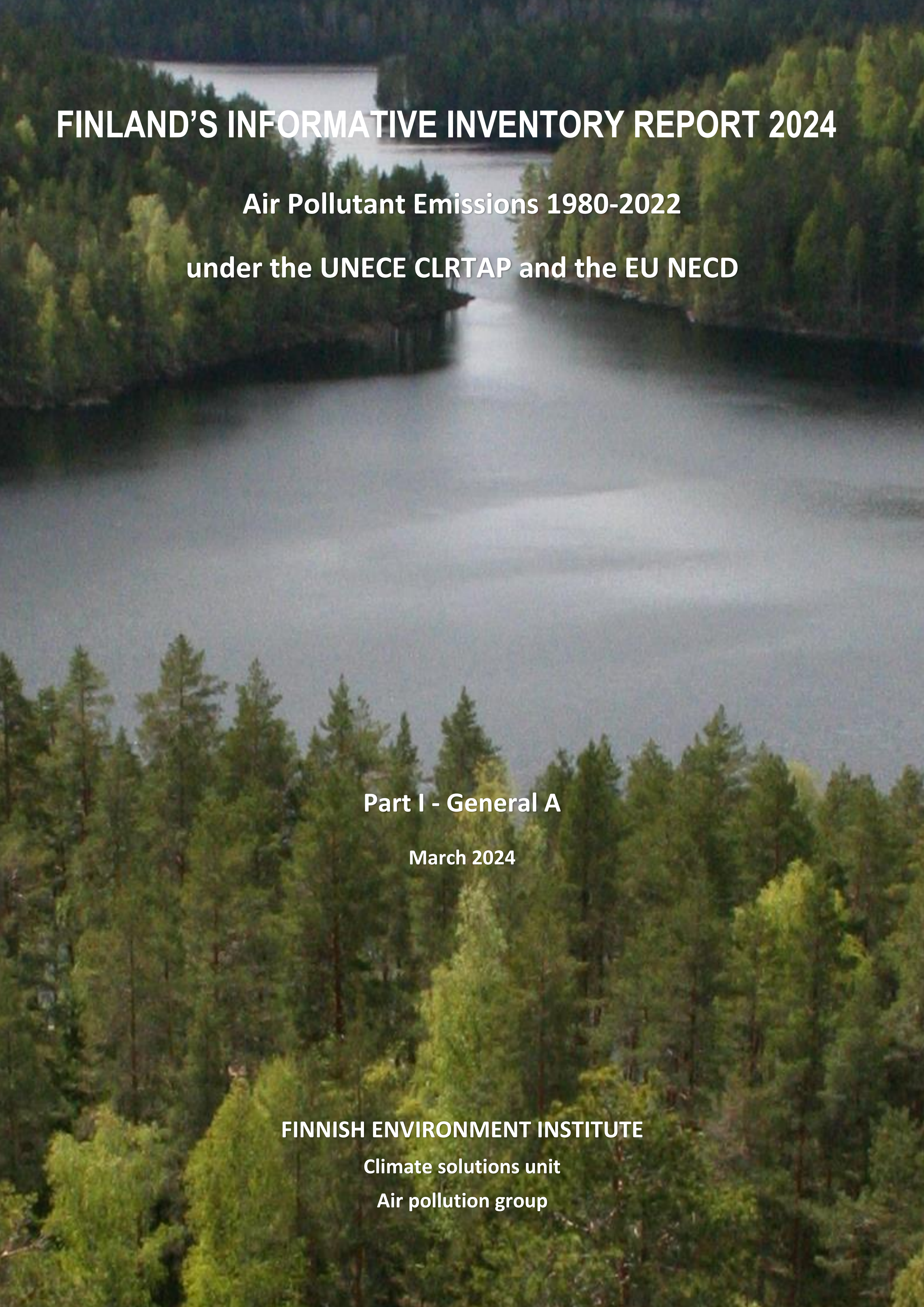

FINLAND’S INFORMATIVE INVENTORY REPORT 2024

Air Pollutant Emissions 1980-2022

under the UNECE CLRTAP and the EU NECD

Part I - General A

March 2024

FINNISH ENVIRONMENT INSTITUTE

Climate solutions unit

Air pollution group

PART 1

GENERAL A

Cover page Part 1: Esa Nikunen (2016) Repovesi, Ympäristöhallinnon kuvapankki

PREFACE

Finland’s Informative Inventory Report (IIR) 2024 under the United Nations Economic Commission for Europe's (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP) and under the EU National Emission Ceilings Directive (NECD) contains information on the organisation of the national air pollutant emissions inventory, on emission sources, trends, methods and data analysis for the emissions time series 1980-2022.

The IIR is prepared according to the Guidelines for Reporting Emission Data under the Convention on Long-Range Transboundary Air Pollution[1] and its structure follows the template of the Informative Inventory Report. The report is reviewed and completed annually to include updated information.

The IIR consists of the following general parts

Part 1A General	General information, data analysis, emission trends, progress in meeting targets. Time series of emissions are summarised in Tables 1.1-1.3.
Part 1B General	Recalculations, projections, inventory improvement, gridded data, LPS, adjustments, memo items

Methods used to estimate emissions are presented in Parts 2-6 of the IIR
Part 2 Energy
Part 3 Transport
Part 4 Industrial processes and product use
Part 5 Agriculture
Part 6 Waste
Part 7 Annexes

The Finnish submissions of NFR tables and IIR can be downloaded from the EIONET CDR website. The reported data is presented also in Finnish Environmental Administration’s website https://www.ymparisto.fi/en/pollution-and-environmental-risks/clean-air/air-pollutant-emissions-finland (in English). The website contains tools and maps to explore air pollutant emissions. The website is updated annually by 31st March at the latest with the latest data.

