Biological treatment of waste - Composting

There have been recalculations in the period 2017-2021. This is due to updates in the activity data for home composting in 2021 and a new source for activity data in municipal composting and biogas facilities in 2017-2021. The updates have led to a decrease in the SO2 and NH3 emissions in 2017-2020 and a minor increase in 2021.

5C1a Municipal waste incineration

Recalculations are made due to revised activity data, affecting most components. The input data on landfill gas went through quality control, resulting in a recalculated time series from 2010 to 2021. All components in all years have reduced emissions compared to the 2023 submission.

5C1Bi Industrial Waste Incineration

Correction of an error in the activity data in 2019-2021 has resulted in a reduction in the emissions of particles.

5D1 Domestic Wastewater

Correction of error in the calculation. A double counting is removed in the calculation, leading to a 50 per cent reduction in the NMVOC emissions in the whole time series.

5D2 Industrial Wastewater

Correction of an error in the calculation has led to small changes in the whole time series. The revised emissions of NMVOC have a change lower than 2 per cent in 1990-2011. The highest change is in 2021 with an increase of 8.2 per cent.

5E Other waste

Updated activity data related to house fires has resulted in a recalculation of emissions of particles in 2020 and 2021. The updated information led to a decrease of 11 per cent in 2020 and 10 per cent in 2021.

8.1.3 Implications of the recalculations for long-range transboundary air pollutants

8.1.3.1 Implications for emissions levels

Table 8.1 shows the effects of recalculations on the emission figures for the main pollutants 1990-2021 and Table 8.2 the effects on the particles and Table 8.3 the effects on heavy metal emission figures.

Table 8.1 Recalculations in 2024 submission compared to the 2023 submission. Main pollutants

Year	SO2 tonnes	NOx tonnes	NMVOC tonnes	CO tonnes	NH3 tonnes
1990	-	-41.3	-6 368	-	-239
1991	-	-43.4	-6 015	-	-269
1992	-	-39.7	-4 169	-	-217
1993	-	-42.4	-5 259	-	-237
1994	-	-41.0	-6 319	-	-227
1995	-	-40.8	-7 515	-	-230
1996	-	-39.3	-7 687	-	-214
1997	-	-36.3	-9 887	-	-163
1998	-	-38.1	-7 636	-	-208
1999	-	-29.4	-5 360	-	-144
2000	-	-28.0	-5 061	-	-170
2001	-	-33.5	-5 132	-	-231
2002	-	-34.4	-6 799	-	-222
2003	-	-41.9	-7 447	-	-301
2004	-	-37.1	-7 061	-	-242
2005	-	-36.4	-6 028	-	-243
2006	-	-33.1	-6 927	0	-208
2007	-	-34.9	-6 566	0	-223
2008	-	-32.1	-8 447	1	-191
2009	-	-28.9	-8 732	1	-149
2010	0	-28.9	-8 502	8	-115
2011	-0	-39.3	-8 491	15	-80
2012	0	-53.6	-11 524	17	-177
2013	0	-57.5	-10 542	22	-240
2014	1	-43.6	-9 768	20	-224
2015	1	-51.4	-9 628	18	-334
2016	0	-51.1	-7 687	69	-345
2017	0	-68.2	-5 963	166	-435
2018	2	34.2	-4 509	287	-470
2019	-59	-110.6	-4 295	252	-457
2020	-27	-164.8	-2 890	-737	-527
2021	-54	-234.6	7 050	-162	-596

Source: Statistics Norway

Table 8.2 Recalculations in 2024 submission compared to the 2023 submission. Particulate matter

Year	TSP (Tonnes)	PM_{10} (Tonnes)	$PM_{2.5}$ (Tonnes)	BC (Tonnes)
1990	25 952	14 434	2 442	432
1991	24 838	13 815	2 336	415
1992	25 098	13 967	2 365	421
1993	26 315	14 391	2 413	427
1994	26 868	14 728	2 480	445
1995	27 601	15 105	2 564	478
1996	28 572	15 575	2 657	510
1997	29 895	16 252	2 773	547
1998	24 389	13 331	2 277	478
1999	22 335	12 148	2 072	452
2000	20 846	11 314	1 934	440
2001	20 594	11 158	1 909	444
2002	20 629	11 112	1 899	452
2003	20 322	10 937	1 862	454
2004	20 244	10 890	1 864	467
2005	21 050	11 236	1 924	491
2006	20 577	11 124	1 911	495
2007	21 680	11 658	1 996	501
2008	21 442	11 510	1 963	474
2009	20 604	11 074	1 885	436
2010	20 885	11 233	1 910	454
2011	21 630	11 607	1 965	446
2012	20 609	11 076	1 868	413
2013	20 520	11 037	1 856	397
2014	20 578	11 038	1 851	381
2015	20 920	11 183	1 868	369
2016	17 222	9 301	1 546	303
2017	16 350	8 864	1 470	281
2018	17 834	9 607	1 591	291
2019	17 282	9 297	1 532	272
2020	15 980	8 514	1 256	225
2021	15 943	8 585	1 356	229

Source: Statistics Norway

Table 8.3 Recalculations in 2024 submission compared to the 2023 submission. Heavy metals and POPs

	Lead kg	Cadmium kg	Mercury Kg	Arsenic Kg	Chromium Kg	Copper Kg	PAH-4 Kg	Dioxins mg	PCB g	HCB mg
1990	0	325	2	0	0	0	79	0	0	0
1991	0	311	2	0	0	0	76	0	0	0
1992	0	315	2	0	0	0	77	0	0	0
1993	0	324	2	0	0	0	79	0	0	0
1994	0	332	2	0	0	0	81	0	0	0
1995	0	340	2	0	0	0	83	0	0	0
1996	0	349	2	0	0	0	85	0	0	0
1997	0	365	2	0	0	0	89	0	0	0
1998	0	298	2	0	0	0	73	0	0	0
1999	0	270	2	0	0	0	66	0	0	0
2000	0	251	2	0	0	0	61	0	0	0
2001	0	248	0	0	0	0	61	0	0	0
2002	0	246	0	0	0	0	60	0	0	0
2003	0	243	0	7	0	0	59	0	0	0
2004	0	241	0	7	0	0	59	0	0	0
2005	0	248	0	7	0	0	61	0	0	0
2006	0	247	0	7	0	0	60	0	0	0
2007	0	257	0	7	0	0	63	0	0	0
2008	0	253	0	6	0	0	62	0	0	0
2009	0	243	0	6	0	0	59	0	0	0
2010	0	248	0	6	0	0	61	1	0	0
2011	0	256	-1	6	0	0	63	1	0	0
2012	0	243	-2	6	0	0	59	-1	0	0
2013	0	243	0	6	0	0	59	1	0	0
2014	0	243	0	5	0	0	59	1	0	0
2015	0	246	0	0	0	0	60	2	0	0
2016	0	203	0	0	0	0	50	1	0	0
2017	0	193	0	0	0	2	47	1	-1	0
2018	0	210	0	0	0	3	52	0	-1	0
2019	-4	202	-1	-2	-5	0	50	0	-1	0
2020	-3	183	-6	-9	-9	-20	38	-362	4	-5
2021	-69	185	-2	-7	-151	-126	36	-272	-2	-2

Source: Statistics Norway

8.1.3.2 Implications for emission trends

As a result of the different recalculations for 1990-2021 there have been some changes in the trends. The differences are shown in the tables below.

Table 8.4 Trends in emissions 1990-2021. 2024 submission compared to the 2023 submission. Main pollutants

	SO_2	NO_X	NMVOC	CO	NH_3
2024 submission	-70.4	-28.5	-52.3	-46.1	-3.3
2023 submission	-68.9	-25.7	-53.7	-48.7	-3.6

Source: Statistics Norway

Table 8.5 Trends in emissions 1990-2021. 2024 submission compared to the 2023 submission. Particles

	TSP	PM_{10}	$PM_{2.5}$	BC
2024 submission	-28.5	-36.1	-40.5	-40.4
2023 submission	-25.5	-35.6	-41.2	-39.6

Source: Statistics Norway

Table 8.6 Trends in emissions 1990-2021. 2024 submission compared to the 2023 submission. Heavy metals and POPs.

	Pb	Cd	Hg	Ar	Cr	Cu	PAH-4	Dioxins	PCB	HCB
2024 submission	-97.2	-66.2	-85.2	-67.2	-75.5	13.6	-77.0	-74.4	-81.2	-68.9
2023 submission	-97.2	-71.3	-85.1	-71.4	-73.7	10.6	-74.1	-82.7	-88.4	-99.0

Source: Statistics Norway

8.2 Planned improvements

8.2.1 Implemented and planned improvements in response to the review process

The Norwegian Environment Agency co-ordinates the development and improvements of the inventory's different sectors. The recommendations from the review process are recorded in a spread sheet together with the needs recognized by the Norwegian inventory experts to form a yearly inventory improvement plan. Needs identified by use of the data for purposes other than reporting are also included. The overall aim of inventory improvement is to improve the accuracy and reduce uncertainties associated with the national inventory estimates. Each issue is assigned to a sector/theme and the overview tracks where the issue has originated from and the organization/person responsible for following up the recommendations. The overview is discussed among the agencies and each issue is given a priority and a deadline. Each organization in the inventory preparation therefore has responsibility for the development of the inventory. The issues are prioritized based on the recommendations from the ERT and available human and financial resources. The national inventory has undergone substantial improvements over the recent years, and the inventory is considered to be largely complete and transparent.

The status of implementation of the recommendations given in the most recently published LRTAP review report is given in Table 8.7.

Table 8.7 Status of implementation of the recommendations given in the most recently published LRTAP review report

NFR category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the IIR
General - Cross cutting issues	Complete time series for all pollutants	2019, para 46 (a)	Addressing	
General - Cross cutting issues	Include all pollutants and source categories in the inventory for which methodologies exist in the Guidebook	2019, para 46 (b)	Addressing	
General - Cross cutting issues	Correct the use of notation keys according to the definitions in the Reporting Guidelines	2019, para 46 (c)	Addressed	See 1.8
General - Cross cutting issues	Include explanations on the emissions and activity data trends, and to justify dips and jumps	2019, para 46 (d)	Not addressed	
General - Cross cutting issues	Justify in detail the reasons for not estimating emissions and to provide schedules for actions and plans of improvements in the improvement plan	2019, para 46 (e)	Addressed. See sector specific chapters and chapter 1.8	
General - Cross cutting issues	Complete missing activity data	2019, para 46 (f)	Addressed. See appendix F	See Appendix F
General - Cross cutting issues	Improve the QA/QC procedures to capture all source categories	2019, para 46 (g)	Addressed/addressing. See response to 2019, para 100 and para 151.	
General - Cross cutting issues	Complete the documentation in the IIR according to the sector specific recommendations	2019, para 46 (h)	Addressing. See description under the relevant sectors	See 8.2.1
General - Cross cutting issues	Include information on condensable particulate matter	2019, para 46 (i)	Addressed. See response to 2019, para 57, 101 and 152.	
General - Cross cutting issues	Change the format of data in the NFR tables into numbers with three decimals	2019, para 46 (j)	Addressed. See NFR table	See NFR annex I
General - Cross cutting issues	Update the uncertainty analysis	2019, para 46 (k)	Addressed. See Appendix C	See Appendix C

General - Cross cutting issues	Include information of how the KCA and uncertainty analysis are used in inventory improvement	2019, para 46 (l)	Addressed. New text is added to IIR chapter 1.2	See 1.2
Energy - Cross cutting issues	The ERT noted that the IIR gives general descriptions for the energy sector (NFRs 1A, 1A1, 1A2, 1A4, 1A5, 1B) but does not provide detailed explanations for all of the sub-categories, especially not on the methods and the tier level used for the key categories, activity data and an assessment of the emission time series, although estimates are provided at the most detailed level in the NFR tables. This was already pointed out in the 2013 Stage 3 Review Report. During the review, Norway agreed with the ERT's observations and indicated that the missing information will be provided in the next submission. The ERT recommends Norway to include information on the tiers of the methods used, references of data sources, activity data and assessment of the emission time series as well as more detailed explanations for recalculations, as explained below, in the next submission.	2019, para 47	Addressing. Descriptions of the methodology for each subsector are being written and incorporated in the IIR	See Chapter 3.2.3
Energy - Cross cutting issues	The ERT thanks Norway for its comprehensive explanations in the IIR about the recalculations carried out. However, the IIR does not include all the necessary explanations. The ERT encourages Norway to provide more detailed explanations of recalculations, especially regarding extensive recalculations affecting pollutants for each key category sector as explained in the sub-sector specific recommendations.	2019, para 48	Addressed. More details justifications of recalculations are included in the IIR	See Chapter 8.1.2
Energy - Cross cutting issues	The Party did not provide information of whether particle emissions include or exclude the condensable component. The ERT recommends Norway to include such information in the next submission	2019, para 57	Addressed. Specified in footnote in IIR chapter 3.2.1	See Chapter 3.2.1
Energy - 1B2av - NMVOC	The ERT noted that Norway explains in its IIR that the method used to calculate emissions from the sector 1B2av is a tier 1 method, although this sector is a key category for NMVOC and it is considered good practice to use a higher tier methodology for key categories. During the review process, Norway explained that the method used to estimate the emissions from this sector was based on measurements and that the tier indicated in the IIR should have been tier II or III. The ERT recommends that Norway include the appropriate correction in their next submission to improve the transparency of the reporting	2019, para 59	Addressed. Correction made to text in table	See Chapter 3.3

Energy - 1A1c Manufacture of solid fuels and other energy industries - SOx - 2005	The ERT noted that Norway did not provide an explanation in its IIR regarding the sudden rise of 109 % in SOX emissions in NFR sector 1A1c in 2005. During the review, Norway explained that this was an error and that it will be corrected in the next submission. The ERT recommends Norway to improve the efficiency of its QA/QC checks in order to detect this sort of errors prior to official reporting	2019, para 60	Addressed. The data has been corrected. We are also working on improving out QAQC-routines	
Energy - 1A1a Public electricity and heat production - Hg - 2008	The ERT noted that Norway did not provide an explanation in its IIR regarding the sudden rise of 251% in Hg emissions in NFR sector 1A1a in 2008. During the review, Norway explained that the reason behind the anomalous value has not yet been further investigated but that it was due to the reporting of a single plant and that this will be corrected to the next submission. The ERT recommends Norway to correct the data and recommends Norway to improve the efficiency of its QA/QC checks in order to detect this sort of error prior to official reporting and particularly to improve its checks regarding to the integrity of the data directly reported by plants.	2019, para 61	Addressed. The data has been corrected. We are also working on improving out QAQC-routines	
Energy - 1A5a - Other stationary combustion - NOx, NMVOC, Sox, PM2,5, PM10, TSP, BC, CO, Pb, CD, HG, AS, CR, Cu and POPs	The ERT noted that Norway has not reported any emissions for the sector 1A5a for the years 1990-1994 in its 2019 submission whereas emissions had been reported in the previous submission. The ERT noted as well that the notation keys used between the emissions ("NE") and the activity data ("NO") in the reporting tables were not consistent. During the review, Norway explained that the correct notation key should have been "IE", and that this case was due to the level of precision of the updated Energy Balance and that Norway expected to be able to report the emissions in NFR sector 1A5a in the next submission. The ERT recommends Norway to improve the efficiency of its QA/QC checks in order to detect this sort of errors regarding the use of notation keys prior to official reporting. Furthermore, the ERT recommends Norway to ensure completeness and consistency of the time series of this sector by estimating the splits necessary to complete the missing years	2019, para 62	Addressed. Data has been reported for the whole time series	
Energy - 1A2a - Iron and steel - CO	The ERT noted that there was no information available in the IIR regarding an update in the methodology for this pollutant and this sector following the recommendations of the previous Stage 3 review. During the review, Norway	2019, para 63	Addressing. Descriptions of the methodology for each	See Chapter 3.2.3

	explained that the recommendation from the previous review had been implemented. In order to improve transparency, the ERT recommends Norway to describe in a more detailed manner the methodology used for each subsector in its IIR for the next submission as presented in the cross-cutting recommendations above		subsector are being written and incorporated in the IIR	
Energy - 1A2c Chemicals - Cr, Cd	The ERT noted that Norway did not provide any specific explanation in its IIR about the significant recalculations (more than 20 % in relative difference observed for some years) in this sector for these pollutants although the sector is a key category for Cr and Cd. During the review, Norway provided a comprehensive explanation for these recalculations. The ERT recommends Norway to include more detailed justifications of the recalculations in its IIR for the next submission to improve transparency	2019, para 64	Addressed. More details justifications of recalculations are included in the IIR	See Chapter 8.1.2
Energy - 1A4ai - Small combustion, commercial/intstitutional - Cr, Hg	The ERT noted that Norway did not provide an explanation for the significant recalculations (more than 20 % in relative difference observed for some years) in its IIR although the sector is a key category for Cr and Hg. During the review, Norway provided a comprehensive explanation for these recalculations. The ERT recommends Norway to include more detailed justifications of the recalculations in its IIR for the next submission to improve transparency.	2019, para 65	Addressed. More details justifications of recalculations are included in the IIR	See Chapter 8.1.2
Energy - 1A4bi - Small combustion, residential - Sox	The ERT noted that Norway did not provide an explanation in its IIR for the significant recalculations (more than 20 % in relative difference observed for some years) in this sector for these pollutants although the sector is a key category for SOX. During the review, Norway provided a comprehensive explanation for these recalculations. The ERT recommends Norway to include more detailed justifications of the recalculations in its IIR for the next submission to improve transparency	2019, para 66	Addressed. More details justifications of recalculations are included in the IIR	See Chapter 8.1.2
IPPU, transparency	However, the ERT recommends Norway to include in the IIR a presentation of activity statistics at least for key categories	2019, para 85	Addressed. Activity data used in the Norwegian inventory has been included as an Appendix F since IIR 2020.	See Appendix F