The submissions to the UNECE CLRTAP and the EU NECD are prepared at the Finnish Environment Institute SYKE by the Air Emission Team: Mr Tommi Forsberg, Mr Juha Grönroos, Mr Olli Koskivaara, Ms Johanna Mikkola-Pusa, Mr Joonas Munther, Mr Markus Niemelä and Ms Kristina Saarinen. Transport sector emissions are calculated by Mr Arttu Lauhkonen (VTT) and Mr Kari Grönfors (Statistics Finland).

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Helsinki 15th March 2024

The requested information on the inclusion of the condensable part of PM emissions is summarized on the next page, page 4.

[1] https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2022/emissions_reporting_guidelines_2023_final.pdf

A summary of information on the condensable part of particulate matter

The summary presented in the table below on whether the condensable part of particulate matter is included or not in the emissions estimates, covers only those cases where (1) emission data reported by the plants are used in the inventory, or (2) domestic emission factors used in the calculation.

Information on whether the emission factors from the EMEP/EEA Emission Inventory Guidebook include or exclude the condensable part has not thoroughly been studied.

Table – Inclusion/exclusion of the condensable component from PM_{10} and $PM_{2.5}$ in the emission data

Source	Included	Excluded	Comments	Reference
Energy				
NFRs 1A1/1A2	see comments		Combustion in the energy production units - TSP emission concentrations are measured in the stack according to the agreed the EN standards (EN 13284-1), which is a gravimetric particle measurement and thus does not cover condensable particles. In cases where PM10 and PM2.5 are calculated from reported TSP emissions or using domestic TSP EFs, the condensable part of PMs is not included.	Part 2 Energy p. 32
NFR 1A4	see comments		For small scale wood combustion, country specific emission factors are based on measurements where the condensable part is included. For coal combustion, Guidebook EFs are used and we refer to the knowledge of the Guidebook regarding inclusion or exclusion of condensables.	Part 2 Energy
Transport				
NFR 1A3	see comments		For all transport modes Guidebook EFs are used - According to general information, the transport sector standard measurements include dilution of the sample and cooling it to 51 °C temperature, which enables the measurement to capture most of the condensable part of particulate matter	Part 3 Transport
Industry and product use				
NFR 2	see comments		Industrial processes - TSP emission concentrations are measured in the stack according to the agreed the EN standards (EN 13284-1), which is a gravimetric particle measurement and thus does not cover condensable particles. When Guidebook EFs for particles are used, we refer to the Guidebook in the knowledge of inclusion or exclusion of condensables. Each NFR sub-category covers both data reported by plants and data calculated with Guidebook EFs.	Part 4 IPPU p. 5
Agriculture				
NFR 3F	see comments		Field burning - When Guidebook EFs for particles are used, we refer to the Guidebook in the knowledge of inclusion or exclusion of condensables.	Part 5 Agriculture
Waste				
NFR 5C	see comments		Waste incineration - TSP emission concentrations are measured in the stack according to the agreed the EN standards (EN 13284-1), which is a gravimetric particle measurement and thus does not cover condensable particles. When Guidebook EFs for particles are used, we refer to the Guidebook in the knowledge of inclusion or exclusion of condensables.	Part 6 Waste and Other

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AGRICULTURE (NFR 3)

The documentation of the Agricultural Emissions Calculation Model is saved in the 2018 CDR folder "Revised IIR 2018 – Annexes Part 5"

PART 6 - WASTE AND OTHER SOURCES

6 WASTE (NFR 5)

ABBREVIATIONS

CEPMEIP	Co-ordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance
CLRTAP	Convention on Long Range Transboundary Air Pollution
CRF	Common Reporting Format tables, reported to the UNFCCC Secretariat
GNFR	Gridding NFR (emissions gridded for each GNRF aggregated sector)
GPG	IPCC Good Practice Guidance
EEA	European Environment Agency
EMEP	Cooperative programme for the monitoring and evaluation of the long range transmission of air pollutants in Europe (European Monitoring and Evaluation Programme)
E-PRTR	European Pollutant and Transfer Register
EU	European Union
EUMM	Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol, OJ L 49, 19.02.2004
IED	Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)
ILMI	Calculation model for emissions from aviation at VTT Technical Research Centre of Finland
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
IPTJ	Air pollutant emission data system at the Finnish Environment Institute SYKE
LCP	Large combustion plant
LIISA	Calculation model for the road transport sector emissions at VTT Technical Research Centre of Finland
LIPASTO	Calculation system for the transport sector emissions at VTT Technical Research Centre of Finland
LPS	Large point sources, equals to the definition of E-PRTR installations
LUKE	Natural Resources Institute Finland (Luonnonvarakeskus)
MEERI	Calculation model for emissions from navigation at VTT Technical Research Centre of Finland
MTT	MTT Agrifood Research Finland
NECD	Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC
NFR	Nomenclature for Reporting
SYKE	Finnish Environment Institute
SNAP	Selected Nomenclature for Air Pollution
TIKE	Information Center of the Ministry of Agriculture and Forestry
TYKO	Calculation model for emissions from off-road machinery at VTT Technical Research Centre of Finland
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention for Climate Change
USEPA	United States Environmental Protection Agency
VTT	VTT Technical Research Centre of Finland
YLVA	Compliance Monitoring Data System at the Centres for Economic Development, Transport and the Environment (formerly VAHTI)

Pollutants

As	Arsenic
BC	Black carbon
Cd	Cadmium
Cr	Chromium
Cu	Copper
CO	Carbon monoxide
HCB	Hexachlorobenzene
HCl	Hydrochloric acid
Hg	Mercury
HM	Heavy metals
SO_2	Sulphur dioxide, all sulphur compounds expressed as sulphur dioxide
NH_3	Ammonia
Ni	Nickel
NMVOC	Non-methane volatile organic compounds, any organic compound, excluding methane, having a vapour pressure of 0.01 kPa or more at 293.15 K, or having a corresponding volatility under the particular conditions of use. For the purpose of the UNECE CLRTAP Reporting Guidelines, the fraction of creosote which exceeds this value of vapour pressure at 293.15 K is considered as a NMVOC
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides, nitric oxide and nitrogen dioxide, expressed as nitrogen dioxide
PAH-4	Polyaromatic hydrocarbons expressed as the sum of benzo(a)pyrene, benzo(b)fluoranthene,benzo(k), fluoranthene and indeno(1,2,3,-cd)pyrene
Pb	Lead
PCDD/F	Dioxins and furans: 1,2,3,7,8-PeCDD; 2,3,4,7,8-PeCDF; 1,2,3,4,7,8-HxCDF;1,2,3,6,7,8-HxCDF
PCB	Polychlorinated biphenyls
PCP	Pentachlorophenol
$PM_{2.5}$	Particulate matter, the mass of particulate matter that is measured after passing through a size-selective inlet with a 50 per cent efficiency cut-off at 2.5 µm aerodynamic diameter
PM_{10}	Particulate matter, the mass of particulate matter that is measured after passing through a size-selective inlet with a 50 per cent efficiency cut-off at 10 µm aerodynamic diameter
POP	Persistent organic pollutants, (lindane, dichloro-diphenyl-trichloroethane (DDT), polychlorinated biphenyl (PCBs), pentabromodiphenyl ether (PeBDE), perfluorooctane sulfonate (PFOS), hexachlorobutadeine (HCBD), octabromodiphenyl ether (OctaBDE), polychlorinated naphthalenes (PCNs), pentachlorobenzene (PeCB) and short-chained chlorinated paraffins (SCCP)
SCCP	Short-chained chlorinated paraffins
TSP	Total suspended particulates. the mass of particles, of any shape, structure or density, dispersed in the gas phase at the sampling point conditions which may be collected by filtration under specified conditions after representative sampling of the gas to be analyzed, and which remain upstream of the filter and on the filter after drying under specified conditions
Zn	Zinc

Notation keys

IE	Included elsewhere – Emissions for this source are estimated and included in the inventory but not presented separately for this source (the source where included is indicated).
NA	Not applicable – The source exists but relevant emissions are considered never to occur. Instead of NA, the actual emissions are presented for source categories where both the sources and their emissions are well-known due to availability of bottom-up data (i.e. mainly in the energy and industrial processes sectors). When pointing the value "0.000" with the cursor, the actual emissions can be seen and the value "0.000" is shown due to the rounding of data to three significant decimals.
NE	Not estimated – Emissions occur but have not been estimated or reported.
NO	Not occurring – A source or process does not exist within the country.
C	Confidential information – Emissions are aggregated and included elsewhere in the inventory because reporting at a disaggregated level could lead to the disclosure of confidential information.
NR	Not relevant - According to paragraph 9 in the Emission Reporting Guidelines, emission inventory reporting should cover all years from 1980 onwards if data are available. However, “NR” (not relevant) is introduced to ease the reporting where emissions are not strictly required by the different protocols, e.g. for some Parties emissions of NMVOCs prior to 1988. – NR is not in use in the Finnish inventory report.

The use of notation keys in the Finnish inventory is explained in the sector specific Chapters 4 - 9.

i Background information on air pollutants inventories

Changes in chapter	
February 2024	TF

Responsibilities in the Finnish national system for air emission inventories are divided between Statistics Finland, responsible for greenhouse gas inventories, and the Finnish Environment Institute, responsible for air pollutant emission inventories, as shown in Figure 1.1.

UNECE CLRTAP

The United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution (UNECE CLRTAP) entered into force in 1983. Under the Convention there are eight protocols: the protocol on Reduction of Sulphur Emissions and their Transboundary Fluxes (entered into force in 1987), protocol on Control of Nitrogen Oxides or their Transboundary Fluxes (entered into force in 1991), protocol on Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (entered into force in 1997), protocol on Further Reduction of Sulphur Emissions (entered into force in 1998), protocol on Persistent Organic Pollutants POPs (entered into force in 2003, protocol on Heavy Metals (entered into force in 2003) and protocol on Abating Acidification, Eutrophication and Ground-level Ozone (entered into force in 2005). Reduction targets and base years for the emission inventories are specified for the substances covered by each Protocol.

The annual reports under the UNECE CLRTAP Convention include emission inventories for sulphur as SO_2, nitrogen oxides, ammonia, non-methane volatile organic compounds (NMVOCs), heavy metals and persistent organic compounds since their base years as specified in the relevant protocols. Projected emissions for sulphur dioxide, nitrogen oxides, ammonia, particulate matter and NMVOCs are reported for the years 2025 to 2050. Methods used to quantify emissions as well as data analysis and other additional information to understand the emission trends as required in the reporting guidelines[2] are included in national Informative Inventory Reports (IIRs) submitted annually.