IPPU, transparency	The ERT recommends that the AD that were used to calculate emissions is presented in the IIR because it cannot be presented in the NFR tables.	2019, para 86	Addressed. Activity data used in the Norwegian inventory has been included as an Appendix F since IIR 2020.	See Appendix F
IPPU, transparency	Therefore, the ERT recommends Norway to include missing trend descriptions for key categories in the IIR for the next submission	2019, para 87	Addressed.	See chapter 2 and Appendix A.
IPPU, transparency	The ERT recommends Norway to use appropriate notation keys (e.g. "NO" where emissions are "Not Occurring", "NE" where emissions are "Not Estimated", "IE" where emissions are "Included Elsewhere" and "NA" where emissions are "Not Applicable") for the reporting of emissions and activity data.	2019, para 88	Addressed. The approach is followed.	
IPPU, transparency	The ERT also recommends Norway to explain the usage of notation keys in chapter 1.8 general assessment of completeness of the IIR for each of source for which Norway uses "NE", "IE" and "NO".	2019, para 89	Addressed. The IIR has tables that provide an overview of the use of the notation keys NE, IE and NO.	See Chapter 1.
IPPU, consistency including recalculation and time series	The ERT recommends Norway to include detailed explanations for all existent outliers in the time series for activity data and emissions in the next IIR	2019, para 92	Addressed. Explanations for main dips and jumps in activity data are included in the IPPU chapter of the IIR (see response to paragraph 129) and the IIR now includesd a chapter with explanations of key trends.	
IPPU, general	Particle size distribution: recommends Norway to update them in line with EMEP/EEA's latest version of the guidebook, or alternatively, to provide justifications on their use in the IIR in case Norway considers these to be more accurate for the Norwegian conditions.	2019, para 95	Addressed. The IIR and NFR as of 2020 reflects the particle size distribution in the 2019 EMEP guidebook.	
IPPU, accuracy and uncertainties	The ERT recommends Norway to update the uncertainty quantification for all pollutants with the most appropriate methodologies available, taking into account guidance provided in the EMEP/EEA Guidebook	2019, para 98	Addressed.	See Annex C

IPPU, accuracy and uncertainties	The ERT also recommends Norway to include heavy metals, POPs, particulate matter (including BC) and CO in the next uncertainty analysis.	2019, para 98	Addressed.	See Annex C
IPPU, accuracy and uncertainties	The ERT notes that Norway does not report in the IIR if the results of the uncertainty analysis are used to prioritize further improvements in the inventory and recommends that this information is to be included in the IIR	2019, para 99	Addressed.	See text describing how this is used in IIR chapter 1.2
IPPU, accuracy and uncertainties	The ERT notes based on responses from Norway that source specific QA/QC procedures at the inventory agency are not extended to some source categories under NFR 2A, especially for 2A5a, 2A5b and 2A6 (except for ceramics). The ERT recommends Norway to cover all sources by source category specific QA/QC procedures and to document both those QA/QC activities carried out by authorities and those carried out in the preparation of the inventory, in the IIR. The ERT also notes, based on Norway´s IIR that source specific QA/QC procedures are not extended to following source categories: NFR 2.B.5 Carbide production, NFR 2.B.6 Production of titanium dioxide, NFR 2.B.10.a Other chemical industry, NFR 2.C.6 Zinc production, NFR 2.C.7.b Nickel production, NFR 2.C.7.c Other metal production, NFR 2.D.3.b Road paving with asphalt, NFR 2.H.1 Pulp and paper industry, NFR 2.H.2 Food and beverages industry, NFR 2.H.3 Other industrial processes, NFR 2.I Wood processing) and recommends Norway to include source specific QA/QC procedures for these source categories	2019, para 100	Addressed. The IIR now reflects the source specific QA/QC procedures that exist.	See Chapter 1.6
IPPU, condensable particulate matter	Norway does not provide explanatory information in the IIR on whether PM2.5 includes/excludes the condensable component. The ERT recommends Norway to include such information in the next submission	2019, para 101	Addressed. The information is included in the IIR	See Footnote in Table 1.1
IPPU - Ni, Se og Zn	The ERT encourages Norway to pick up the voluntary reporting of nickel (Ni), selenium (Se) and zinc (Zn) in the future.	2019, para 104	Not addressed. Norway does not plan to pick up this voluntary reporting	
IPPU - 2.A.1 Cement production - NOx,	The ERT recommends that Norway uses notation keys according to their definition under Reporting Guidelines paragraph 12. The ERT also recommends that Norway will further investigate this issue for the next submission. If the emissions are	2019, para 105	Addressed.	

NMVOC, CO, NH3 and PAHs	included in the energy sector the ERT recommends Norway to change the notation key to “NA” as these emissions are assumed to be related to combustion of fuels, see Guidebook Chapter 2A1 p.6 and p.10 under Table 3.1. If the emissions are not included in the energy sector, the ERT recommends Norway to estimate the emissions and to report them under the energy sector			
IPPU - 2.A.2 Lime production - NOx, SO2, NMVOC, CO, Pb and Hg	The ERT recommends that Norway uses notation keys according to their definition under Reporting Guidelines paragraph 12. The ERT recommends that Norway will further investigate this issue for the next submission and in case the emissions are included in the energy sector, to change the notation key to “NA” as these emissions are assumed to be related to combustion of fuels and not the process, see Guidebook Chapter 2A2 p.8 under Table 3.1. If the emissions are not included in the energy sector, the ERT recommends Norway to estimate the emissions and to report them under the energy sector	2019, para 106	Addressed.	
IPPU - 2.A.2 Lime production - all	The ERT recommends Norway to include the AD in the NFR tables in the 2020 submission. Due to transparency and completeness, the ERT recommends Norway to follow the recommended structure for the Informative Inventory Report (IIR) (Annex II to Reporting Guidelines, revised in 2018) and to at least include a presentation of activity statistics for key categories in the IIR for the next submission of the IIR in 2020. In case of confidential data, this should be clearly explained in the IIR.	2019, para 107	Addressed. AD was included in the NFR from the reporting in 2020	See NFR table and Appendix F
IPPU - 2A5a Quarrying and mining minerals other than coal- all	Recommends Norway to use the correct notation key “C” instead of “NE” and to put a clear explanation on this in its IIR for the next submission in 2020	2019, para 108	Addressed.	
IPPU - 2A5b Construction and demolition- TSP, PM10, PM2.5	Norway responded that they were not aware of the new emission factors in the EMEP/EEA 2016 Guidebook, and that they will investigate for which areas there are activity data available and will include the emissions where possible in the next submission. The ERT recommends Norway to search for activity data and to include the emissions into the 2020 submission	2019, para 109	Addressing. 2A5B is updated with the equation and emission factors from the 2019 Guidebook. AD from road construction is still	

			missing, but a project collecting AD from road constuction and inculsion of this in the calculations will take place in 2024.	
IPPU - 2A5b Construction and demolition- TSP, PM10, PM2.5	The ERT recommends Norway include the emissions and the activity data in the 2020 submission. Due to transparency and completeness and also due to NFR 2A5b being a key source in 2017 for TSP and PM10 emissions, the ERT recommends Norway to follow the recommended structure for the Informative Inventory Report (IIR) (Annex II to Reporting Guidelines, revised in 2018) and to include a presentation of activity data used to calculate emissions in the IIR for the next submission. In case of confidential data, this should be clearly explained in the IIR.	2019, para 110	Addressed. This was included from the reporting in 2020.	See 4.2.5and appendix F.
IPPU - 2A5c. Storage, handling and transport of mineral products - NOx, SOx, NH3, PM2.5, PM10, TSP, BC, CO, Pb, Cd, Hg, As, Cr, PCDD/ PCDF, Cu, Ni, Se, Zn, PAHs, HCB and PCBs	The ERT recommends Norway to correct the “NE” and "IE" notation keys to “NA” and to document the allocation of emissions reported as “IE” in the IIR to the next submission.	2019, para 111	Addressed	
IPPU - 2.A.6 Other mineral products - all	The ERT thanks Norway for providing the ERT with activity data and recommends, due to transparency and completeness and also as NFR 2A6 is a key source for TSP and PM10 emissions, Norway to follow the recommended structure for the Informative Inventory Report (IIR) (Annex II to Reporting Guidelines, revised in 2018) and at least include a presentation of activity statistics for key categories in the IIR for the next submission of the IIR in 2020.	2019, para 112	Addressed. Activity data has been included as an Appendix F since IIR 2020.	See Appendix F

IPPU - 2.A.6 Other mineral products – NH3	The ERT recommends Norway to reallocate the emissions under NFR 2D3g to document this in the next submission of the IIR	2019, para 113	Addressed.	
IPPU - 2A6. Other mineral products and 2.D.3.b Road paving with asphalt - NMVOC, TSP, PM10, PM2.5, BC, PCDD/PCDF	The ERT recommends Norway to reallocate the emissions and to document the allocation in the next submission of the IIR.	2019, para 114	Addressed.	
IPPU - 2.C Metal industry - all	Recommends the Party to include the missing activity data in the NFR tables in the 2020 submission instead of using notation key "NE". Moreover, as NFR 2C4 is a key source for HCB (in 2005) in Norway and due to transparency and completeness, the ERT encourages Norway to at least include a presentation of activity statistics for key categories in the IIR of the next submission according to the recommended structure for the Informative Inventory Report (IIR) (Annex II to Reporting Guidelines, revised in 2018).	2019, para 118	Addressed	See AnneX F
IPPU - 2.D.3.b Road paving with asphalt, allocation, all	The ERT recommends Norway reallocate the documentation under to the correct NFR codes	2019, para 119	Addressed	
IPPU - 2.H.1 Pulp and paper - all	The ERT recommends Norway to clearly state the confidentiality of the activity data in the IIR in the next submission. Due to transparency and completeness and also as NFR 2H1 is a key source for SO2 emissions (e.g. 2010, 2005), the ERT recommends Norway to follow the recommended structure for the Informative Inventory Report (IIR) (Annex II to Reporting Guidelines, revised in 2018) and to at least include a presentation of aggregated activity statistics in the IIR for the next submission.	2019, para 120	Addressed. Activity data presented.	See Appendix F

2.H.1 Pulp and paper - all	The ERT notes that the question on if fuel based NOx, NMVOC and CO emissions are included under the energy sector was not raised during the review, however, notes that information on this should be clearly documented in the IIR and that in this case those emissions should be reported under NFR 2H1 as “NA”. In case the emissions would not be included under the energy sector, the ERT notes that the emissions should be estimated and reported under the energy sector (NFR 1A2d). The ERT also notes that the notation key “NO” is reserved for cases where the activity does not exist (see Reporting Guidelines para 12).	2019, para 121	Addressed.	
IPPU - 2.H.2 Food and beverages industry - all	Due to completeness, transparency and comparability to other Parties, the ERT recommends Norway to report the activity data on the aggregated level in the NFR tables. Norway uses notation key “NE” for reporting of AD for 2H2 (food and beverages) since in their opinion there is no common unit for AD for these two activities. Since the reported unit is in kilotonnes [kt] of food and beverages production and statistical data for wine, beer, and spirits are in hectoliters [hl], the ERT recommends Norway to convert [hl] in [kt] by using density for beer, ethanol and wine (red and white) as other Parties do and to document this in the IIR. In cases where the activity data cannot be presented in the NFR tables due to inclusion of activities from several sources with different activity data the ERT recommends Norway to present the activity data used to calculate the emissions in the IIR, because it cannot be presented in the NFR tables. The ERT notes that Norway can keep all products in the original units when the data is provided in the IIR separately for each product.	2019, para 122	Addressed. Activity data used in the Norwegian inventory has been included as an Appendix F since IIR 2020.	See Appendix F
2.H.2 Food and beverages industry - all	The ERT recommends Norway to improve the completeness of the inventory by including all sources for which methods exist in the Guidebook to the next submission or to demonstrate at least for the years 1990, 2005, 2010 and the last historic year that the production rates of these activities are insignificant in Norway and to document this demonstration in the IIR of the next submission.	2019, para 123	Addressing.	
IPPU - 2.I Wood processing - NMVOC	The ERT thanks Norway for providing the historic trend of production volumes of wood processing and recommends Norway to include this data in the NFR tables of the next submission.	2019, para 125	Addressed. AD was included in the NFR from the reporting in 2020	See NFR table and appendix F

IPPU - 2.K Consumption of POPs and heavy metals - Hg, PCBs	The ERT is aware that the method in the 2016 Guidebook will be removed from the 2019 version of the Guidebook and recommends that Norway reviews the methods in the updated 2019 version of the Guidebook for the next submission.	2019, para 126	Addressed.	
IPPU - 2.K Consumption of POPs and heavy metals - Hg, PCBs	The ERT thanks Norway on the information provided and recommends Norway to include the information provided to the ERT in the 2020 IIR.	2019, para 127	Addressed	
IPPU - 2.A Mineral products - all	… Statistics Norway does not have source specific QA/QC procedures for 2A5a, 2A5b and the rest of 2A6 because the companies and activities are so different. The sources are however covered by the general QA/QC of the time series. The ERT thanks Norway for providing this clarification and recommends Norway to include the information in the IIR for the next submission.	2019, para 128	Addressed	
IPPU - 2.A.1, 2.B.1, 2.B.2, 2.B.5, 2.C.2, 2.C.3 trends - all	The ERT noted that in the IIR there is no information about dips and jumps in the activity data trend for the following NFR categories and years: 2A1- dips in 1991 and 2004; 2B1 – dip in 1999 and peaks in 2004 and 2015; 2B2 - dips in 1992 and 2009; 2B5 – dip in 2003; 2C1 – dip in 2008 and peak in 2012; 2C2 – dips in 1991 and 2009; 2C3 – dip in 2009…….The ERT thanks Norway for the explanations and recommends Norway to include explanations in the IIR for key categories of the next submission.	2019, para 129	Addressed. Explanations for main dips and jumps in activity data are included in the IPPU chapter of the IIR.	See Chapter 4 and Chapter 2
IPPU - 2.B.10.a Other Chemical industry - all	The ERT noted that in the IIR there is no information about the existence of the following activities in the scope of the source category 2B10a other chemical industry in Norway and that for these activities there are emission factors in the Guidebook: SNAP 040404 Ammonium sulphate, SNAP 040405 Ammonium nitrate, SNAP 040406 Ammonium phosphate, SNAP 040407 NPK fertilisers, SNAP 040408 Urea, SNAP 040409 Carbon black, SNAP 040411 Graphite SNAP 040413 Chlorine production, SNAP 040414 Phosphate fertilisers, SNAP 040508 Polyvinylchloride, SNAP 040509 Polypropylene, SNAP 040510 Styrene, SNAP 040511 Polystyrene, SNAP 040512 Styrene butadiene, SNAP 040513 Styrene-butadiene latex, 040514 Styrene-butadiene rubber (SBR), SNAP 040515 Acrylonitrile Butadiene Styrene (ABS) resins, SNAP 040516 Ethylene oxide, SNAP 040517 Formaldehyde, SNAP 040518	2019, para 130	Addressed.	

	Ethylbenzene, SNAP 040519 Phtalic anhydride, SNAP 040520 Acrylonitrile, SNAP 040523 Glyoxylic acid, SNAP 040525 Pesticide production. The ERT recommends Norway to check if these activities occur and in case they are, to estimate and report emissions from all existing activities to the next submission, or, if not occurring, to document this in the IIR of the next submission emissions			
IPPU - 2.A, 2.B, 2.C, 2.D.3.b, 2.H.2 - all	… particle size distributions….. The ERT recommends Norway check the use of most suitable methodologies and to carefully document these in the IIR and also to check and correct information provided in the IIR	2019, para 131	Addressed.	
IPPU - 2.G Activity data trends	Due to transparency and completeness and also as NFR 2G is a key category for Hg, Pb and Cr emissions, the ERT recommends Norway to follow the recommended structure for the Informative Inventory Report (IIR) (Annex II to Reporting Guidelines, revised in 2018) and at least include a presentation of activity statistics for key categories in the IIR for the next submission of the IIR in 2020. Moreover, as the source category 2G includes many activities and the activity data cannot be presented in the NFR tables as it includes several activities for which the activity data is not the same, the ERT recommends that the activity data that were used to calculate these emissions will be presented in the IIR. In case of confidential data, this should be clearly explained in the IIR	2019, para 132	Addressed. Activity data used in the Norwegian inventory has been included as an Appendix F since IIR 2020.	See Appendix F
IPPU - 2.A.2 Lime production - PM10	The ERT recommends Norway to check the emission levels for these years, e.g. by comparing to the relevant activity data and to make relevant corrections to the next submission, or to justify the dips in the IIR of the submission in 2020.	2019, para 134	Addressed.	
IPPU - 2.J, 2.L, notation keys	The ERT notes that when the Guidebook does not provide EFs or there are no other methods available that the country prefers to use, these pollutants should be reported as “NA” (not available) and not “NE” (not estimated), which is reserved for cases where the emissions are not estimated by the Party although an EF is presented in the Guidebook, see Reporting Guidelines paragraph 12. The ERT therefore recommends Norway to change the notation keys to “NA” to the next submission	2019, para 135	Not addressed. For some emission sources the guidebook does not provide EF while emissions happen. For thoses emission sources Has Norway chosen to use the notation key NE.	
IPPU - 2.D.3.c, NE	The ERT notes from the Norway´s IIR that Norway uses the notation key “NE” for NMVOC, CO, TSP, PM10, PM2.5 and BC from NFR 2D3c Asphalt roofing, although EFs	2019, para 136	Addressed. The AD is considered as confidential	S

	are provided in the Guidebook. The ERT notes that the issue was not raised during the review and not in the draft review report. However, the ERT believes that Norway would be willing to accept this note for further improvement of the inventory to collect data and to estimate relevant emissions for the next submission.		and the emissions from this source have been assessed as insignificant.	
Solvents - consistency including recalculation and time series	The ERT recommends Norway to include detailed explanations for all outliers in its IIR as indicated in the sub-sector specific recommendations.	2019, para 145	Addressing. Ongoing project expected to be finalized in 2025	See 8.2.5
Solvents - accuracy and uncertainties	The ERT recommends Norway to update the uncertainty quantification in its emission estimates with the most appropriate methodologies available, taking into account the guidance provided in the EMEP/EEA Guidebook to the next submission	2019, para 149	Addressed.	See Appendix C
Solvents - accuracy and uncertainties	The ERT recommends Norway to use the results of the uncertainty analysis to prioritize improvements in the inventory.	2019, para 150	Addressed. See text describing how this is used in IIR chapter 1.2	See 1.2
Solvents - accuracy and uncertainties	The ERT found that there were some source categories, such as NFR 2.D.3.g Chemical products (Creosote-treated materials) and NFR 2.G Other product use (Mercury-containing products, Tobacco, Use of fireworks), where no QA/QC is carried out and recommends Norway to perform QA/QC procedures also for these source categories and to include information on these in the IIR	2019, para 151	Addressed	See 4.5.6, 4.5.7
Solvents - condensable particulate matter	Norway did not provide explanatory information in the IIR on the condensable component of PM for categories in the scope of the solvent sector. The ERT recommends Norway to include such information in the next submission.	2019, para 152	Addressed. The information is included in the IIR	See footnote in Table 1.1
Solvents - improvement	In the IIR Norway has not presented any improvement plans for the solvent sector. However, the ERT highlights that several source categories can be improved and recommends Norway to check/review them, include new information and implement improvement plans as soon as possible as indicated in the sub-sector specific recommendations below.	2019, para 153	Addressed. Improvement plans are included	See 8.2.5

Solvents -2.D.3.i – allocation, NMVOC	The ERT recommends Norway to document the existence of activities falling under this category in Norway and the inclusion of the emissions in the inventory in the IIR of the next submission.	2019, para 155	Addressed. A reference has been inserted to where a detailed description of the allocation can be found.	See 4.5.1.2
Solvents -2.D.3.i – missing emissions, TSP, PM10, PM2.5	The ERT notes that the emissions are below the threshold of significance for a technical correction, however for the completeness of the inventory, recommends Norway to include this activity in the inventory as the relevant activity statistics are the quantities of seeds used in units of tonnes (Mg) that is available in the Statistics Norway – PRODCOM (CPA: 10.41.41 oil-cake and other solid residues, of vegetable fats or oils: 10.41.41.30, 10.41.41.50, 10.41.41.70, 10.41.41.90) and to document this in the IIR for the next submission.	2019, para 156	Addressing. Ongoing project expected to be finalized in 2021	See 8.2.5
Solvents -2.D.3.g, 2.D.3.i – allocation, NMVOC	The ERT noted that Norway has included creosote-treated materials in the inventory in the scope of category 2D3g and that this activity falls under 2D3i according to 2016 EMEP/EEA methodology. To the question on the issue Norway responded that they can correct the allocation to the next submission. The ERT recommends Norway to correct the allocation to the 2020 submission.	2019, para 157	Addressed.	
Solvents -2.D.3.g, 2.D.3.i – allocation, NMVOC	However, the ERT wants to draw Norway's attention on water-borne wood preservatives that are, according to the EMEP/EEA Guidebook 2016, also a source of NMVOC emissions (EFNMVOC = 5 g/kg waterborne preservative) and also recommends Norway to confirm that these are included in the inventory and to document this in the IIR of the next submission.	2019, para 158	Addressed. Documentation has been inserted.	See 4.5.1.2
Solvents -2.D.3.a, 2.D.3.c, 2.D.3.d, 2.D.3.e, 2.D.3.f, 2.D.3.g, 2.D.3.h, 2.D.3.i – gaps 1990-2004 all pollutants	The ERT strongly recommends Norway to estimate the missing NMVOC emissions from NFRs 2D3a, 2D3c and 2D3h for the period 1990-2004 to the next submission by using some surrogate data e.g. GDP and methods provided in the Guidebook for these cases.	2019, para 159	Addressed. Calculated activity data are inserted in Annex 1.	See Appendix F

Solvents -2.D.3.a, 2.D.3.d, 2.D.3.e, 2.D.3.f, 2.D.3.g, 2.D.3.h – trends, all pollutants	In response to the issue Norway provided justifications to the trends which the ERT accepted. The ERT thanks Norway for the justifications and recommends Norway to include the information provided in the IIR of the next submission.	2019, para 160	Addressed. A section has been inserted with a description of the effect that variations in solvent imports have on emissions of NMVOC	See 4.5.1
Solvents -2.D.3.d – IEF, NMVOC	To the question on the issue Norway responded that there was a high import in a product group with a low EF. The unusual high import (high AD) leads to a low IEF compared to years with lower import. The ERT thanks Norway for the clarification and recommends Norway to include this information in the IIR of the next submission.	2019, para 161	Addressed. A section has been inserted with a description of the effect that variations in solvent imports have on IEF's	See 4.5.1.2
Solvents -2.D.3.f – IEF, NMVOC	To the question on the issue Norway responded that there is an error in the emission of NMVOC in 2014, that the emissions should be the same as in 2013 i.e. 0.123791 kt, which corresponds to an IEF of 0.57. Norway said that the figure will be corrected in the next submission. The ERT recommends Norway to include this correction in the NFR tables and the IIR of the next submission.	2019, para 162	Addressed. New emissions have been calculated for 2014.	
Solvents -2.D.3.i – IEF, NMVOC	Norway responded that from 2006 and onwards, except for 2015, there have been high imports of certain petroleum products with low NMVOC content leading to a low IEF compared to years with lower import. The ERT thanks Norway for the clarification and recommends Norway to include this information in the IIR of the next submission	2019, para 163	Addressed. A notation has been inserted with a description of the effect that variations in solvent imports have on the implied emission factors	See 4.5.1.2
Solvents -2.D.3.g – IEF, NMVOC	Norway responded that in 2008 there was an extraordinary import of a product with a high NMVOC content in the category raw materials and that this import led to a high emission in 2D3g. The ERT thanks Norway for the clarification and recommends Norway to include this information in the IIR of the next submission.	2019, para 164	Addressed	See 4.5.1.2
Agriculture 3I	The ERT noticed that the reasons for a sharp rise in ammonia emissions from 3I in 2018 were not described in the IIR. During the review Norway explained that the sharp rise was due to an increase in the NH3 treatment of straw to compensate for the reduced production of hay due to the unusually dry and hot summer that year.	2023, para 9 (a)	Addressed. The explanation is included in IIR 2024.	See Chapter 5.1

	The ERT recommends Norway to include in its IIR the explanation on the sharp rise of NH3 emissions from treatment of straw with ammonia for the year 2018.			
Agriculture 3Da2c	The ERT noticed with reference to 3Da2c in 2013-2021 that activity data as well as emissions of NH3 and NO2 were the same. Reasons for the data replication in the time series were not described in the IIR. During the review Norway explained that activity data - annual amount of nitrogen in other organic fertilizers applied to soil - was last assessed in 2014 and that these estimates are still used. The reassessment of activity data has not been prioritized, as it seems to be representative for the current situation and because of the minor size of this emission source. The relevant description (explanation) had been available in the previous submissions under section 5.5.2.1.4, but it was excluded incorrectly in the 2023 submission and will be back again in the next submission according to Norway. With reference to 3Da2c the ERT recommends Norway to include in its IIR the explanation on the replication of activity data and NH3 and NO2 emissions data for the years 2013-2021.	2023, para 9 (b)	Addressed. The explanation of how the emission source 3Da2c is estimated has been included in the IIR 2024.	See section 5.5.2.1.4
Agriculture 3Dc	The ERT noticed that emissions of PM from 3Dc category, which is considered by Norway as a key category for PM emissions, is calculated based on Tier 1 approach. The ERT notes that using a Tier 1 method is not best practice, and could result in an over and/or underestimate of emissions. During the review Norway responded that an advanced method for estimating PM emissions from farm-level agricultural operations was not applied because of the absence of country-specific data (the number of times that each operation is performed for each crop type throughout the year). The ERT notes that if relevant country-specific data is not available, efforts to collect this data need to be undertaken. However, Norway has no plans to change to a Tier 2 method. The ERT recommends Norway to explore possibilities to obtain the relevant country-specific data and estimate PM emissions from 3Dc using a Tier 2 approach.	2023, para 9 (c)	Not addressed. The tier 2 method for estimating PM emissions from farm-level agricultural operations requires country-specific data - for instance the number of times that each operation is performed for each crop type throughout the year is needed. This data is not available for Norway, and there are no plans to change to a tier 2 method for the time being.	

Agriculture 3De	"The ERT noted that activity data for 3De was marked as "Not Estimated" (NE) for the whole time series in the NFR tables while activity data was available in the IIR and emissions of NMVOC have been calculated from the source. During the review Norway expressed readiness to include activity data ""Area of cultivated cropland and grassland, [km2]"" in the NFR for the next submission. With the reference to activity data of 3De in the NFR the ERT recommends Norway to replace the notation key "NE" with activity	2023, para 9 (d)	Addressed. For 3De in the NFR 2024 activity data information "Area of cultivated cropland and grassland, [km2]" is included.	See Appendix F
Waste-Condenable particulate matter	The Party did not provide explanatory information on the condensable component of PM emissions for the waste sector. The ERT recommends the Party to include such information in the next submission.	2019, para 197	Addressed.	See chapter 6
Waste-5.A Solid waste disposal on land – NMVOC	the ERT recommends Norway to include activity data in the IIR and in the NFR tables.	2019, para 200	Addressed. Activity data is included in IIR	See 6.2.3.
Waste-5.B.1 Composting – NH3 and CO	The ERT recommends Norway to improve QC procedures to avoid mistakes.	2019, para 201	Addressed.	See 6.3.6
Waste-5.B.2 Anaerobic digestion at biogas facilities	The ERT recommends Norway to improve QC procedures to avoid mistakes.	2019, para 202	Addressed.	See 6.4.6
Waste-5.C.1.A Waste incineration – all relevant pollutants	There is one facility which incinerates waste without energy recovery which has been included in this sector in this submission. This will be added in the next IIR". The ERT recommends Norway to correct the information to the IIR of the next submission.	2019, para 203	Addressed.	See 6.4.1

8.2.2 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.

8.2.3 General

- Complete time series for all pollutants.
- Updating of Uncertainty Analysis. The analysis will include uncertainties on particulate matter and CO.
- Update the methodologies used in the Norwegian inventory according to the EMEP/EEA guidebook 2023.
- Include explanations on the emissions and activity data trends, and to justify dips and jumps.

8.2.4 Energy

- Include more information on methodology
- 1A3bvii Automobile road abrasion: The review of the method will continue improving the calculation on PM_{10}

8.2.5 Industrial processes and product use

- 2A1 Cement production. Consider the HCB emissions as these are based on an old emission factor from the EEA and that there are no emission factors in the recent versions of the EEA/EMEP guidebooks.
- 2A2 Lime production. Current estimates of BC emissions are based on a factor of 0.46 per cent of TSP emissions. The estimates will be updated in line with the most recent EEA/EMEP guidebook.
- 2A5b Construction and demolition – review possible activity data for road construction.
- 2A6 Ceramics. Update the particle size distribution for PM10 and PM2.5 in line with the most recent EEA/EMEP guidebook.
- 2B1. Consider NMVOC emissions as there are emission factors in the EEA/EMEP guidebook
- 2C1. Consider further components as there are emission factors in the EEA/EMEP guidebook.
- 2C3. Production of secondary aluminium. Consider the time series for HCB and PCB.
- 2C6. Consider dioxin emissions as there are emission factors in the EEA/EMEP guidebook.
- 2D3 Solvent losses. A thorough review of the calculations in 2D3 is planned. In this project we will consider:
    - Improvements in the allocation of the solvents. This includes:
        - a review of how the UCN-codes, CAS-numbers and NACE are combined and allocated to subcategories.
        - a review of the water borne wood preservatives and the corresponding EF used in the calculations.
        - As a result of the above issues raised in the review, we will provide an

improved description of the allocation.
    - Methods to calculate emissions of TSP, PM10 and PM2.5 from the production of oil from seeds.
- 2D3b. Road paving with asphalt. Update estimates of BC in line with the most recent EEA/EMEP guidebook.
- 2H2 – Review possible activity data in addition to beer and bread.

8.2.6 Agriculture

- 3Da1: NH3 from inorganic N-fertilizer. NH_3 emissions estimation will be considered with the use of EEA/EMEP guidebook 2023 methodology and EF.
- 3Da4: NH3 from crop residues. NH_3 emissions estimation will be considered with the use of EEA/EMEP guidebook 2023 methodology and EF.

8.2.7 Waste

- 5.B – Biological treatment of waste: NH_3 emissions estimation will be considered with the use of EEA/EMEP guidebook 2023 methodology and EF;
- 5.C.1.a – Municipal waste incineration: NH_3 emissions estimation will be considered with the use of EEA/EMEP guidebook 2023 methodology and EF;
- 5C - Waste incineration: the completeness of the inventory will be improved for POPs and HM. The work is planned to be finished in 2023.

9. Projections

Last update: 20.02.23

9.1 Introduction

This chapter describes the projections of long-range transboundary air pollutants in Norway up to 2035. Methodology and key assumptions for the projections are described in section 9.3. In line with international reporting guidelines under the Framework Convention on Climate Change these projections are based on an extension of measures and policies implemented by the June 2021. The base year for the projections is 2020.

9.2 The baseline scenario

Emissions of NOx have fallen by 25 per cent since 1990 (see Table 9.1 Anthropogenic emissions of NOx, NMVOCs, SO2, NH, PM2.5 and BC. Kilotonnes and Figure 9.1). This is mainly due to lower emissions from road traffic and primarily because the exhaust gas requirements have been sharpened, and in recent years because there are more electric cars. There has also been a decrease in emissions from domestic shipping and fishing. On the other hand, emissions from petroleum activities have increased by 62 per cent since 1990 and now account for almost 30 per cent of the total NOx emissions.

Table 9.1 Anthropogenic emissions of NOx, NMVOCs, SO2, NH, PM2.5 and BC. Kilotonnes

	2020	2025	2030	2035
NO_X	147.78	118.22	93.89	75.99
SO_2	15.62	15.68	15.29	14.66
NMVOC	152.89	121.31	114.64	107.78
NH_3	28.60	29.32	29.86	29.85
$PM_{2,5}$	24.73	22.10	20.78	19.78
BC	2.90	2.51	2.25	2.09

According to the projections, emissions of NOx decrease by more than 48 per cent by 2035 compared to 2020. The decrease is due to several factors. Emissions from passenger cars are expected to decrease because of an increase in the number of zero- and low emission vehicles. Emissions from domestic shipping are estimated to decrease significantly in the future as a result of the transition to low- and zero emission technologies, among other things, in the ferry network. It is also assumed that the NOx Fund will finance NOx reduction measures in sea transport. In addition, emissions from oil and gas activities are assumed to decrease.

In 2020, emissions of NMVOC were 64 per cent lower than in the peak year 2001. It is primarily lower emissions from loading and storing of crude oil offshore that have contributed to this decline. In addition, emissions of NMVOC from road traffic have been declining for a long time, partly because of changes in the composition of the fleet.

In the projections, emissions of NMVOC will decrease by almost 30 per cent towards 2035, primarily as a result of lower emissions from oil and gas production.

The emissions of SO2 have decreased by almost 70 per cent since 1990. In the projections, a further decrease in SO2 emissions is estimated.

Emissions of NH3 are estimated to be increased with 4 percent towards 2035. Agriculture is by far the largest source of emissions. The Agricultural and Environmental Authorities cooperate to assess measures and instruments for further reduction of ammonia emissions.

Figure 9.1 Historic emissions and projections. Kilotonnes

9.3 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.

In the projections, current policies are assumed to be continued. This implies that the scope and rates of the CO2 tax and other taxes are maintained at the 2020-level and that the observed EU ETS prices for future delivery are applied.

The projections of emissions from oil and gas production have been prepared by the Norwegian Petroleum Directorate and are based on reporting from the oil companies. In order to ensure that the projections are in line with the requirements of the emission inventory, this is supplemented with information such as emissions from processing of gas at onshore facilities.

The Norwegian Environment Agency has developed a model for projection of emissions from road traffic based on Statistics Norway's model for calculating national emissions for this source.

Consumption of electricity in power-intensive manufacturing is projected to increase slightly, in line with NVE's power market analysis. Consumption in the transport sector is also expected to increase. In households and other industries, consumption is estimated to remain at current levels. The production of electricity is estimated to increase more than the consumption.

Based on activity data from the Norwegian Institute for Bioeconomics (NIBIO), the Norwegian Environment Agency prepares projections of emissions from agriculture. Reduced emissions per manufactured unit is assumed based on a slight increase in efficiency.

10. Reporting on gridded emissions and LPS

Last update: 01.03.22

10.1 Gridded emissions

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.

10.1.1 EMEP grid squares

Emissions by EMEP 0.1° x0.1° 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
- Emissions at sea from national sea traffic are allocated to squares on the basis of a AIS-data analysis.
- The remaining emissions are allocated to squares according to the following:
  - When figures for the activity used to calculate emissions are available *directly* at geographical level, these figures are used. Examples are fuel combustion in manufacturing industries and emissions from animals.
  - When the activity at the geographical 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.

10.1.2 Scope

Gridded emissions were last reported in 2020 for the years 1990, 1995, 2000, 2005, 2010, 2015 and 2019, at the EMEP 0.1° x0.1° grid. Gridded emissions have been reported on G-NFR sources. Gridded emissions of the following components are reported: NO_X, NMVOC, SO_X, NH_3, TSP, $PM_{2.5}$, PM_{10}, CO, As, Cd, Cr, Cu, Hg, Pb, Dioxins, HCB, PCB, BC, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene.