Finland has annually submitted emission data and inventory reports to the UNECE Secretariat since the 1980s to meet the obligations of the United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution (UNECE CLRTAP). The inventory reports submitted to the UNECE Secretariat and to the EEA are uploaded to the EIONET CDR (http://cdr.eionet.europa.eu/) as specified in the reporting instructions. Information on air pollutant inventories under the UNECE CLRTAP is provided on the website of Finland's Environmental Administration[3].

EU NECD

The aim of Directive 2001/81/EC, revised 2016/2284, of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants is to limit emissions of acidifying and eutrophying pollutants and ozone precursors. The Directive establishes national emission ceilings as benchmarks, for SO_2, NO_x, NH_3, NMVOC and $PM_{2.5}$ emissions. Emission inventories and projections as well as additional data are reported since the 2017 submission according to the revised NEC Directive (Directive 2016/2284) reporting requirements.

Finland has submitted emission inventories to the European Commission and to the EEA annually since the first reporting under the NECD in 2002 for the year 2000 final data. The data and reports

[2] https://www.ceip.at/fileadmin/inhalte/ceip/00_pdf_other/2022/emissions_reporting_guidelines_2023_final.pdf
[3] https://www.ymparisto.fi/en/pollution-and-environmental-risks/clean-air/air-pollutant-emissions-finland

are uploaded to the EIONET CDR (http://cdr.eionet.europa.eu/). Detailed information on air pollutant inventories is provided on the website of Finland's Environmental Administration[4].

ii Summary of national emissions related to trends

Changes in chapter	
February 2024	TF

Summaries of air pollutant emissions in Finland for the years 1980-2022 are presented in Tables 1.1, 1.2 and 1.3.

The methodology presented in the EMEP EEA Emission Inventory Guidebook has been applied in the inventory and completed by national methods where available, according to the Guidebook principles.

Table 1.1. Summary of main air pollutant emissions in Finland for 1980–2022. Corrections to data reported in 2023 to data reported in 2024 are printed in red.

kt/a	NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	CO	$PM_{2.5}$	PM_{10}	TSP	BC
1980	307	*	585	42					
1981	288	*	535	43					
1982	283	*	485	43					
1983	273	*	373	44	*	*	*	*	*
1984	269	*	369	44					
1985	287	*	383	44	* No estimates for total national emissions are available for 1980-1989 although estimates are provided for individual NFR categories				
1986	289	*	332	43					
1987	301	229	329	42					
1988	303	240	303	41					
1989	310	234	245	40					
1990	307	234	249	41	764	47	74	99	10
1991	304	224	206	39	736	43	67	86	9
1992	288	219	156	38	715	39	61	79	9
1993	294	213	138	38	700	36	56	73	9
1994	294	211	123	39	687	35	56	74	9
1995	273	204	105	39	662	32	51	68	8
1996	278	197	109	40	657	31	50	65	8
1997	272	196	101	41	651	31	49	65	7
1998	258	191	94	41	646	28	45	59	7
1999	253	185	92	43	630	28	46	61	7
2000	241	178	82	39	594	26	43	56	7
2001	245	176	96	40	596	27	44	58	7
2002	243	167	90	41	577	27	44	59	7
2003	249	163	101	42	556	27	45	60	6
2004	237	158	84	42	542	27	44	59	6
2005	208	147	70	42	519	26	42	57	6
2006	224	141	83	41	499	26	43	59	6
2007	211	137	81	41	486	24	41	56	6
2008	194	121	67	40	452	23	38	53	5
2009	177	113	59	39	429	22	37	52	5
2010	187	113	66	40	446	23	38	54	5
2011	171	105	60	39	407	20	36	51	5
2012	162	102	50	39	402	20	34	48	5
2013	159	98	48	39	389	20	34	49	5
2014	151	95	44	39	383	19	34	48	5

[4] https://www.ymparisto.fi/en/pollution-and-environmental-risks/clean-air/air-pollutant-emissions-finland

kt/a	NO_x (as NO_2)	NMVOC	SO_x (as SO_2)	NH_3	CO	$PM_{2.5}$	PM_{10}	TSP	BC
2015	139	91	41	38	359	17	31	45	4
2016	135	91	40	36	366	18	32	47	4
2017	131	89	35	36	357	17	31	45	4
2018	127	87	33	36	349	17	31	45	4
2019	120	85	30	35	343	16	30	45	4
2020	105	85	23	34	317	14	27	40	3
2021	104	83	23	33	333	14	27	41	3
2022	99	75	23	32	310	13	27	42	3

Remark 1: Due to rounding the sum of subtotals does not equal to total figure

Table 1.2. Summary of heavy metal emissions in Finland for the years 1990–2022.

Year	Heavy Metals (t/a)								
	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
1990	321	7	1	35	48	157	78	NE[5]	683
1991	237	4	1	24	60	149	61		473
1992	165	3	1	18	48	124	52		374
1993	105	3	1	16	38	112	46		349
1994	74	3	1	11	41	106	45		406
1995	73	2	1	5	36	116	47		403
1996	49	2	1	8	33	110	37		270
1997	34	2	1	14	33	129	38		152
1998	37	2	1	14	30	84	34		151
1999	34	2	1	5	31	68	37		141
2000	31	1	1	4	29	65	35		128
2001	30	2	1	5	26	66	32		131
2002	31	1	1	4	39	69	38		147
2003	25	1	1	4	29	62	35		127
2004	26	2	1	4	26	60	31		125
2005	21	1	1	3	20	58	26		119
2006	25	1	1	3	25	59	28		119
2007	22	1	1	3	29	44	25		108
2008	20	1	1	3	27	42	22		117
2009	17	1	1	3	17	40	20		116
2010	20	1	1	3	26	42	23		129
2011	19	1	1	3	17	42	20		124
2012	16	1	1	3	19	41	19		127
2013	16	1	1	3	18	42	17		124
2014	17	1	1	3	23	43	17		132
2015	15	1	1	2	17	41	16		119
2016	16	1	1	3	18	42	16		127
2017	16	1	1	2	17	41	15		120
2018	15	1	1	2	15	40	14		118
2019	13	1	1	2	14	40	12		130
2020	12	1	1	2	14	38	10		116
2021	13	1	1	2	14	39	10		134
2022	13	1	1	2	15	38	10		132