10.1.3 Recent improvements

In 2017, emissions have been reported for the first time using a 0.1° x 0.1°grid.

10.1.4 Planned improvements

For the next reporting, the Norwegian Environment Agency plans to reduce uncertainty in the methodologies used to allocate emissions on the grid.

10.2LPS

In 2020, large point sources data have been reported for NO_X, NMVOC, SO_X, NH_3, TSP, $PM_{2.5}$, PM_{10}, CO, As, Cd, Cr, Cu, Hg, Pb, Dioxins, HCB, PCB, BC, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and Indeno(1,2,3-cd)pyrene, where emissions exceed the reporting limits included in the 2014 reporting guidelines.

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Appendix A

Tier 1 Key Category Analysis- Norway – 2024 submission

Last update: 15.02.2024

- *Methodology*

The submission includes tier 1 key category analysis for the years 1990 and 2022 for the components SO_2, NO_X, NH_3, NMVOC, CO, TSP, PM_{10}, $PM_{2.5}$, Pb, Hg, Cd, dioxins, PAH, HCB and PCB. The same procedure has been performed for 1990 and 2022. The emissions are analysed using the NFR19 sources (from the NFR 2019-1 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 per cent of total emissions are covered. For convenience, the analysis was performed with a few exceptions from the NFR19 (Gasoline evaporation (1A3bv) is included in 1A3bi-iv). 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 1-18 are sorted by share of total emissions in 2022 for each component separately. Key categories in 1990 which were not key in 2022 are placed at the bottom of each table. When a source has become key in 2022, 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 cannot be used to evaluate trends in emission levels for any given source.

- *Results*

70 per cent of the 93 sources with emissions in 2022 were key to at least one component. This means that 28 sources have emissions but are not key category for any component. Some sources are key category to a wide range of components. This is the case in particular for public electricity and heat production (1A1a), manufacture of solid fuels and other energy industries (1A1c), road transport (1A3bi-iii), national navigation (1A3dii), residential plants (1A4bi), ferroalloys production (2C2) and aluminium production (2C3).

Looking at the three most dominant sources of emissions for each component in 2022, it becomes clear that there are some sources that are responsible for a large proportion of emissions. This is the case for emissions from combustion in households, aluminium production, passenger cars, automobile road abrasion, ferroalloys production and public electricity and heat 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 aluminum production dominate the emissions for SO_2, some heavy metals and PAH.

▪ *Key categories for SO_2*

Production of ferroalloys was the dominant source for emissions of SO_2 in both 1990 and 2022, with, respectively, 24 and 41 per cent of the total (Table A 1). The importance of public electricity and heat production has grown considerably, from 2 per cent in 1990 to 12 per cent in 2022. Several sources which were key in 1990 are no longer so in 2022. Particularly, this is the case for road traffic, due to lower sulphur content in petrol and auto diesel.

Table A 1. Key categories for SO_2 emissions, 1990 and 2022. Key categories are given in bold italic

	Source	1990	2022
2C2	Ferroalloys production	24.3 %	***41.0 %***
1A1A	Public electricity and heat production	2.3 %	***12.3 %***
2C3	Aluminium production	8.7 %	***10.9 %***
1A3DII	National navigation (shipping)	4.3 %	***6.4 %***
1A4BI	Residential: Stationary	2.4 %	***3.8 %***
2C7C	Other metal production (specified in the IIR)	0.9 %	***3.4 %***
2B5	Carbide production	9.0 %	***3.1 %***
1A1C	Manufacture of solid fuels and other energy industries	0.9 %	***3.1 %***
2A1	Cement production	1.2 %	***2.4 %***
1A1B	Petroleum refining	0.8 %	***2.4 %***
1A4CIII	Agriculture/Forestry/Fishing: National fishing	1.8 %	***2.2 %***
1B2AIV	Fugitive emissions oil: Refining / storage	7.3 %	***1.8 %***
1A4AI	Commercial/institutional: Stationary	1.7 %	***1.1 %***
1A2D	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	2.8 %	***1.1 %***
1A2F	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	2.3 %	1.0 %
2H1	Pulp and Paper	3.8 %	0.3 %
1A2E	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	3.3 %	0.3 %
1A3BIII	Road transport: Heavy duty vehicles and buses	3.1 %	0.1 %
1A2GVIII	Stationary Combustion in manufacturing industries and construction: Other (specified in the IIR)	2.8 %	0.6 %
2B10A	Chemical industry: Other (specified in the IIR)	2.6 %	0.0 %
1A3BI	Road transport: Passenger cars	2.1 %	0.1 %
1A2C	Stationary combustion in manufacturing industries and construction: Chemicals	1.7 %	0.6 %
1A2GVII	Mobile Combustion in manufacturing industries and construction: (specified in the IIR)	1.2 %	0.0 %
2B6	Titanium dioxide production	1.0 %	0.1 %
1A4AII	Commercial/institutional: Mobile	0.8 %	0.0 %
1A3BII	Road transport: Light duty vehicles	0.8 %	0.1 %
1A2B	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	0.8 %	0.0 %
2H3	Other industrial processes (specified in the IIR)	1.2 %	.

Source: Statistics Norway/Norwegian Environment Agency

- *Key categories for NO_X*

Manufacture of solid fuels and other energy industries was the most dominant emission source of NOx in 2022, with 28 per cent of the emissions (Table A 2). In 1990, passenger cars and national navigation (shipping) was the dominant sources, and the three road transport groups together were responsible for one third of the emissions. In 2022, this share was reduced to less than one fifth. The actual emissions from road transport were more than halved in the period, partly due to an increased share of cars with catalysts.

Table A 2. Key categories for NOX emissions, 1990 and 2022. Key categories are given in bold italic

	Source	1990	2022
1A1C	Manufacture of solid fuels and other energy industries	12.5 %	***28.2 %***
1A3DII	National navigation (shipping)	15.2 %	***17.8 %***
1A3BI	Road transport: Passenger cars	16.9 %	***8.5 %***
1A4CIII	Agriculture/Forestry/Fishing: National fishing	6.3 %	***5.3 %***
2C2	Ferroalloys production	4.7 %	***5.2 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	13.3 %	***5.1 %***
1A3BII	Road transport: Light duty vehicles	2.9 %	***4.1 %***
1A2GVII	Mobile Combustion in manufacturing industries and construction: (specified in the IIR)	4.2 %	***3.2 %***
3DA1	Inorganic N-fertilizers (includes also urea application)	2.2 %	***3.0 %***
1A4AII	Commercial/institutional: Mobile	2.9 %	***2.6 %***
1A4BII	Residential: Household and gardening (mobile)	1.0 %	***1.7 %***
1A1A	Public electricity and heat production	0.7 %	***1.7 %***
3DA2A	Animal manure applied to soils	1.0 %	***1.6 %***
1A2F	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	1.8 %	***1.3 %***
1A4CII	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.6 %	***1.0 %***
1A4BI	Residential: Stationary	0.9 %	***0.9 %***
1A3AII(I)	Domestic aviation LTO (civil)	0.4 %	***0.8 %***
1A2A	Stationary combustion in manufacturing industries and construction: Iron and steel	0.1 %	***0.8 %***
2C3	Aluminium production	0.3 %	***0.8 %***
3DA3	Urine and dung deposited by grazing animals	0.5 %	***0.7 %***
1B2AIV	Fugitive emissions oil: Refining / storage	0.6 %	***0.7 %***
1A3C	Railways	0.7 %	***0.6 %***
1A5B	Other, Mobile (including military, land based and recreational boats)	1.8 %	0.4 %
2B2	Nitric acid production	1.2 %	0.5 %
1A2C	Stationary combustion in manufacturing industries and construction: Chemicals	1.1 %	0.5 %
1A1B	Petroleum refining	0.9 %	0.2 %
1A2D	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.7 %	0.2 %

Source: Statistics Norway/Norwegian Environment Agency

- *Key categories for NH_3*

There have been small changes in the key categories for NH_3 from 1990 to 2022 (Table A 3). Agricultural sources are dominant, particularly animal manure applied to soils, which was responsible for 42 per cent of the emissions in 2022. However, field burning of agricultural residue, which was a key category in 1990, was no longer so in 2022. There has been an opposite development for Sewage sludge applied to soils and manure management for horses and for broilers – these were key categories only in 2022.

Table A 3. Key categories for NH3 emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
3DA2A	Animal manure applied to soils	42.8 %	***41.8 %***
3B1B	Manure management - Non-dairy cattle	8.8 %	***15.2 %***
3B1A	Manure management - Dairy cattle	14.9 %	***12.8 %***
3DA3	Urine and dung deposited by grazing animals	6.0 %	***6.2 %***
3DA1	Inorganic N-fertilizers (includes also urea application)	5.2 %	***4.2 %***
3B3	Manure management - Swine	4.1 %	***3.8 %***
3B2	Manure management - Sheep	3.6 %	***3.0 %***
3B4E	Manure management - Horses	0.8 %	***2.2 %***
2B2	Nitric acid production	1.5 %	***1.4 %***
3I	Agriculture other (specified in the IIR)	4.7 %	***1.4 %***
3B4GI	Manure mangement - Laying hens	0.9 %	***1.4 %***
3B4GII	Manure mangement - Broilers	0.6 %	***1.1 %***
3DA2B	Sewage sludge applied to soils	0.4 %	***1.0 %***
3F	Field burning of agricultural residue	3.1 %	0.4 %

Source: Statistics Norway/Norwegian Environment Agency

- *Key categories for NMVOC*

NMVOC emissions are spread on a wide range of sources. In 2022, "other solvent use" was the dominant emission source and contributed with 21 per cent of the emissions (Table A 4). Due to decreases in emissions from other sources, particularly oil loading, the share is much higher than in 1990, although the actual emissions have been reduced. Offshore loading of oil was the most dominant source in 1990, but due to increased use of emission reducing technology, this source has become less dominant during the period. Emissions from this source amounted to 37 per cent of the total in 1990, but only 11 per cent in 2022. Passenger cars was the second largest emission source for NMVOC in 1990, but this source's share of total emissions was reduced from 18 per cent in 1990 to only 2 per cent in 2022.

Table A 4. Key categories for NMVOC emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
2D3I	Other solvent use (specified in the IIR)	7.5 %	***20.8 %***
2D3A	Domestic solvent use including fungicides	2.7 %	***14.9 %***
1A4BI	Residential: Stationary	6.9 %	***13.9 %***
1B2AI	Fugitive emissions oil: Exploration, production, transport	36.9 %	***11.4 %***
1B2C	Venting and flaring (oil, gas, combined oil and gas)	2.2 %	***5.7 %***
1A4BII	Residential: Household and gardening (mobile)	3.9 %	***4.3 %***
2D3D	Coating applications	4.1 %	***4.0 %***
3B1B	Manure management - Non-dairy cattle	0.9 %	***2.7 %***
1A3DII	National navigation (shipping)	0.5 %	***2.2 %***
3B1A	Manure management - Dairy cattle	1.1 %	***2.0 %***
3DA2A	Animal manure applied to soils	1.0 %	***1.9 %***
1A3BI	Road transport: Passenger cars	18.4 %	***1.8 %***
1A1A	Public electricity and heat production	0.1 %	***1.4 %***
1A1C	Manufacture of solid fuels and other energy industries	0.3 %	***1.3 %***
1B2AV	Distribution of oil products	3.1 %	***1.3 %***
2C2	Ferroalloys production	0.4 %	***1.1 %***
2H2	Food and beverages industry	0.5 %	***1.1 %***
1A3BIV	Road transport: Mopeds & motorcycles	0.7 %	***1.1 %***
1B2AIV	Fugitive emissions oil: Refining / storage	0.6 %	***0.7 %***
2D3E	Degreasing	0.4 %	***0.6 %***
3DE	Cultivated crops	0.2 %	***0.5 %***
3B4E	Manure management - Horses	0.1 %	***0.4 %***
1A3BII	Road transport: Light duty vehicles	1.7 %	0.1 %
1A3BIII	Road transport: Heavy duty vehicles and buses	0.9 %	0.1 %
2D3G	Chemical products	0.9 %	0.2 %
2D3F	Dry cleaning	0.5 %	0.1 %

Source: Statistics Norway/Norwegian Environment Agency

- *Key categories for CO*

Aluminium production was the most important emission source for CO in 2022 (Table A 5). This source's share grew from 13 per cent in 1990 to 41 per cent in 2022. Emissions from combustion in households, primarily of firewood, increased its emission share from 13 per cent in 1990 to 26 per cent in 2022, although the actual emissions were reduced. In 1990, passenger car was the dominant source, with 43 per cent of the total CO emissions; this share was reduced to only 4 per cent in 2022. Emission reductions from some sources are the reason that several minor sources have become key categories, although their actual emissions may have been reduced.

Table A 5. Key categories for CO emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
2C3	Aluminium production	13.2 %	***40.6 %***
1A4BI	Residential: Stationary	13.3 %	***25.8 %***
1A4BII	Residential: Household and gardening (mobile)	7.9 %	***14.3 %***
1A3BI	Road transport: Passenger cars	42.7 %	***4.2 %***
1A1A	Public electricity and heat production	0.1 %	***2.6 %***
1A1C	Manufacture of solid fuels and other energy industries	0.6 %	***2.1 %***
2B5	Carbide production	5.1 %	***1.6 %***
1A3BIV	Road transport: Mopeds & motorcycles	0.7 %	***1.2 %***
1A3DII	National navigation (shipping)	0.2 %	***1.1 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	1.0 %	***0.9 %***
1A2GVIII	Stationary Combustion in manufacturing industries and construction: Other (specified in the IIR)	0.5 %	***0.8 %***
1A3BII	Road transport: Light duty vehicles	6.5 %	0.6 %
3F	Field burning of agricultural residue	3.4 %	0.7 %
2C4	Magnesium production	2.5 %	.

Source: Statistics Norway/Norwegian Environment Agency

- *Key categories for particulates*

The dominant emission source for TSP is automobile road abrasion both in 1990 and 2022 with 34 and 27 per cent respectively (Table A 6). The second largest contributor to TSP is burning of fuel wood in small stoves in households. This is the largest contributor to PM_{10} and $PM_{2.5}$ emissions (

Table A 7, Table A 8). The importance of the other emission sources varies between the different PM fractions.

Table A 6. Key categories for TSP emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
1A3BVII	Road transport: Automobile road abrasion	33.9 %	***26.7 %***
1A4BI	Residential: Stationary	24.3 %	***22.7 %***
2A6	Other mineral products (specified in the IIR)	6.4 %	***12.8 %***
1A3BVI	Road transport: Automobile tyre and brake wear	3.0 %	***6.4 %***
2D3B	Road paving with asphalt	3.5 %	***6.3 %***
2A5B	Construction and demolition	2.2 %	***4.6 %***
1A1A	Public electricity and heat production	0.5 %	***2.7 %***
2C2	Ferroalloys production	4.0 %	***2.2 %***
1A3DII	National navigation (shipping)	1.0 %	***1.8 %***
1A1C	Manufacture of solid fuels and other energy industries	0.5 %	***1.4 %***
3B4GI	Manure management - Laying hens	0.6 %	***1.3 %***
2C3	Aluminium production	2.5 %	***1.2 %***
1A2GVIII	Stationary Combustion in manufacturing industries and construction: Other (specified in the IIR)	1.0 %	***0.7 %***
3DC	Farm-level agricultural operations including storage, handling and transport of agricultural products	0.7 %	***0.7 %***
3B4GII	Manure management - Broilers	0.2 %	***0.7 %***
1A4CIII	Agriculture/Forestry/Fishing: National fishing	0.4 %	***0.6 %***
3B3	Manure management - Swine	0.4 %	***0.6 %***
1A4BII	Residential: Household and gardening (mobile)	0.5 %	***0.6 %***
2G	Other product use (specified in the IIR)	0.3 %	***0.6 %***
3B1B	Manure management - Non-dairy cattle	0.4 %	***0.5 %***
3F	Field burning of agricultural residue	2.4 %	0.4 %
2B5	Carbide production	1.4 %	0.0 %
1A3BIII	Road transport: Heavy duty vehicles and buses	1.4 %	0.1 %
2B10A	Chemical industry: Other (specified in the IIR)	1.3 %	0.4 %
1B2C	Venting and flaring (oil, gas, combined oil and gas)	1.1 %	0.3 %
2H3	Other industrial processes (specified in the IIR)	0.6 %	0.0 %
1A4CII	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.6 %	0.2 %
1A3BII	Road transport: Light duty vehicles	0.5 %	0.2 %
3B1A	Manure management - Dairy cattle	0.5 %	0.4 %

Source: Statistics Norway/Norwegian Environment Agency

Table A 7. Key categories for PM10 emissions, 1990 and 2022. Key categories are given in bold italic

	Source	1990	2022
1A4BI	Residential: Stationary	34.0 %	***35.5 %***
1A3BVII	Road transport: Automobile road abrasion	24.8 %	***21.5 %***
2A6	Other mineral products (specified in the IIR)	4.7 %	***10.1 %***
1A1A	Public electricity and heat production	0.5 %	***4.0 %***
2C2	Ferroalloys production	5.8 %	***3.5 %***
1A3DII	National navigation (shipping)	1.5 %	***2.9 %***
2A5B	Construction and demolition	1.0 %	***2.3 %***
2D3B	Road paving with asphalt	1.1 %	***2.2 %***
1A1C	Manufacture of solid fuels and other energy industries	0.7 %	***2.2 %***
2C3	Aluminium production	3.0 %	***1.6 %***
1A3BVI	Road transport: Automobile tyre and brake wear	0.6 %	***1.3 %***
3DC	Farm-level agricultural operations including storage, handling and transport of agricultural products	1.0 %	***1.2 %***
1A2GVIII	Stationary Combustion in manufacturing industries and construction: Other (specified in the IIR)	1.4 %	***1.1 %***
1A4CIII	Agriculture/Forestry/Fishing: National fishing	0.6 %	***1.0 %***
1A4BII	Residential: Household and gardening (mobile)	0.7 %	***0.9 %***
2G	Other product use (specified in the IIR)	0.4 %	***0.9 %***
3F	Field burning of agricultural residue	3.4 %	***0.6 %***
3B4GII	Manure management - Broilers	0.2 %	***0.6 %***
2B10A	Chemical industry: Other (specified in the IIR)	1.5 %	***0.5 %***
1B2C	Venting and flaring (oil, gas, combined oil and gas)	1.5 %	***0.5 %***
5E	Other waste	0.3 %	***0.5 %***
1A4AI	Commercial/institutional: Stationary	0.1 %	***0.4 %***
2B5	Carbide production	2.1 %	0.0 %
1A3BIII	Road transport: Heavy duty vehicles and buses	2.0 %	0.2 %
1A4CII	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	0.8 %	0.3 %
1A3BII	Road transport: Light duty vehicles	0.7 %	0.3 %
1A2GVII	Mobile Combustion in manufacturing industries and construction: (specified in the IIR)	0.5 %	0.1 %
2H1	Pulp and Paper	0.5 %	0.1 %
2H3	Other industrial processes (specified in the IIR)	0.4 %	0.0 %

Source: Statistics Norway/Norwegian Environment Agency

Table A 8. Key categories for PM2.5 emissions, 1990 and 2022. Key categories are given in bold italic

	Source	1990	2022
1A4BI	Residential: Stationary	47.1 %	***53.0 %***
1A1A	Public electricity and heat production	0.4 %	***6.1 %***
1A3BVII	Road transport: Automobile road abrasion	6.3 %	***5.8 %***
2C2	Ferroalloys production	8.9 %	***5.7 %***
1A3DII	National navigation (shipping)	2.2 %	***4.5 %***
1A1C	Manufacture of solid fuels and other energy industries	1.0 %	***3.4 %***
2C3	Aluminium production	3.7 %	***2.1 %***
2A6	Other mineral products (specified in the IIR)	0.9 %	***1.8 %***
1A2GVIII	Stationary Combustion in manufacturing industries and construction: Other (specified in the IIR)	2.0 %	***1.8 %***
1A4BII	Residential: Household and gardening (mobile)	1.0 %	***1.5 %***
1A4CIII	Agriculture/Forestry/Fishing: National fishing	0.9 %	***1.5 %***
1A3BVI	Road transport: Automobile tyre and brake wear	0.6 %	***1.5 %***
3F	Field burning of agricultural residue	5.0 %	***0.9 %***
1B2C	Venting and flaring (oil, gas, combined oil and gas)	1.9 %	***0.9 %***
2G	Other product use (specified in the IIR)	0.6 %	***0.9 %***
5E	Other waste	0.5 %	***0.8 %***
1A2C	Stationary combustion in manufacturing industries and construction: Chemicals	0.3 %	***0.7 %***
2B10A	Chemical industry: Other (specified in the IIR)	1.8 %	***0.6 %***
1A4AI	Commercial/institutional: Stationary	0.1 %	***0.6 %***
1A3BI	Road transport: Passenger cars	0.5 %	***0.5 %***
1A4CII	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	1.2 %	***0.5 %***
2D3B	Road paving with asphalt	0.2 %	***0.5 %***
2B5	Carbide production	3.2 %	0.1 %
1A3BIII	Road transport: Heavy duty vehicles and buses	3.1 %	0.4 %
1A3BII	Road transport: Light duty vehicles	1.1 %	0.5 %
1A2GVII	Mobile Combustion in manufacturing industries and construction: (specified in the IIR)	0.7 %	0.1 %
2H1	Pulp and Paper	0.5 %	0.1 %
1A4AII	Commercial/institutional: Mobile	0.5 %	0.1 %

Source: Statistics Norway/Norwegian Environment Agency

Key categories for lead (Pb)

There has been a dramatic change in dominant sources for emissions of lead from 1990 to 2022 (Table A 9). Due to high lead content in petrol in 1990, passenger car was by far the most important source, and accounted for 79 per cent of total lead emissions. In 2022, petrol no longer contained significant amounts of lead, and other sources had become dominant. The most significant emission source in 2022 was tyre and brake wear in vehicles, with 32 per cent of the emissions. Residential, primarily combustion of firewood, was the second most important source with 11 per cent of the total emissions. Due to the reduced importance of road traffic, far more sources were key in 2022 than in 1990.

Table A 9. Key categories for Pb emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
1A3BVI	Road transport: Automobile tyre and brake wear	0.6 %	***31.8 %***
1A4BI	Residential: Stationary	0.3 %	***11.0 %***
2C1	Iron and steel production	1.3 %	***8.9 %***
1A3AII(I)	Domestic aviation LTO (civil)	0.2 %	***8.4 %***
2C3	Aluminium production	0.3 %	***5.0 %***
1A2F	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.1 %	***4.8 %***
2B6	Titanium dioxide production	0.1 %	***4.5 %***
2C2	Ferroalloys production	0.7 %	***4.0 %***
5E	Other waste	0.2 %	***4.0 %***
1A4AI	Commercial/institutional: Stationary	0.0 %	***3.7 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	0.8 %	***2.0 %***
1A3BI	Road transport: Passenger cars	79.1 %	***2.0 %***
1A1A	Public electricity and heat production	1.1 %	***2.0 %***
1A3DII	National navigation (shipping)	0.0 %	***1.5 %***
1A3BII	Road transport: Light duty vehicles	7.1 %	***1.0 %***
1A1C	Manufacture of solid fuels and other energy industries	0.0 %	***0.7 %***
1A4BII	Residential: Household and gardening (mobile)	4.1 %	0.1 %
5C1A	Municipal waste incineration	1.1 %	0.0 %
1A3BIV	Road transport: Mopeds & motorcycles	1.0 %	0.0 %
2A3	Glass production	0.8 %	0.0 %

Source: Statistics Norway/Norwegian Environment Agency

Key categories for mercury (Hg)

Mercury emissions stem from a wide variety of sources (Table A 10). In 1990, ferroalloys production and other product use (thermometers, fluorescent tubes and other instruments) dominated, with more than half of the total emissions altogether. In 2022, ferroalloys production had a share of 12 per cent and was the third largest contributor. The largest sources were national navigation (shipping) with a share of 17 per cent, and public electricity and heat production with 13 per cent. National navigation has increased from 2 per cent in 1990.

Table A 10. Key categories for Hg emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
1A3DII	National navigation (shipping)	2.0 %	***16.9 %***
1A1A	Public electricity and heat production	6.7 %	***13.4 %***
2C2	Ferroalloys production	34.4 %	***11.6 %***
1A1C	Manufacture of solid fuels and other energy industries	0.6 %	***9.2 %***
1A4CIII	Agriculture/Forestry/Fishing: National fishing	0.8 %	***5.7 %***
2A1	Cement production	1.8 %	***5.2 %***
1A4AI	Commercial/institutional: Stationary	0.9 %	***3.5 %***
2G	Other product use (specified in the IIR)	19.5 %	***3.2 %***
1A2F	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.8 %	***3.1 %***
2C7C	Other metal production (specified in the IIR)	0.2 %	***2.9 %***
1A3BI	Road transport: Passenger cars	0.9 %	***2.7 %***
3F	Field burning of agricultural residue	3.9 %	***2.7 %***
1A2D	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	1.8 %	***2.6 %***
1A4BI	Residential: Stationary	1.3 %	***2.4 %***
2A6	Other mineral products (specified in the IIR)	0.4 %	***1.8 %***
1A3BVI	Road transport: Automobile tyre and brake wear	0.2 %	***1.5 %***
1A3AII(I)	Domestic aviation LTO (civil)	0.1 %	***1.1 %***
1A2GVIII	Stationary Combustion in manufacturing industries and construction: Other (specified in the IIR)	1.3 %	***1.1 %***
1B2C	Venting and flaring (oil, gas, combined oil and gas)	0.0 %	***1.0 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	0.1 %	***0.9 %***
2B6	Titanium dioxide production	0.2 %	***0.8 %***
1A3AI(I)	International Aviation (LTO)	0.1 %	***0.7 %***
1A2C	Stationary combustion in manufacturing industries and construction: Chemicals	0.8 %	***0.7 %***
2C6	Zinc production	0.6 %	***0.6 %***
2C1	Iron and steel production	6.9 %	0.6 %
2B10A	Chemical industry: Other (specified in the IIR)	4.9 %	0.0 %
5C1A	Municipal waste incineration	4.1 %	0.0 %
5C1BV	Cremation	1.4 %	0.5 %
1A2E	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	1.3 %	0.5 %

Source: Statistics Norway/Norwegian Environment Agency

Key categories for cadmium (Cd)

Automobile road abrasion was the largest contributor to cadmium emissions in 1990 and 2022 (Table A 11). The second largest in 2022 was combustion in households, particularly of firewood. More minor sources were key in 2022 than in 1990.

Table A 11. Key categories for Cd emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
1A3BVII	Road transport: Automobile road abrasion	19.0 %	***31.0 %***
1A4BI	Residential: Stationary	8.3 %	***27.1 %***
1A1A	Public electricity and heat production	5.0 %	***9.3 %***
3F	Field burning of agricultural residue	17.9 %	***5.9 %***
1A2GVIII	Stationary Combustion in manufacturing industries and construction: Other (specified in the IIR)	1.7 %	***3.2 %***
2C3	Aluminium production	4.6 %	***2.9 %***
1A3BI	Road transport: Passenger cars	0.8 %	***2.1 %***
1A4AI	Commercial/institutional: Stationary	0.2 %	***1.9 %***
1A2D	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	6.1 %	***1.8 %***
1A2F	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	1.1 %	***1.7 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	0.3 %	***1.6 %***
1A1C	Manufacture of solid fuels and other energy industries	0.3 %	***1.6 %***
2C2	Ferroalloys production	12.8 %	***1.4 %***
1A3DII	National navigation (shipping)	0.3 %	***1.2 %***
1A2C	Stationary combustion in manufacturing industries and construction: Chemicals	0.3 %	***1.2 %***
2C6	Zinc production	7.7 %	***1.2 %***
1A3BII	Road transport: Light duty vehicles	0.1 %	***0.8 %***
5C1A	Municipal waste incineration	5.1 %	0.0 %
2B5	Carbide production	4.5 %	0.1 %
2C1	Iron and steel production	2.4 %	0.7 %

Source: Statistics Norway/Norwegian Environment Agency

- *Key categories for dioxins*

In 1990, other industrial processes, i.e. ore mines, and magnesium production were the largest sources of dioxin emissions (Table A 12). The enterprises responsible for these emissions have been shut down since 1990, and thus other sources have become dominant. In 2022, residential was responsible for 35 per cent of the dioxin emissions in Norway. Most of these emissions came from use of firewood. Since the major emission sources in 1990 have disappeared, several minor sources have become key in 2022.

Table A 12. Key categories for dioxin emissions, 1990 and 2022. Key categories are given in bold italic

	Source	1990	2022
1A4BI	Residential: Stationary	8.1 %	***34.8 %***
1A3DII	National navigation (shipping)	1.7 %	***16.4 %***
5E	Other waste	1.7 %	***11.0 %***
1A1C	Manufacture of solid fuels and other energy industries	0.5 %	***8.1 %***
1A4CIII	Agriculture/Forestry/Fishing: National fishing	0.8 %	***5.6 %***
2C3	Aluminium production	0.6 %	***5.3 %***
1A1A	Public electricity and heat production	10.3 %	***5.1 %***
2C2	Ferroalloys production	1.2 %	***2.8 %***
2A1	Cement production	0.2 %	***2.5 %***
2C1	Iron and steel production	0.9 %	***1.9 %***
1A2GVIII	Stationary Combustion in manufacturing industries and construction: Other (specified in the IIR)	0.2 %	***1.1 %***
1A2D	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	0.9 %	***1.1 %***
1A3BI	Road transport: Passenger cars	1.7 %	0.7 %
2H3	Other industrial processes (specified in the IIR)	41.5 %	.
2C4	Magnesium production	24.4 %	.
5C1BIII	Clinical waste incineration	4.1 %	.

Source: Statistics Norway/Norwegian Environment Agency

- *Key categories for PAH*

Aluminium production was the most important emission source of PAH emissions in both 1990 and 2022, although it was less dominant in 2022 (Table A 13-Table A 16). For benzo(k)fluoranthene, there is a break in the time series between 2015 and 2016, due to the introduction of a new calculation methodology. Road transport and combustion of firewood in households is also important emissions source for PAH.

Table A 13. Key categories for benzo(a)pyrene emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
1A4BI	Residential: Stationary	18.5 %	***36.9 %***
2C3	Aluminium production	68.7 %	***32.4 %***
1A3BI	Road transport: Passenger cars	2.1 %	***12.0 %***
1A3BII	Road transport: Light duty vehicles	0.4 %	***6.2 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	0.5 %	***3.1 %***
5E	Other waste	0.7 %	***2.1 %***
3F	Field burning of agricultural residue	3.8 %	***1.8 %***
1A2GVII	Mobile Combustion in manufacturing industries and construction: (specified in the IIR)	0.1 %	***1.1 %***
2C7C	Other metal production (specified in the IIR)	2.3 %	0.2 %

Source: Statistics Norway/Norwegian Environment Agency

Table A 14. Key categories for benzo(b)fluoranthene emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
2C3	Aluminium production	70.3 %	***35.3 %***
1A4BI	Residential: Stationary	13.3 %	***23.2 %***
1A3BVI	Road transport: Automobile tyre and brake wear	1.8 %	***11.3 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	1.3 %	***7.8 %***
1A3BI	Road transport: Passenger cars	1.1 %	***5.7 %***
1A3BII	Road transport: Light duty vehicles	0.2 %	***2.9 %***
1A2F	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.2 %	***2.7 %***
1A3BVII	Road transport: Automobile road abrasion	1.0 %	***2.2 %***
3F	Field burning of agricultural residue	4.9 %	***2.1 %***
5E	Other waste	0.5 %	***1.3 %***
1A3DII	National navigation (shipping)	0.2 %	***1.0 %***
2C7C	Other metal production (specified in the IIR)	2.3 %	0.4 %
2B5	Carbide production	1.6 %	0.7 %

Source: Statistics Norway/Norwegian Environment Agency

Table A 15. Key categories for benzo(k)fluoranthene emissions, 1990 and 2022. Key categories are given in bold italic

	Source	1990	2022
2C3	Aluminium production	78.2 %	***32.5 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	2.9 %	***24.3 %***
1A4BI	Residential: Stationary	6.7 %	***15.7 %***
1A3BI	Road transport: Passenger cars	1.6 %	***12.1 %***
1A3BII	Road transport: Light duty vehicles	0.3 %	***6.3 %***
3F	Field burning of agricultural residue	4.2 %	***2.5 %***
5E	Other waste	0.4 %	***1.6 %***
2C7C	Other metal production (specified in the IIR)	2.6 %	0.3 %
2B5	Carbide production	1.7 %	0.2 %

Source: Statistics Norway/Norwegian Environment Agency

Table A 16. Key categories for indeno(1,2,3_cd)pyrene emissions, 1990 and 2022. Key categories are given in bold italic

	Source	1990	2022
1A4BI	Residential: Stationary	22.7 %	***35.6 %***
2C3	Aluminium production	58.2 %	***17.6 %***
1A3BI	Road transport: Passenger cars	4.4 %	***16.1 %***
1A3BII	Road transport: Light duty vehicles	0.8 %	***7.9 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	1.2 %	***6.5 %***
1A3DII	National navigation (shipping)	1.0 %	***5.8 %***
5E	Other waste	1.4 %	***3.3 %***
3F	Field burning of agricultural residue	5.5 %	***2.1 %***
1A4CIII	Agriculture/Forestry/Fishing: National fishing	0.5 %	2.0 %
2C7C	Other metal production (specified in the IIR)	1.9 %	0.1 %
2B5	Carbide production	1.3 %	0.3 %

Source: Statistics Norway/Norwegian Environment Agency

- *Key categories for HCB*

In 1990, magnesium production was by far the largest source for HCB emissions, with 99 per cent of the total. This production has ceased, and in 2022 road transport is the dominant source. The three groups of road transport were together responsible for about half of the emissions. Aluminium production was the second most important source in 2022. However, HCB emissions in Norway are now negligible.

Table A 17. Key categories for HCB emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
1A3BI	Road transport: Passenger cars	0.0 %	***32.1 %***
2C3	Aluminium production	0.1 %	***15.1 %***
1A3BII	Road transport: Light duty vehicles	0.0 %	***14.0 %***
1A1A	Public electricity and heat production	0.4 %	***10.0 %***
1A4BI	Residential: Stationary	0.1 %	***7.7 %***
1A3BIII	Road transport: Heavy duty vehicles and buses	0.0 %	***6.2 %***
1A3DII	National navigation (shipping)	0.0 %	***5.1 %***
1A4CIII	Agriculture/Forestry/Fishing: National fishing	0.0 %	***1.7 %***
2C1	Iron and steel production	0.0 %	***1.7 %***
1A2GVIII	Stationary Combustion in manufacturing industries and construction: Other (specified in the IIR)	0.0 %	***1.5 %***
2C4	Magnesium production	99.1 %	.

Source: Statistics Norway/Norwegian Environment Agency

- *Key categories for PCB*

Road traffic is by far the most important source for emissions of PCB. There has, however, been a strong shift between the different road traffic groups. In 1990, most of the emissions came from passenger cars, whereas heavy good vehicles and buses were dominant in 2022.