Remark 1: Due to rounding the sum of subtotals does not equal to total figures.

[5] The time series for Se emissions is not complete.

Table 1.3. Summary of persistent organic pollutant emissions in Finland for the years 1990–2022.

Year	Persistent Organic Pollutants			
	PCDD/F (g I-TEQ)	PAH-4 (Mg)	HCB (kg)	PCB (kg)
1990	18	18	36	29
1991	19	18	36	25
1992	18	18	36	26
1993	19	18	36	28
1994	18	19	36	29
1995	19	17	36	29
1996	17	19	38	27
1997	17	19	38	29
1998	18	19	38	31
1999	18	19	38	30
2000	18	18	39	30
2001	16	20	18	29
2002	16	20	12	29
2003	14	21	10	30
2004	14	21	26	31
2005	14	22	32	31
2006	15	21	36	31
2007	14	22	38	32
2008	14	21	19	31
2009	12	23	27	21
2010	16	25	9	28
2011	14	22	26	27
2012	15	24	9	24
2013	15	22	17	23
2014	16	23	22	24
2015	14	22	16	24
2016	15	23	60	25
2017	13	23	33	23
2018	14	23	32	23
2019	10	22	23	20
2020	10	18	21	20
2021	11	20	23	23
2022	9	19	29	20

Remark 1: Due to rounding the sum of subtotals do not equal to total figures

iii Overview of source category specific emission estimates and trends

Changes in chapter	
February 2024	TF

The sources of air pollutants are discussed in detail in Sections 3 - 10 of this report. For the land use change and forestry sector no air pollutant emissions have been estimated thus far.

Energy

Combustion of fuels in the energy and heat production sectors is the main source of SO_2, NO_x, particulate matter and heavy metal emissions. NMVOC and POP compounds are released especially from small combustion sources. Emissions from the energy sector are related to the production, distribution and consumption of fuels and fluctuate from year to year due to the economic trends, variations in the energy supply structure and due to climatic conditions (cold weather). The availability of hydropower in the integrated Nordic electricity market has a notable decreasing impact on the emission levels.

Transport

Transport sector is a significant source of NO_x, CO and NMVOC emissions. In the transport sector, emissions have a decreasing trend though the use of fuels is increasing. One of the most essential emission reduction measures in the transport sector is the EU level agreement with car manufacturers on reducing vehicles' fuel consumption. Emissions from the off-road sector are increasing.

Industrial Processes

Emissions from the industrial processes sector are in general decreasing but variations due to fluctuations in production occur annually. Emissions cover process-based sulphur compounds (mainly Total Reduced Sulphur, TRS), NMVOCs, heavy metals, particles and POP compounds, depending on the industrial activity.

Solvent and other product use

The inventory of the solvent and other product use sector covers NMVOC compounds, particles, heavy metals and POP compounds. Domestic solvent use and paint application are the most significant NMVOC sources. The trends of emissions are generally decreasing. From 2020 to 2021 NMVOC emissions from the use of hand desinfectants peaked due to the Covid19 pandemic.

Agriculture

Agriculture is the main source for ammonia emissions and, also a source of particle, NOx and NMVOC emissions. The main emission sources for ammonia are manure management and fertilizers. The emissions trends are decreasing due to decreases in the numbers of livestock and in nitrogen fertilisation.

Waste

Emissions from the waste sector include SO_2, NO_x, CO, NMVOC, particulate matter, heavy metals and POPs. The trends of these emissions are generally declining. All waste incineration occurs currently with energy recovery and these emissions are reported under the Energy sector.

Other

The source category other includes ammonia emissions from animals that cannot be attributed to the agricultural or natural sectors. Because in the Finnish emission inventory all horses - including agricultural, recreational and racing horses - are included in the agriculture sector, the category other considers only pets, i.e., cats and dogs.

1 INTRODUCTION

1.1 Background information on air pollutants emissions and their impact on the environment

Changes in chapter	
February 2024	TF

1.1.1 National circumstances relevant to air pollutant emissions

Population and geography

The population of Finland was 5 563 970 at the end of 2022 (Figure 1.1). As a result of the low population density, 18 inhabitants per km², and the geographical extent of the country, the average distances travelled for different purposes can be quite long.