Table A 18. Key categories for PCB emissions, 1990 and 2022. Key categories are given in bold italic

	Source	**1990**	**2022**
1A3BIII	Road transport: Heavy duty vehicles and buses	5.6 %	***86.9 %***
5E	Other waste	1.5 %	***4.1 %***
1A3BI	Road transport: Passenger cars	77.8 %	***3.4 %***
1A3BII	Road transport: Light duty vehicles	7.0 %	***2.0 %***
1A4BII	Residential: Household and gardening (mobile)	4.1 %	0.0 %
1B2C	Venting and flaring (oil, gas, combined oil and gas)	2.6 %	0.0 %

Source: Statistics Norway/Norwegian Environment Agency

Emission factors used in the estimations of emissions from combustion

Statistics Norway presents an inventory over important emission factors on the website for the statistics *Emissions to air*, see “About the statistics” and “Relevant documentation” on https://www.ssb.no/en/natur-og-miljo/forurensning-og-klima/statistikk/utslipp-til-luft.
In the calculations, the numbers are used with the highest available accuracy. In the tables, though, they are only shown rounded off, which in some cases can cause the exceptions to appear identical to the general factors. The tables include the emission factors used for estimating the acidifying pollutants, heavy metals and persistent organic pollutants. For practical reasons, the emission factors used for the Norwegian greenhouse gas inventory are also included in the tables.

A description of the sector codes used in the tables is given in Appendix D.
The emission factors for BC, PCB and HCB are not included in Statistics Norway’s inventory, but some of the factors are presented in Table B1. These factors vary greatly between sectors, combustion technology and years. In several cases, particularly for PCB and HCB, factors are not available, and emissions have not been estimated.

Table B1. Emission factors for BC, PCB and HCB

	BC kg/tonne	PCB ug/tonn	HCB ug/tonn
Coal	0.016[1]	160.170[1]	17.422
Coke	0.016[1]	160.170[1]	17.422
Petrol coke	0.016[1]	160.170[1]	NE
Motor gasoline	0.004[2]	20[3]	0.422[14]
Aviation gasoline	0.005[4]	NE	NE
Kerosene (heating)	0.029	4.008	NE
Jet kerosene/bio-jet kerosene	**0.069**[13]	NE	NE
Auto diesel	**0.089**[2]	986.339[2]	456.017[2]
Marine gas oil/diesel	0.600[6]	355.656	80
Light fuel oils	0.096[5]	4.008	9.482
Heavy distillate	2.210[6]	603.400[6]	140[6]
Heavy fuel oil	2.210[6]	603.400[6]	140[6]
Bio ethanol	**0.004**[2]	20[3]	0.422[14]
Bio diesel	**0.089**[2]	986.34[2]	456.02[2]
Natural gas (1000 Sm^3) .	0.009[8]	NE	NE
LPG	0.009[8]	NE	NE
Refinery gas	0.010	NE	NE
CO gas	0.010	NE	NE
Fuel gas	0.010	NE	NE
Landfill gas	0.010	NE	NE
Biogas	0.010[8]	4.518	NE
Fuel wood	0.653[9]	15.641[9]	84
Wood waste	0.294	47.040	84
Black liquor	NE	19.395	2.381
Wood pellets	0.406[10]	7.829	84
Municipal waste	0.0005	0.032[11]	45.150[12]
Special waste	1.008[1]	0.195[11]	225.750[12]

[1] Industrial combustion. [2] Private cars in 2022. [3] 1997-. [4] Helicopter, LTO. (Cruise=0.001.) [5] Households.

[6] Ships. [7] Services. [8] Stationary combustion. [9] New stoves. [10] Households: 0.037. [11] 2006-.
[12] 2005-. [13] Jet/turboprop, LTO. (Cruise= 0.088). Helicopter (LTO/cruise) = 0.005/0.001. [14] 2011-

Appendix C

Uncertainty analysis

The uncertainty estimates for long-range transboundary air pollutants are taken from Rypdal and Zhang (2001). The uncertainty assessment was updated both with respect to methodology and activity data in 2022 for the main pollutants SO_2, NO_X, NMVOC, NH_3 and for particle $PM_{2.5}$. In 2023, emissions from PM10 and CO were included in the analysis.

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 fertilizer	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 - Fertilizer 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, fertilizer	± 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 and 2022

1990	μ Tonnes	Relative standard deviation (σ/μ)	Uncertainty 2σ (% of mean)	Uncertainty 2σ (ktonnes)
SO_2	49.5	0.03	5.6	2.7
NO_x,	196.6	0.04	8.4	16.5
NMVOC	319.0	0.07	13.5	43.0
NH_3	31.2	0.09	18.7	5.8
$PM_{2.5}$	43.9	0.34	67.2	29.5
PM_{10}	67.4	0.25	50.5	34.0
CO	792.2	0.17	34.9	276.6

2022	μ Tonnes	Relative standard deviation (σ/μ)	Uncertainty 2σ (% of mean)	Uncertainty 2σ (ktonnes)
SO_2	14.3	0.07	13.0	1.9
NO_x,	132.5	0.05	10.1	13.4
NMVOC	143.3	0.08	15.1	21.6
NH_3	29.5	0.09	18.1	5.3
$PM_{2.5}$	27.1	0.32	63.3	17.2
PM_{10}	43.9	0.25	49.1	21.6
CO	417.5	0.21	42.7	178.1

Table C5. Uncertainties in emission trends 1990-2022

1990-2021	Absolute change (μ2020-μ1990)	% change ((μ2020-μ1990)*100/μ1990)	Relative standard deviation (σ/(μ2020-μ1990))	Uncertainty 2σ (% point of change)
SO_2	-35.1	-71.03	-0.03	3.80
NO_x,	-64.0	-32.56	-0.10	6.25
NMVOC	-175.8	-55.09	-0.07	8.17
NH_3	-1.7	-5.60	-1.09	12.23
$PM_{2.5}$	-16.7	-38.16	-0.33	25.21
PM_{10}	-23.5	-34.84	-0.27	18.86
CO	-374.6	-47.29	-0.35	32.75

Table C6: Uncertainty estimates for different sources and main pollutants NOx, NMVOC, SOx, NH3, CO and particles PM2.5 and PM10.

NFR code	Emission source	Combined uncertainty as % of total national emissions in year 2022*						
		NOx	NMVOC	SOx	NH3	$PM_{2.5}$	PM_{10}	CO
1A1a	Public electricity and heat production	36.6	50.9	100.6	10.6	100.6	100.6	100.6
1A1b	Petroleum refining	20.0	28.9	1.5	1.1	150.0	150.0	70.0
1A1c	Manufacture of solid fuels and other energy industries	20.0	47.8	1.0	0.2	100.0	100.0	100.0
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	19.3	40.3	11.0	4.6	70.1	70.1	70.1
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals	10.2	40.1	3.3	3.1	70.1	70.1	70.1
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals	15.2	70.8	70.8	10.9	100.6	100.6	107.6
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print	27.8	46.8	24.3	24.3	102.9	102.9	351.8
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco	70.1	70.1	70.1	3.7	100.1	100.1	351.0
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	11.3	55.7	24.5	24.5	102.9	102.9	109.8
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)	57.1	100.0	2.8	100.0	100.0	100.0	100.0
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)	26.4	55.7	24.5	24.5	102.9	102.9	109.8
1A3ai(i)	International aviation LTO (civil)	22.4	22.4	20.0	20.0	92.2	22.4	22.4
1A3aii(i)	Domestic aviation LTO (civil)	22.4	22.4	20.0	20.0	92.2	22.4	22.4
1A3bi	Road transport: Passenger cars	15.8	18.7	5.1	50.2	13.9	13.9	30.4
1A3bii	Road transport: Light duty vehicles	15.8	18.7	5.1	50.2	13.9	13.9	30.4
1A3biii	Road transport: Heavy duty vehicles and buses	15.8	18.7	5.1	50.2	13.9	13.9	30.4
1A3biv	Road transport: Mopeds & motorcycles	15.8	18.7	5.1	57.2	13.9	13.9	30.4
1A3bv	Road transport: Gasoline evaporation	5.0	40.3	5.0	5.0	5.0	5.0	5.0
1A3bvi	Road transport: Automobile tyre and brake wear	5.0	5.0	5.0	5.0	68.2	68.2	5.0
1A3bvii	Road transport: Automobile road abrasion	5.0	5.0	5.0	5.0	68.2	68.2	5.0
1A3c	Railways	40.3	40.3	5.1	86.1	180.1	200.1	89.1
1A3di(ii)	International inland waterways	25.0	-	-	20.0	20.0	20.0	20.0
1A3dii	National navigation (shipping)	25.0	53.9	32.0	20.0	102.0	102.0	53.9
1A3ei	Pipeline transport	0.0	0.0	-	-	0.0	0.0	0.0
1A3eii	Other (please specify in the IIR)	0.0	0.0	-	-	0.0	0.0	0.0
1A4ai	Commercial/institutional: Stationary	51.6	51.6	13.8	12.8	100.8	100.8	351.2
1A4aii	Commercial/institutional: Mobile	44.7	44.7	20.0	102.0	102.0	102.0	53.9
1A4bi	Residential: Stationary	77.9	77.9	77.9	77.9	104.3	104.3	128.5
1A4bii	Residential: Household and gardening (mobile)	41.1	41.1	9.5	72.6	100.4	100.4	41.1

1A4ci	Agriculture/Forestry/Fishing: Stationary	48.7	48.7	27.7	27.7	169.3	192.0	111.5
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	41.2	41.2	10.0	100.5	100.5	190.3	108.5
1A4ciii	Agriculture/Forestry/Fishing: National fishing	48.7	48.7	27.7	27.7	103.8	103.8	103.8
1A5a	Other stationary (including military)	30.4	50.2	5.1	5.0	167.1	100.1	50.2
1A5b	Other, Mobile (including military, land based and recreational boats)	30.4	50.2	5.1	5.0	167.1	100.1	50.2
1B1a	Fugitive emission from solid fuels: Coal mining and handling	3.0	107.0	3.0	3.0	700.0	700.0	3.0
1B1b	Fugitive emission from solid fuels: Solid fuel transformation	3.0	3.0	3.0	3.0	3.0	3.0	3.0
1B1c	Other fugitive emissions from solid fuels	0.0	0.0	-	-	0.0	0.0	0.0
1B2ai	Fugitive emissions oil: Exploration, production, transport	3.0	30.1	3.0	3.0	3.0	3.0	3.0
1B2aiv	Fugitive emissions oil: Refining / storage	10.4	45.1	5.8	3.0	100.0	100.0	3.0
1B2av	Distribution of oil products	5.0	40.3	5.0	5.0	5.0	5.0	5.0
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	3.0	30.1	3.0	3.0	3.0	3.0	3.0
1B2c	Venting and flaring (oil, gas, combined oil and gas)	38.1	52.6	29.8	29.7	171.6	171.6	58.2
1B2d	Other fugitive emissions from energy production	0.0	0.0	-	214.0	0.0	0.0	0.0
2A1	Cement production	12.0	0.4	12.0	0.4	75.0	75.0	0.4
2A2	Lime production	0.4	0.4	0.4	0.4	133.0	133.0	0.4
2A3	Glass production	12.0	14.1	14.1	232.0	101.0	101.0	14.1
2A5a	Quarrying and mining of minerals other than coal	20.0	20.0	20.0	20.0	102.0	102.0	20.0
2A5b	Construction and demolition	20.0	20.0	20.0	20.0	175.1	175.1	20.0
2A5c	Storage, handling and transport of mineral products	0.0	0.0	-	-	0.0	0.0	0.0
2A6	Other mineral products (please specify in the IIR)	0.1	0.1	12.0	214.0	200.0	200.0	0.1
2B1	Ammonia production	0.0	0.0	-	-	0.0	0.0	167.0
2B2	Nitric acid production	75.0	3.0	3.0	10.4	100.0	3.0	3.0
2B3	Adipic acid production	0.0	-	-	-	0.0	0.0	0.0
2B5	Carbide production	3.0	50.0	3.2	3.0	75.1	75.1	224.0
2B6	Titanium dioxide production	10.0	3.0	5.8	3.0	200.0	200.0	93.0
2B7	Soda ash production	0.0	-	-	-	0.0	0.0	0.0
2B10a	Chemical industry: Other (please specify in the IIR)	39.4	94.0	50.8	100.4	200.2	200.2	75.5
2B10b	Storage, handling and transport of chemical products (please specify in the IIR)	0.0	0.0	-	-	0.0	0.0	0.0
2C1	Iron and steel production	1.2	1.2	1.2	1.2	179.0	179.0	1.2
2C2	Ferroalloys production	20.0	72.0	3.6	3.0	500.0	500.0	3.0
2C3	Aluminium production	100.0	3.0	5.8	3.0	200.0	200.0	63.1
2C4	Magnesium production	0.0	0.0	5.0	-	200.0	200.0	63.0
2C5	Lead production	0.0	0.0	-	-	0.0	0.0	0.0
2C6	Zinc production	5.0	5.0	5.4	5.0	242.1	242.1	5.0
2C7a	Copper production	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2C7b	Nickel production	10.0	10.0	10.2	100.5	100.5	100.5	10.0

2C7c	Other metal production (please specify in the IIR)	10.0	10.0	10.2	10.0	397.1	397.1	10.0
2C7d	Storage, handling and transport of metal products	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2D3a	Domestic solvent use including fungicides	0.0	30.0	-	-	-	-	-
2D3b	Road paving with asphalt	5.0	30.4	5.0	5.0	250.0	250.0	5.0
2D3c	Asphalt roofing	0.0	-	-	-	-	-	-
2D3d	Coating applications	0.0	30.0	-	-	-	-	-
2D3e	Degreasing	0.0	57.0	-	-	-	-	-
2D3f	Dry cleaning	0.0	-	-	-	-	-	-
2D3g	Chemical products	0.0	30.0	-	147.0	-	-	-
2D3h	Printing	0.0	30.0	-	-	-	-	-
2D3i	Other solvent use (please specify in the IIR)	0.0	30.0	-	-	-	-	-
2G	Other product use (please specify in the IIR)	100.0	100.0	75.0	53.0	87.0	87.0	52.0
2H1	Pulp and paper industry	100.0	100.0	100.0	0.9	150.0	150.0	0.9
2H2	Food and beverages industry	10.0	156.3	10.0	10.0	10.0	10.0	10.0
2H3	Other industrial processes (please specify in the IIR)	5.0	5.0	7.1	5.0	150.1	150.1	5.0
2I	Wood processing	5.0	-	6.4	5.0	5.0	5.0	5.0
2J	Production of POPs	0.0	0.0	-	-	-	-	-
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	0.0	0.0	-	-	-	-	-
2L	Other production, consumption, storage, transportation or handling of bulk products (please specify in the IIR)	0.0	0.0	-	-	-	-	-
3B1a	Manure management - Dairy cattle	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3B1b	Manure management - Non-dairy cattle	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3B2	Manure management - Sheep	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3B3	Manure management - Swine	100.2	100.2	7.0	26.0	250.1	250.1	7.0
3B4a	Manure management - Buffalo	0.0	0.0	-	-	250.0	250.0	-
3B4d	Manure management - Goats	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3B4e	Manure management - Horses	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3B4f	Manure management - Mules and asses	0.0	0.0	-	-	250.0	250.0	0.0
3B4gi	Manure mangement - Laying hens	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3B4gii	Manure mangement - Broilers	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3B4giii	Manure mangement - Turkeys	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3B4giv	Manure management - Other poultry	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3B4h	Manure management - Other animals (please specify in IIR)	100.1	100.1	5.0	25.5	250.0	250.0	5.0
3Da1	Inorganic N-fertilizers (includes also urea application)	180.1	5.0	5.0	20.6	5.0	5.0	5.0
3Da2a	Animal manure applied to soils	101.8	101.8	19.0	35.5	19.0	19.0	19.0
3Da2b	Sewage sludge applied to soils	131.4	19.0	19.0	35.5	19.0	19.0	19.0
3Da2c	Other organic fertilisers applied to soils (including compost)	131.4	19.0	19.0	35.5	19.0	19.0	19.0
3Da3	Urine and dung deposited by grazing animals	102.4	102.4	22.0	137.8	22.0	22.0	22.0
3Da4	Crop residues applied to soils	30.0	30.0	30.0	30.0	30.0	30.0	30.0
3Db	Indirect emissions from managed soils	50.4	50.4	50.4	50.4	50.4	50.4	50.4

3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	2.0	2.0	2.0	2.0	250.0	250.0	2.0
3Dd	Off-farm storage, handling and transport of bulk agricultural products	0.0	0.0	-	-	-	-	-
3De	Cultivated crops	2.0	200.0	2.0	5.4	2.0	2.0	2.0
3Df	Use of pesticides	0.0	0.0	0.0	-	0.0	0.0	0.0
3F	Field burning of agricultural residues	63.8	80.6	70.7	75.7	62.8	62.8	71.7
3I	Agriculture other (please specify in the IIR)	2.0	2.0	2.0	100.0	2.0	2.0	2.0
5A	Biological treatment of waste - Solid waste disposal on land	20.0	22.4	20.0	20.0	242.8	242.8	20.0
5B1	Biological treatment of waste - Composting	20.0	20.0	20.0	78.6	20.0	20.0	91.2
5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities	20.0	20.0	20.0	20.0	20.0	20.0	20.0
5C1a	Municipal waste incineration	117.0	113.1	67.1	306.5	58.3	58.3	310.5
5C1bi	Industrial waste incineration	30.0	30.0	30.0	30.0	153.0	153.0	500.9
5C1bii	Hazardous waste incineration	0.0	0.0	-	-	-	-	-
5C1biii	Clinical waste incineration	61.4	102.0	61.4	20.0	500.4	500.4	526.4
5C1biv	Sewage sludge incineration	19.0	19.0	19.0	19.0	19.0	19.0	19.0
5C1bv	Cremation	20.1	20.1	20.1	2.0	500.0	500.0	500.0
5C1bvi	Other waste incineration (please specify in the IIR)	0.0	0.0	-	-	-	-	-
5C2	Open burning of waste	51.0	50.0	50.2	50.0	50.0	50.0	50.0
5D1	Domestic wastewater handling	30.0	169.7	30.0	104.4	30.0	30.0	30.0
5D2	Industrial wastewater handling	100.0	194.7	100.0	100.0	100.0	100.0	100.0
5D3	Other wastewater handling	0.0	0.0	-	-	-	-	-
5E	Other waste (please specify in IIR)	153.0	169.7	104.4	153.0	104.4	104.4	104.4

* Where uncertainty is marked as “- “ no emissions are occurring and this source has no corresponding uncertainty.