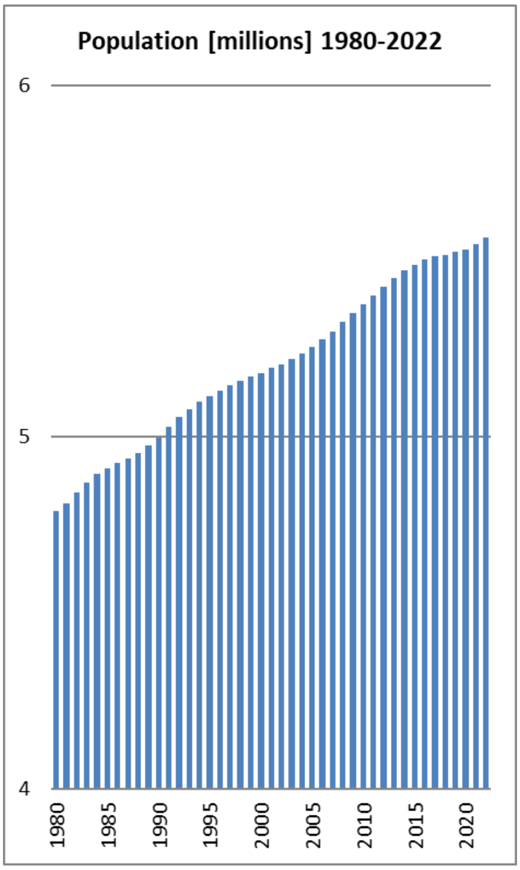


Figure 1.1 Population and geographical location of Finland

Finland is located between latitudes of 60 and 70 degrees north, while a quarter of the country extends north of the Arctic Circle. With a total area of 338,432 km^2, it is Europe's seventh largest country. Nearly all of Finland is situated in the boreal coniferous forest zone, and 72 per cent of the total land area is classified as forest land, while only some 8 per cent is farmed. Finland has more than 34,300 km^2 of inland water systems, which represents approximately 10 per cent of its total area. There are some 190,000 lakes and 180,000 islands.

Climate

Finland's northern location increases the demand for energy and natural resources, but the cold climate has also forced efficient use of energy.

The climate of Finland displays features of both maritime and continental climates, depending on the direction of air flow. Considering its northern location, the mean temperature in Finland is several degrees higher than in most other areas at these latitudes. The temperature is higher due to the Baltic Sea, because of the inland waters and, above all, as a result of air flows from the Atlantic Ocean, which are warmed by the Gulf Stream. The mean annual temperature is approximately 5.5°C in south-western Finland and decreases towards the northeast.

<u>Winter</u> – Winter begins around mid-October in Lapland and during November in the rest of Finland, while not until December in the southwestern archipelago. The sea and large lakes, where existing, slow down the progress of winter. Winter is the longest season in Finland, lasting for about 100 days in southwestern Finland and 200 days in Lapland. The mean temperature in winter remains below 0°C. North of the Arctic Circle, part of winter is the period known as the "polar night", when the sun does not rise above the horizon at all. In the northernmost corner of Finland, the polar night lasts for 51 days. In southern Finland, the shortest day is about 6 hours long. Permanent snow covers open grounds about two weeks after winter begins. The snow cover is deepest around mid-March, with an average of 60 to 90 cm of snow in eastern and northern Finland and 20 to 30 cm in southwestern Finland. The lakes freeze over in late November and early December. The ice is thickest in early April, at about 50 to 65 cm. In severe winters, the Baltic Sea may ice over almost completely, but in mild winters it remains open except for the far ends of the Gulf of Bothnia and the Gulf of Finland. The coldest temperatures in winter are from -45°C to -50°C in Lapland and eastern Finland; from -35°C to -45°C elsewhere; and -25°C to -35°C over islands and coastal regions. The lowest temperature recorded in Helsinki is -34.3°C (1987). The lowest temperature recorded at any weather station in Finland as of 2010 is -51.5°C (1999).

<u>Spring -</u> In spring, the mean daily temperature rises from 0°C to 10°C. Spring begins in a month earlier in the southern part of the country, early April, and proceeds to Lapland in early May, ranging from 45 to 65 days, and being longest in the maritime islands and coastal regions, because of the coolness of the sea. Once the mean daily temperature exceeds 5°C, the thermal growing season is considered to have begun. This takes place about one month after the beginning of spring: at the end of April in southern Finland and at the end of May in northernmost Lapland. For the real growing season to begin the snow must melt. Melting depends on the amount of snow, elevation and the position of the region relative to the sea. Open areas lose their snow cover within two to three weeks of the beginning of spring, whereas on average the snow in the forest smelts about two weeks later. The lakes usually become ice-free soon after the growing season begins in April in southwestern Finland, in May in the interior and in June in Lapland.

<u>Summer -</u> In summer the mean daily temperature is consistently above 10°C. Summer usually begins in late May in southern Finland and lasts until mid-September, while in Lapland it starts about one month later and ends a month earlier. The regions north of the Arctic Circle are characterized by "polar days", when the sun does not set at all, 73 days in the northernmost area. In southern Finland, the longest day (around Midsummer) is nearly 19 hours long. The highest summer temperatures measured in the Finnish interior are from 32°C to 35°C. Near the sea and over the maritime islands, temperatures over 30°C are extremely rare; the highest temperature ever recorded in Helsinki is 31.6°C. Heat waves, with a maximum daily temperature exceeding 25°C, occur on an average of 10 to 15 days per summer inland in southern and central Finland, and 5 to 10 days in northern Finland and on the coast. In the course of the summer, thunderstorms occur on 8 to 14 days in the interior and 4 to 8 days in coastal areas and northern Lapland.

<u>Autumn - D</u>aily mean temperature in the Autumn remains below 10°C. Autumn begins around the last week of August in northern Finland and about one month later in southwestern Finland. The growing

season ends in autumn when the mean daily temperature drops below 5°C around the last week of September in northern Finland and in late October in southwestern Finland. The average length of the growing season is 180 days in the southwestern archipelago, 140 to 175 days elsewhere in southern and central Finland and 100 to 140 days in Lapland. The first snow falls in northern Finland in September and elsewhere in October.

Source: Finnish Meteorological Institute FMI

Economy and industrial activities

Finland has an open economy with prominent service and manufacturing sectors. The main manufacturing industries include electrical and electronics, forest and metal and engineering industries. Foreign trade is important, with exports accounting for about 40 per cent of the gross domestic product (GDP).

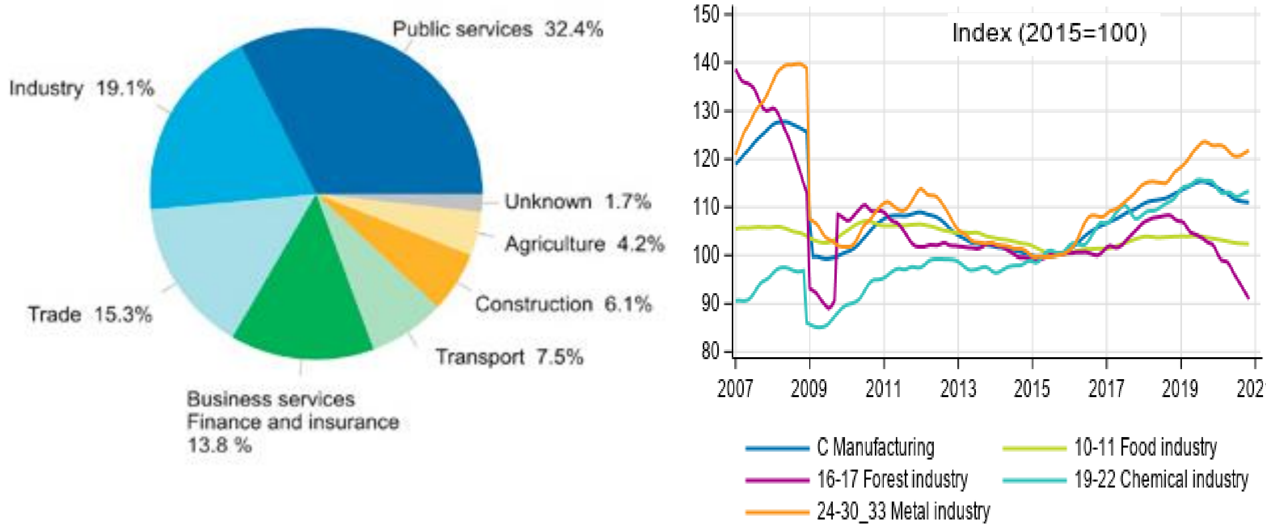


Figure 1.2 Economic Structure Finland (Statistics Finland 2021)

The total annual energy consumption is around 1 300 PJ, out of which the domestic industry uses approximately half. For decades, the use of primary energy as well as electricity has been increasing, and they reached their top values in the years 2006–2007. Demand rose more rapidly than GDP until 1994. Since then, parallel with the structural changes in the economy, both the energy intensity and the electricity intensity of the economy have decreased. Finland has a high share in non-fossil energy sources in power and heat production, i.e. hydro, nuclear and biomass sources.

Finland has significant forest resources that have led to the development of forest industries. Metal, technology and refinery industries developed due to paying reparations to the Soviet Union and due to the bilateral trade with the Soviet Union. The great depression in the beginning of the 1990's was due to the collapse of the Soviet Union as well as the unsuccessful monetary policy. Finland recovered from the depression that brought down thousands of enterprises and the mass unemployment through the growth of information technologies, mobile phones and telecommunication services. In 2009 there was a recession with the value of industrial output felling by approximately one third from year before. (Figure 1.3)

Finland joined the EU in 1995 and the Euro zone in 2001.