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.

Table D1. Economic sectors in the Norwegian emission model.

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
0240	02.4	Services related to forestry
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
1922	19.2 part	Manufacture of refined petroleum products

Sector number	SIC code	Sector name
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
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
1070	10.7	Manufacture of bakery and farinaceous products
1080	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 fertilizers and nitrogen compounds
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

Sector number	SIC code	Sector name
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
3700	37	Collection and treatment of wastewater
3800	37-39	Sewerage, waste collection, treatment and disposal activities; materials recovery
3900	39	Remediation activities and other waste management services
Construction		
20	41.2, 42, 43	Construction
Wholesale and retail trade		
4500	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
4600	46	Wholesale trade, except of motor vehicles and motorcycles
4700	47	Retail trade, except of motor vehicles and motorcycles
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
4950	49.5	Transport via pipeline
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
5210	52.1	Warehousing and storage
5222	52 except 52.215, 79	Supporting and auxiliary transport activities

Sector number	SIC code	Sector name
5300	53, 61	Post and telecommunications
Accommodation and food service activities		
5500	55	Accommodation
5600	56	Food and beverage service activities
Business services		
5800	58	Publishing activities
5900	59	Motion picture, video and television programme production, sound recording and music publishing activities
6000	60	Programming and broadcasting activities
6100	61	Telecommunications
6200	62, 95	Information technology services
6490.2N	64.9	Other financial service activities, except insurance and pension funding, international
6490	64.9	Other financial service activities, except insurance and pension funding
6510	65.1	Insurance
6530	65.3	Pension funding
6600	64, 65, 66	Financial and insurance activities
6810	41.1, 68.1	Buying and selling of own real estate
6810.2N	68.1	Buying and selling of own real estate, international
6820	68.2	Renting and operating of own or leased real estate
7100	69-71, 73-74, 78, 80-82	Other business activities
7100-2N	71	
7200	72	Research and development
7700	77	Rental and leasing activities
8500	85	Education
8500.2N	85	Education, international
8600	75, 86-88	Health and social work
8700	87	Residential care activities
9000	90	Creative, arts, and entertainment activities
9300	59-60, 90-93	Recreational, cultural and sporting activities
9400	94, 99	Activities of membership organisations
9400.2N	94	Activities of membership organisations, international
9500	95	Repar of computers and personal household goods
9600	96	Other service activities
9700	97	Activities of households as employers of domestic personnel
Central government		
7200	72	Research and development
8410	84.1, 84.21, 84.23, 84.24, 84.25, 84.3	Public administration
8410.2N	84.1	Public administration, international
8422	84.22	Defence
8422.2N	84.22	Defence, international
8500	85	Education
8600	75, 86-88	Health and social work
8700	87	Residential care activities
8891	88.91	Child day-care activities
9300	59-60, 90-93	Other service activities

Sector number	SIC code	Sector name
Local government		
253700	37	Sewerage
3800	38	Waste collection, treatment and disposal activities; materials recovery
6000	59-60, 90-93	Other service activities
8500	85	Education
8600	75, 86-88	Health and social work
9600	96	Other personal service activities
Private households		
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

Source classifications used in the Norwegian emission inventory

Source classifications used in the official statistics on emissions to air published by Statistics Norway is given at the webpage: http://www.ssb.no/en/klass/klassifikasjoner/113

In the reported inventory EMEP/NFR14 source sector categories are used.

Table E1. EMEP/NFR14 source sector categories

1A1a	Public electricity and heat production
1A1b	Petroleum refining
1A1c	Manufacture of solid fuels and other energy industries
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel
1A2b	Stationary combustion in manufacturing industries and construction: Non-ferrous metals
1A2c	Stationary combustion in manufacturing industries and construction: Chemicals
1A2d	Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print
1A2e	Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals
1A2gvii	Mobile Combustion in manufacturing industries and construction: (please specify in the IIR)
1A2gviii	Stationary combustion in manufacturing industries and construction: Other (please specify in the IIR)
1A3ai(i)	International aviation LTO (civil)
1A3aii(i)	Domestic aviation LTO (civil)
1A3bi	Road transport: Passenger cars
1A3bii	Road transport: Light duty vehicles
1A3biii	Road transport: Heavy duty vehicles and buses
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

1A3di(ii)	International inland waterways
1A3dii	National navigation (shipping)
1A3ei	Pipeline transport
1A3eii	Other (please specify in the IIR)
1A4ai	Commercial/institutional: Stationary
1A4aii	Commercial/institutional: Mobile
1A4bi	Residential: Stationary
1A4bii	Residential: Household and gardening (mobile)
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)
1A5b	Other, Mobile (including military, land based and recreational boats)
1B1a	Fugitive emission from solid fuels: Coal mining and handling
1B1b	Fugitive emission from solid fuels: Solid fuel transformation
1B1c	Other fugitive emissions from solid fuels
1B2ai	Fugitive emissions oil: Exploration, production, transport
1B2aiv	Fugitive emissions oil: Refining / storage
1B2av	Distribution of oil products
1B2b	Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)
1B2c	Venting and flaring (oil, gas, combined oil and gas)
1B2d	Other fugitive emissions from energy production
2A1	Cement production
2A2	Lime production
2A3	Glass production
2A5a	Quarrying and mining of minerals other than coal
2A5b	Construction and demolition
2A5c	Storage, handling and transport of mineral products
2A6	Other mineral products (please specify in the IIR)
2B1	Ammonia production
2B2	Nitric acid production
2B3	Adipic acid production
2B5	Carbide production
2B6	Titanium dioxide production
2B7	Soda ash production
2B10a	Chemical industry: Other (please specify in the IIR)
2B10b	Storage, handling and transport of chemical products (please specify in the IIR)
2C1	Iron and steel production
2C2	Ferroalloys production

2C3	Aluminium production
2C4	Magnesium production
2C5	Lead production
2C6	Zinc production
2C7a	Copper production
2C7b	Nickel production
2C7c	Other metal production (please specify in the IIR)
2C7d	Storage, handling and transport of metal products (please specify in the IIR)
2D3a	Domestic solvent use including fungicides
2D3b	Road paving with asphalt
2D3c	Asphalt roofing
2D3d	Coating applications
2D3e	Degreasing
2D3f	Dry cleaning
2D3g	Chemical products
2D3h	Printing
2D3i	Other solvent use (please specify in the IIR)
2G	Other product use (please specify in the IIR)
2H1	Pulp and paper industry
2H2	Food and beverages industry
2H3	Other industrial processes (please specify in the IIR)
2I	Wood processing
2J	Production of POPs
2K	Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)
2L	Other production, consumption, storage, transportation or handling of bulk products (please specify in the IIR)
3B1a	Manure management - Dairy cattle
3B1b	Manure management - Non-dairy cattle
3B2	Manure management - Sheep
3B3	Manure management - Swine
3B4a	Manure management - Buffalo
3B4d	Manure management - Goats
3B4e	Manure management - Horses
3B4f	Manure management - Mules and asses
3B4gi	Manure mangement - Laying hens
3B4gii	Manure mangement - Broilers
3B4giii	Manure mangement - Turkeys
3B4giv	Manure management - Other poultry

3B4h	Manure management - Other animals (please specify in IIR)
3Da1	Inorganic N-fertilizers (includes also urea application)
3Da2a	Animal manure applied to soils
3Da2b	Sewage sludge applied to soils
3Da2c	Other organic fertilizers applied to soils (including compost)
3Da3	Urine and dung deposited by grazing animals
3Da4	Crop residues applied to soils
3Db	Indirect emissions from managed soils
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products
3Dd	Off-farm storage, handling and transport of bulk agricultural products
3De	Cultivated crops
3Df	Use of pesticides
3F	Field burning of agricultural residues
3I	Agriculture other (please specify in the IIR)
5A	Biological treatment of waste - Solid waste disposal on land
5B1	Biological treatment of waste - Composting
5B2	Biological treatment of waste - Anaerobic digestion at biogas facilities
5C1a	Municipal waste incineration
5C1bi	Industrial waste incineration
5C1bii	Hazardous waste incineration
5C1biii	Clinical waste incineration
5C1biv	Sewage sludge incineration
5C1bv	Cremation
5C1bvi	Other waste incineration (please specify in the IIR)
5C2	Open burning of waste
5D1	Domestic wastewater handling
5D2	Industrial wastewater handling
5D3	Other wastewater handling
5E	Other waste (please specify in IIR)

Activity data used in the Norwegian inventory

Table F1. Activity data used for Mineral Products (2A)

	2A1-Cement production	2A2-Lime production	2A5b-Construction and demolition	2A6-Other mineral products
	Clinker produced (kt)	Lime produced (kt)	floor space constructed/ demolished (M^3)	sand and crushed stone produced (kt)
1990	1 244.07	62.04	644.25	59000
1991	1 147.47	58.74	496.85	47000
1992	1 260.22	59.82	414.77	53000
1993	1 605.9	64.77	465.59	49000
1994	1 621.42	70.41	489.53	51000
1995	1 682.94	86.76	538.51	51000
1996	1 655.39	102.43	570.94	52000
1997	1 775.88	100.96	581.35	61000
1998	1 675.49	107.84	670.52	63000
1999	1 663.64	79.96	674.92	62000
2000	1 649.6	84.56	655.79	53000
2001	1 592.68	77.98	683.72	51000
2002	1 634.36	85.95	678.65	50000
2003	1 681.09	115.80	629.39	51000
2004	1 323.96	114.71	643.29	52000
2005	1 454.26	102.62	754.60	53000
2006	1 507.19	113.40	692.39	58700
2007	1 636.82	122.77	827.49	68200
2008	1 533.99	189.01	832.02	69030
2009	1 528.3	188.79	722.08	64500
2010	1 433.78	315.22	648.37	67000
2011	1 415.45	294.37	679.23	78500
2012	1 399.08	289.00	820.32	82000
2013	1 399.81	293.51	805.32	80920
2014	1 374.87	295.31	826.59	78940
2015	1 284.1	286.06	835.08	81710
2016	1 306.29	293.36	897.95	85000
2017	1 461.48	282.09	904.67	90540
2018	1 429.44	269.18	886.64	93780
2019	1 406.88	265.39	890.31	98300
2020	1 407.07	251.65	865.53	92100
2021	1 360.84	272.54	802.5474	90600
2022	1390.72	332.34	802.55	87800

Table F2. Activity data used for Chemical Industry (2B)

	2B1-Ammonia production	2B2-Nitric acid production	2B5-Carbide production
	Ammonia produced (kt)	Nitric acid produced (kt)	Carbide produced (kt)
1990	393.31	1 326.32	197.41
1991	374.14	1 346.80	172.49
1992	330.88	1 143.16	180.58
1993	385.58	1 373.54	164.22
1994	405.49	1 422.18	157.34
1995	433.62	1 493.81	164.82
1996	415.36	1 478.92	157.24
1997	372.13	1 449.02	152.89
1998	242.07	1 507.32	160.35
1999	148.23	1 481.67	142.91
2000	406.29	1 503.92	140.61
2001	393.13	1 533.66	147.78
2002	407.02	1 546.28	99.09
2003	429.81	1 593.82	36.49
2004	510.26	1 598.82	38.39
2005	366.04	1 589.06	34.96
2006	413.06	1 626.74	26.41
2007	334.70	1 619.88	27.24
2008	394.90	1 565.21	28.88
2009	361.07	1 151.35	18.88
2010	378.51	1 649.98	27.22
2011	352.71	1 660.69	25.33
2012	378.26	1 707.14	15.84
2013	350.63	1 638.95	16.92
2014	333.18	1 669.51	17.87
2015	465.08	1 729.65	17.60
2016	373.77	1 669.20	18.68
2017	244.49	1 733.65	21.20
2018	414.14	1 980.58	21.70
2019	405.18	1 916.47	18.45
2020	401.74	1 951.33	16.48
2021	347.84	2 022.15	16.35
2022	464.69	2028.77	14.24

Table F3. Activity data used for Metal Production (2C)

	2C1-Iron and steel production	2C2-Ferroalloys production	2C3-Aluminium production	2C4-Magnesium production	2C6-Zinc production	2C7b-Nickel production
	Steel produced (kt)	Use of reducing agents (kt)	Aluminium produced (kt)	Magnesium produced (kt)	Zinc produced (kt)	Nickel produced (kt)
1990	289.83	834.02	869.65	48.22	136.75	76.00
1991	372.64	699.51	882.70	44.62	136.75	78.93
1992	455.45	761.27	861.93	32.73	136.75	82.71
1993	506.40	826.98	882.82	27.18	136.75	84.81
1994	454.49	935.77	854.35	29.42	136.75	69.96
1995	505.39	984.98	842.11	31.66	130.74	53.24
1996	500.01	996.00	848.63	37.67	134.36	61.58
1997	566.90	1 010.88	913.79	43.30	142.25	62.71
1998	643.82	1 045.63	990.38	43.35	137.92	70.15
1999	606.55	1 042.57	1 003.55	50.61	143.98	74.14
2000	679.28	1 073.56	1 026.09	49.49	138.39	58.63
2001	629.58	961.85	1 033.16	48.33	144.62	68.22
2002	679.61	829.83	1 072.81	15.30	171.79	83.53
2003	685.99	844.39	1 182.38	19.00	143.63	77.18
2004	710.00	1 012.87	1 317.69	30.06	140.74	71.40
2005	686.94	933.89	1 389.03	23.31	151.39	84.80
2006	669.92	745.97	1 382.55	8.70	160.67	81.97
2007	694.34	831.65	1 363.50	NO	157.28	87.59
2008	546.53	886.61	1 369.54	NO	145.47	88.74
2009	546.06	566.78	1 119.27	NO	139.62	88.60
2010	516.91	858.63	1 101.71	NO	148.89	92.19
2011	598.36	918.88	1 119.51	NO	153.2	92.43
2012	682.13	917.62	1 140.40	NO	152.65	91.69
2013	585.37	1 001.22	1 165.10	NO	143.44	91.02
2014	585.52	1 105.31	1 172.56	NO	165.6	90.53
2015	579.65	1 066.11	1 216.51	NO	162.91	91.22
2016	607.95	1 110.50	1 243.16	NO	170.60	92.74
2017	603.54	1 140.37	1 249.72	NO	172.09	86.50
2018	572.44	1 101.58	1 295.97	NO	190.57	90.76
2019	618.71	1 071.37	1 307.92	NO	195.37	92.13
2020	620.70	1 120.98	1 328.03	NO	143.39	91.12
2021	621.06	1 182.24	1418.74	NO	180.3	91.25
2022	703.63	1190.37	1412.44	NO	181.10	81.90

Table F4. Activity data used for Solvents and Product Use (2D)

	2D3a- Domestic solvent use including fungicides	2D3b- Road paving with asphalt	2D3d- Coating applications	2D3e- Degreasing	2D3f-Dry cleaning	2D3h- Printing	2D3i- Other solvent use
	Population (1990-2004) Solvents used (kt) (2005-)	Asphalt Production (kt)	Solvents used (kt)	Solvents used (kt)	Solvents used (kt)	Solvents used (kt)	Solvents used (kt)
1990	4 233 116.00	246.90	19.14	2.85	2.74	1.39	1 437.96
1991	4 249830.00	246.90	16.20	2.41	2.32	1.39	2 088.17
1992	4 273 634.00	246.90	16.10	1.95	1.88	1.39	2 127.17
1993	4 299 167.00	246.90	16.08	0.37	0.36	1.39	3 926.93
1994	4 324 815.00	246.90	18.56	0.29	0.28	1.39	3 453.77
1995	4 348 410.00	246.90	14.06	0.21	0.21	1.39	4 317.47
1996	4 369 957.00	245.75	14.65	0.36	0.34	1.39	3 942.32
1997	4 392 714.00	258.40	14.42	0.32	0.31	1.29	3 319.31
1998	4 417 599.00	228.10	12.06	0.39	0.37	1.36	3 280.82
1999	4 445 329.00	238.45	13.76	0.38	0.37	1.36	3 165.36
2000	4 478 497.00	225.25	12.63	0.42	0.41	1.28	2 853.34
2001	4 503 436.00	203.00	13.46	0.49	0.41	1.22	2 341.17
2002	4 524 066.00	195.35	14.30	0.57	0.42	1.19	1 858.77
2003	4 552 252.00	205.90	15.14	0.65	0.42	1.23	1 373.30
2004	4 577 457.00	226.70	15.98	0.72	0.43	1.25	965.82
2005	14.49	255.20	14.90	1.77	0.40	1.32	382.22
2006	9.33	255.35	12.15	1.17	1.10	0.81	228.63
2007	8.41	293.40	10.95	0.96	0.25	1.00	240.72
2008	7.63	285.40	9.71	0.91	0.16	0.82	244.89
2009	10.68	328.05	11.21	0.65	0.12	0.60	171.70
2010	9.65	292.50	13.85	0.69	0.12	0.67	161.74
2011	9.74	336.75	62.63	0.73	0.12	0.44	175.67
2012	13.86	315.20	10.49	1.17	0.13	0.27	187.65
2013	13.82	340.45	10.66	1.00	0.14	0.24	178.72
2014	13.41	378.20	10.82	1.21	0.22	0.20	183.34
2015	17.28	344.15	11.65	1.05	0.15	0.32	188.24
2016	22.79	360.05	8.50	1.23	0.15	0.21	200.00
2017	20.56	390.20	8.93	2.69	0.17	0.19	156.20
2018	17.41	376.70	8.09	0.78	0.17	0.08	210.50
2019	15.00	383.25	8.30	0.97	0.46	0.08	162.02
2020	18.38	343.15	9.78	1.20	0.16	0.07	169.92
2021	16.01	348.00	15.81	1.20	0.19	0.06	189.76
2022	21.02	317.50	9.77	1.09	0.22	0.07	308.74

Table F5. Activity data used for Other Production (2H)

	2H1-Pulp and paper industry	2H2-Food and beverages industry	
	Consumption of limestone (kt)	Bread production (kt)	Beer (1000 liter)
1990	23.83	340.00	227 639
1991	24.61	293.70	230 412
1992	24.50	297.67	227 318
1993	23.73	290.06	222 876
1994	25.94	290.06	222 837
1995	24.07	242.92	225 523
1996	24.43	282.52	232 919
1997	24.77	272.90	239 600
1998	21.48	297.84	183 333
1999	21.72	289.31	265 111
2000	23.10	266.45	215 011
2001	20.27	207.84	246 171
2002	20.92	292.25	237 745
2003	22.53	302.46	217 676
2004	25.50	324.84	235 226
2005	29.37	370.24	244 176
2006	32.50	353.90	241 022
2007	22.83	335.11	175 519
2008	28.95	282.92	261 186
2009	20.46	309.78	267 447
2010	23.34	474.30	240 564
2011	20.97	531.27	268 734
2012	21.93	361.54	230 745
2013	22.41	457.11	237 580
2014	19.32	266.56	239 641
2015	20.01	268.08	236 181
2016	21.93	301.17	253 480
2017	19.07	288.32	248 189
2018	18.99	301.17	138 735
2019	19.41	289.99	225 967
2020	20.40	248.74	290 840
2021	20.55	283.41	245 105
2022	19.66	332.03	239 234

Table F6. Activity data used for Other Product use and Production (2G, 2H, 2I)

	2-Other product use		2I-Wood processing
	fireworks (t)	tobacco (t)	Wood product (kt)
1990	557	5 664	116.02
1991	570	6 183	116.02
1992	581	6 183	116.02
1993	618	5 550	121.70
1994	535	5 608	130.84
1995	936	3 475	128.09
1996	885	4 473	134.13
1997	1 090	5 463	135.64
1998	1 492	5 828	157.64
1999	2 550	4 189	174.66
2000	2 213	4 534	181.00
2001	1 860	5 123	170.63
2002	2 280	5 093	156.06
2003	2 664	5 161	181.14
2004	2 472	5 692	203.12
2005	2 539	2 847	203.12
2006	2 071	3 835	207.69
2007	3 007	3 926	207.69
2008	2 609	4 008	165.06
2009	1 747	4 059	128.79
2010	2 990	3 816	162.56
2011	2 529	3 314	163.74
2012	2 493	2 905	151.56
2013	2 497	2 711	139.00
2014	2 778	2 899	155.67
2015	2 740	2 870	159.55
2016	2 200	2 635	147.59
2017	2 235	2 595	161.20
2018	2 235	2 323	172.14
2019	2 485	2 068	150.91
2020	1 381	2 693	178.92
2021	1 777	2583	194.04
2022	2 933	1962	173.66

Table F7. Animal population data used in the estimations (3. Agriculture). Animal numbers. 1990, 1995, 2000, 2005, 2010, 2013-2022.

	1990	**1995**	**2000**	**2005**	**2010**
Mature dairy cattle	325 896	310 346	284 880	255 663	232 294
Beef cow (other mature cattle)	8 193	20 334	42 324	54 841	67 110
Replacement heifer	143 904	138 359	129 500	118 090	111 122
Heifers for slaughter	29 011	27 708	38 710	32 843	29 966
Bulls for slaughter	185 719	179 929	198 396	175 579	160 568
Sheep <1 year (adj. for lifetime)	622 862	683 599	643 141	685 466	659 895
Sheep >1 år	714 384	783 922	766 098	717 098	691 450
Piglets	131 096	139 572	152 387	167 393	190 235
Young pigs for breeding	3 318	5 756	8 976	9 691	10 829
Sows	62 271	62 861	62 936	64 309	69 843
Boars	2 046	1 727	1 453	1 299	1 096
Fattening pigs	1 059 589	1 153 285	1 280 884	1 404 856	1 565 736
Deer	0	0	2 280	4 173	7 249
Dairy goats	64 041	58 630	50 578	44 374	35 706
Other goats	19 759	20 082	19 131	18 163	20 793
Horses	31 430	38 013	51 156	61 784	76 752
Laying hens	2 895 663	3 556 841	3 228 812	3 343 410	3 945 607
Chickens reared for laying	3 459 064	2 984 493	2 184 479	3 066 358	2 777 268
Broilers	15 864 401	23 318 120	35 757 612	43 612 212	61 245 745
Turkeys for slaughter	528 240	776 428	673 282	953 112	1 141 867
Ducks and geese for slaughter	18 551	27 267	81 365	69 368	153 831
Turkeys, ducks and geese reared for laying	15 506	29 930	20 292	45 378	36 901
Reindeer	242 443	212 333	172 407	234 608	254 384
Mink	56 411	44 199	68 526	98 247	107 980
Foxes	104 126	122 146	86 160	76 756	49 213

	2013	2014	2015	2016	2017
Mature dairy cattle	225 163	222 553	222 276	220 461	215 849
Beef cow (other mature cattle)	71 834	73 894	77 408	84 372	88 332
Replacement heifer	109 643	109 813	111 391	113 462	114 771
Heifers for slaughter	27 260	37 538	34 933	34 482	24 171
Bulls for slaughter	160 419	153 566	148 861	149 754	169 625
Sheep <1 year (adj. for lifetime)	642 338	676 867	706 468	757 659	746 214
Sheep >1 year	689 345	683 479	716 252	729 014	730 666
Piglets	182 708	185 346	175 256	177 265	170 140
Young pigs for breeding	11 522	11 670	10 053	11 384	10 779
Sows	67 294	67 753	63 150	63 657	60 919
Boars	1 048	953	1 058	796	799
Fattening pigs	1 540 851	1 587 993	1 537 703	1 591 311	1 589 084
Deer	7 829	7 714	7 469	7 838	7 086
Dairy goats	31 406	31 461	33 627	34 660	34 126
Other goats	21 013	21 750	21 891	22 198	21 112
Horses	79 965	78 635	78 303	77 350	76 511
Laying hens	4 216 858	4 320 632	4 359 188	4 336 730	4 365 344
Chickens reared for laying	2 938 451	2 686 575	2 738 693	2 614 453	2 631 703
Broilers	71 899 359	73 974 651	63 406 519	65 898 097	63 516 948
Turkeys for slaughter	1 174 143	1 245 554	1 260 617	1 179 466	1 037 274
Ducks and geese for slaughter	237 100	302 757	298 089	291 989	278 423
Turkeys, ducks and geese reared for laying	13 257	20 662	23 811	19 530	20 601
Reindeer	248 225	232 905	211 974	211 666	213 913
Mink	182 334	174 613	161 394	143 156	107 039
Foxes	51 916	49 143	40 734	31 828	21 124

	2018	2019	2020	2021	2022
Mature dairy cattle	211 730	199 417	195 076	196 934	189 099
Beef cow (other mature cattle)	92 304	94 001	99 748	106 082	109 517
Replacement heifer	114 249	111 134	111 819	112 613	107 606
Heifers for slaughter	30 193	27 150	29 653	31 946	29 626
Bulls for slaughter	181 684	166 523	158 300	157 299	167 569
Sheep <1 year (adj. for lifetime)	732 206	671 779	660 826	668 023	656 644
Sheep >1 year	676 937	634 028	644 880	621 374	639 278
Piglets	172 919	163 636	157 108	156 336	148 864
Young pigs for breeding	11 428	11 363	10 440	9 596	9 182
Sows	62 517	57 831	54 654	53 419	52 187
Boars	1 344	889	874	884	852
Fattening pigs	1 642 094	1 568 614	1 513 595	1 505 436	1 491 456
Deer	7 970	8 072	8 347	8 302	7 949
Dairy goats	34 583	35 019	33 960	34 443	34 167
Other goats	23 413	24 017	25 236	26 305	26 895
Horses	80 470	80 919	81 877	83 566	85 456
Laying hens	4 308 640	4 627 642	4 585 350	4 666 613	4 667 401
Chickens reared for laying	2 143 725	1 880 977	1 507 652	1 448 201	3 670 383
Broilers	62 738 774	68 409 911	67 262 533	72 350 290	72 328 966
Turkeys for slaughter	825 264	822 691	892 615	922 121	896 361
Ducks and geese for slaughter	274 298	282 672	286611	243 838	349 219
Turkeys, ducks and geese reared for laying	12 336	16 945	14 730	12 180	17 770
Reindeer	213 012	215 144	213 753	212 866	217 809
Mink	136 993	82 540	44 198	7 500	6 376
Foxes	27 554	24 918	18 056	1 626	758

Table F8. Animal population data used in the estimations (3. Agriculture). Animal places. 1990, 1995, 2000, 2005, 2010, 2013-2022.

	Replacement heifer	Heifers for slaughter	Bulls for slaughter	Fattening pigs	Chickens reared for laying	Broilers	Turkeys for slaughter	Ducks and geese for slaughter
1990	311 279	47 020	289 945	376 643	1 729 532	3 172 880	176 080	4 638
1995	299 284	47 103	284 237	355 147	1 424 417	4 352 716	269 504	6 434
2000	280 121	63 512	285 349	319 293	997 262	6 257 582	243 775	18 177
2005	255 862	57 619	263 170	350 665	1 341 532	7 183 188	360 637	14 714
2010	239 839	53 410	230 872	415 686	1 166 453	9 527 116	452 438	31 062
2013	239 386	47 294	220 440	379 345	1 224 355	11 061 440	469 657	47 420
2014	246 165	67 624	208 979	405 176	1 119 406	11 380 716	498 222	60 551
2015	240 419	64 814	206 328	403 399	1 141 122	9 754 849	504 247	59 618
2016	243 942	64 361	217 885	401 455	1 089 355	10 138 169	471 786	58 398
2017	247 715	43 501	250 630	392 141	1 096 543	9 771 838	414 910	55 685
2018	245 636	52 356	260 130	389 589	893 219	9 652 119	330 106	54 860
2019	240 049	47 230	238 845	366 489	783 740	10 524 602	329 076	56 534
2020	245 069	52 767	229 068	360 089	628 188	10 348 082	357 046	57 322
2021	247 748	56 773	229 199	365 452	603 417	11 130 814	368 848	48 768
2022	230 862	44 258	245 355	360 225	1 529 326	11 127 533	358 544	69 337

Table F9. Total value for annual consumption of synthetic fertilizers in Norway based on sale figures (Norwegian Food Safety Authority Annually).

	Total amount of fertilizer sold	Total amount for agriculture purposes
	tonne N	tonne N
1990	110418	110182
1991	110790	110398
1992	110875	110519
1993	109299	109051
1994	108287	108051
1995	110851	110631
1996	111976	111741
1997	112879	112627
1998	112327	112062
1999	106017	105756
2000	107410	107254
2001	100592	100419
2002	101258	101071
2003	104162	104075
2004	105096	105018
2005	106882	106798
2006	104088	104050
2007	107588	107506
2008	103027	102920
2009	93823	93709
2010	85131	85017
2011	96851	96778
2012	95767	95682
2013	97010	97010
2014	102238	102238
2015	104214	104214
2016	102460	102460
2017	99674	99674
2018	102392	102392
2019	106765	106765
2020	105 884	105 884
2021	107 282	107 282
2022	99 043	99 043

Table F10. Total value for annual consumption of synthetic fertilizers in Norway based on sale figures 2022 (Norwegian Food Safety Authority Annually).

Fertilizer type	Amount of fertilizer (tonnes)	Amount of Nitrogen (tonnes)	Loss (g NH_3/kg N applied)
Ammonium nitrate	12	4	15
Ammonium nitrate m/S	88 293	23 711	8
Ammonium sulphate nitrate			
Potassium sulphate	88	0	0
Potassium sulphate m/Mg	953	0	0
Potassium chloride	90	0	0
Kalkamonsalpeter	11 372	3 070	8
Calcium nitrate	7 284	1 129	10
Calcium nitrate m/B	3 550	547	10
NK-fertilizer 22-12	5 112	1 122	15
NP fertilizer 12-23	1 059	111	50
NPK-fertilizer 8-5-19	725	58	15
NPK-fertilizer 12-4-18	18 573	2 192	15
NPK-fertilizer 15-7-12	2 213	332	15
NPK-fertilizer 18-3-15	23 727	4 176	15
NPK-fertilizer 20-4-11	23 789	4 663	15
NPK-fertilizer 8-11-20	1 505	120	15
NPK-fertilizer 17-5-13	2 842	489	15
NPK-fertilizer 21-3-10	0	0	15
NPK-fertilizer 21-6-6	0	0	15
NPK-fertilizer 22-2-12	22 875	4 941	15
NPK-fertilizer 22-3-10	84 017	18 191	15
NPK-fertilizer 24-4-6	10 175	2 442	50
NPK-fertilizer 25-2-6	95 219	23 424	15
NPK-fertilizer 27-3-5	29 793	8 043	50
PK-fertilizer 0-11-21	564	0	0
P-fertilizer 0-20-0	208	0	0
Urea	238	83	155
Other fertilizer with N content	1 065	191	10
Other fertilizer	0	0	0

Table F11. N amounts of the different fertilizers, tonnes N.

Tonnes N	Inorganic fertilizer	Manure applied to fields	Sewage sludge	Other organic fertilizers	Crop residues[1]
	3Da1	3Da2a	3Da2b	3Da3	3Da4
1990	110 182	48 594	738	0	29 861
1991	110 398	49 219	938	0	28 312
1992	110 519	49 811	1 068	0	23 967
1993	109 051	47 212	1 125	0	29 182
1994	108 051	47 469	1 069	0	25 620
1995	110 631	47 370	1 176	0	26 150
1996	111 741	48 402	1 190	7	27 272
1997	112 627	47 514	1 191	7	26 027
1998	112 062	48 015	1 207	7	26 364
1999	105 756	49 437	1 345	7	23 948
2000	107 254	47 826	1 334	172	24 723
2001	100 419	48 198	1 193	175	23 532
2002	101 071	48 184	1 228	251	20 663
2003	104 075	49 949	1 393	1467	20 521
2004	105 018	50 208	1 401	1066	21 941
2005	106 798	50 977	1 484	285	19 460
2006	104 050	51 108	1 433	293	18 177
2007	107 506	51 675	1 818	363	18 059
2008	102 920	52 570	1 922	501	19 713
2009	93 709	53 676	1 849	1170	16 878
2010	85 017	54 238	1 614	1174	17 524
2011	96 778	53 261	1 801	713	15 602
2012	95 682	53 898	1 977	758	16 836
2013	97 010	55 185	2 330	611	15 546
2014	102 238	55 791	2 208	611	18 250
2015	104 214	56 037	2 000	611	19 217
2016	102 460	56 832	1 854	611	19 153
2017	99 674	56 194	1 861	611	18 466
2018	102 392	56 300	1 844	611	12 530
2019	106765	54 519	1 596	611	19 373
2020	105 884	54 266	1 939	611	19 382
2021	107 282	54 959	1 929	611	18 892
2022	99 043	53 788	1 948	611	21 150

[1] The values for crop residues are recalculated due to IPPC Guidelines 2019 refinements model for N-estimation.

Table F12. Decares of cultivated cropland and grassland.

	Cultivated cropland, decares	Cultivated cropland and grassland, decares
	3Dc	3De
1990	4 388 644	8 822 908
1991	4 344 862	8 828 277
1992	4 301 081	8 833 647
1993	4 257 299	8 839 017
1994	4 213 518	8 844 387
1995	4 169 737	8 849 756
1996	4 125 955	8 855 126
1997	4 082 174	8 860 496
1998	4 038 392	8 865 865
1999	3 994 611	8 871 235
2000	3 984 476	8 840 505
2001	3 996 958	8 861 809
2002	3 914 499	8 831 474
2003	3 854 297	8 759 425
2004	3 845 468	8 736 957
2005	3 804 475	8 662 462
2006	3 731 323	8 627 623
2007	3 668 837	8 574 377
2008	3 609 245	8 493 510
2009	3 566 359	8 394 810
2010	3 535 985	8 301 464
2011	3 476 160	8 223 637
2012	3 434 259	8 163 288
2013	3 350 490	8 107 515
2014	3 325 975	8 111 345
2015	3 302 451	8 101 627
2016	3 331 652	8 081 580
2017	3 318 295	8 045 062
2018	3 275 691	8 062 827
2019	3 226 633	8 051 462
2020	3 270 927	8 076 626
2021	3 288 497	8 069912
2022	3 291 973	8 071 913

Table F13. Activity data used for Waste incineration (5C)

	5C1biii-Clinical waste incineration	5C1bv-Cremation
	waste incinerated (kt)	Corpse incineration (number)
1990	0.63	13 916
1991	0.63	13 646
1992	0.63	13 756
1993	0.54	14 067
1994	0.59	14 106
1995	0.48	13 669
1996	0.44	13 876
1997	0.47	13 884
1998	0.49	13 620
1999	0.41	14 182
2000	0.24	14 039
2001	0.24	13 979
2002	0.14	14 154
2003	0.14	13 418
2004	0.14	13 494
2005	0.14	13 894
2006	IE	14 107
2007	IE	14 390
2008	IE	14 451
2009	IE	14 815
2010	IE	14 664
2011	IE	15 176
2012	IE	15 455
2013	IE	15 725
2014	IE	15 641
2015	IE	16 164
2016	IE	16 703
2017	IE	16 903
2018	IE	17 429
2019	IE	17 937
2020	IE	18 881
2021	IE	19 431
2022	IE	21911

Norwegian Environment Agency

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The Norwegian Environment Agency is a government agency under the Ministry of Climate and Environment.

We work for a clean and diverse environment. Our primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature and prevent pollution.