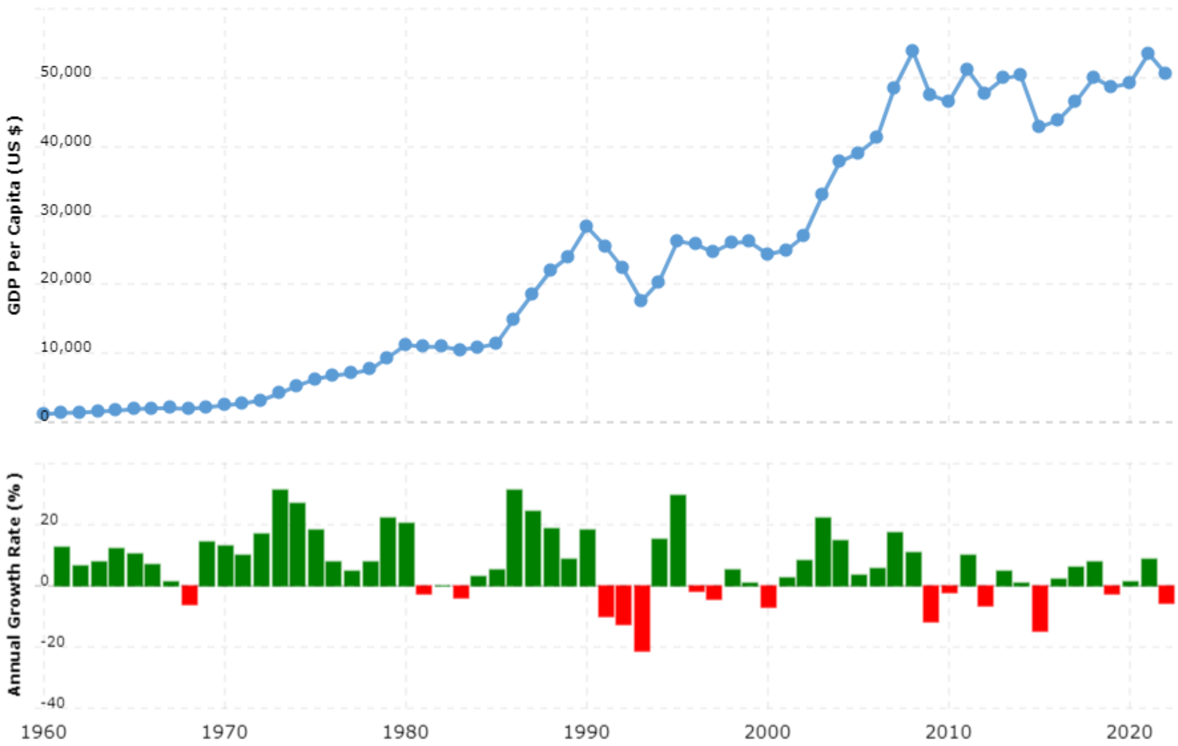


*Figure 1.3 GDP evolution 1960-2022 (***[Finland GDP Per Capita 1960-2024 | MacroTrends]***)*

Domestic passenger transport, measured in terms of passenger-kilometres, has increased by approximately 16 per cent since 1990. Cars account for around 86 per cent of the total passenger-kilometres. Road haulage is the most important form of transport for domestic goods traffic. Three quarters of Finland’s foreign trade goes by sea. Indoor heating is a large source of emissions, however, during the past three decades the consumption of energy per unit of heated space has been reduced significantly, in particular due to tightening building regulations.
(Reference: Finland’s Eighth National Communication under the United Nations Framework Convention on Climate Change. 2022. Ministry of the Environment and Statistics Finland.)

1.1.2 Environmental Protection

Figure 1.4. Snapshots of Finnish Environment

Finland's low population density and comparatively unspoilt natural environment has given good starting points to facilitate nature conservation. Environmental protection actions have resulted in many of the earlier polluted lakes and rivers to be cleaned up. Air quality has improved around industrial locations and a network of protected area has been built up to safeguard biodiversity. Forests are managed more sensitively than in the past and the overall annual growth rate exceeds the total timber harvest.

Finland has been rated among the world's leading countries in many international comparisons of environmental protection standards, such as the Global Economic Forum's regularly compiled Environmental Sustainability Index. Finland's strengths include highly effective environmental administration and legislations, and the ways environmental protection is considered in all sectors of the society. However, Finland has large ecological footprint and high levels of material and energy consumption.

Measures taken to combat acidification have had the desired effects. Finland's soils are naturally vulnerable to acidification since they only contain low concentrations of calcium to buffer the acidifying effects of sulphur and nitrogen compounds deposited in the soils from airborne pollution. The same applies to forests and inland waters. Farmland soils in Finland have to be regularly limed due to their natural acidity.

In Finland well-planned measures to combat air pollution have led to a considerable reduction in the emissions and acidifying deposits over the last 30 years. Instead, the amount of street dust and long-range transport of ozone have not decreased and emissions from agricultural sources continue to be a problem. While the air quality on average is still, in difficult weather conditions in winter and spring, the amounts of pollutants in certain urban areas may rise to the same level as in cities of about the same size in Central Europe.

Unnatural concentrations of toxic chemicals in the environment do not currently represent health risk in Finland. Emissions of the most hazardous substances have been significantly reduced and Finland does not suffer from large quantities of airborne toxic pollution originating from other countries.

Finland's winters are too cold for many crop pests to survive, so there is no need to use as much pesticides as in the south. However, in the harsh conditions, even small quantities of hazardous substances can be fateful for sensitive ecosystems and the cold climate can slow the natural degradation of toxic substances.

Chemicals contaminating soil can cause problems decades after the pollution occurs. In Finland there are approximately 20 000 sites potentially suffering from soil contamination. Efforts to remediate such sites intensified in the late 1990s and more recent clean-up work has been initiated at several hundred sites annually.

Air Pollution Control Programmes 2010 and 2030

In 2002 the Finnish Government adopted a national programme establishing the maximum annual emission levels for sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia as from 2010. The programme sets out the measures to reduce emissions in energy production, transport, agriculture and manufacturing industries as well as actions that contribute to emission reduction in working machinery, pleasure boats and residential wood combustion. Finland has successfully reduced emissions in line with the programme, with ammonia emissions as an exception.

The air pollution control programme up to 2030 was adopted by the Finnish Government in March 2019. The EU's National Emission Ceilings Directive (2016/2284) obliges Member States to update their national air pollution control programmes at least every four years. The Government approved the first update of the National Air Pollution Control Programme 2030 in March 2023.

International cooperation

The air presents an efficient transport route for gaseous and particulate substances, making it possible for emissions to spread to neighboring regions and even to the other side of the globe. This means that, besides national action in Finland, reaching the air pollution control objectives calls for international collaboration. More than half of the small particle loading and acidifying and eutrophying loading comes to Finland as long-range transboundary pollution. All countries in the world share the same ozone layer, which is why the responsibility for its protection rests with the international community.

The most significant international agreements on which air pollution control and the protection of the ozone layer in Finland are based are:

- UN Convention on Long Range Transboundary Air Pollution to control the transport of air pollutants between countries,
- Vienna Convention and the more detailed Montreal Protocol under it, imposing strict restrictions on the manufacture, consumption and trade of substances that deplete the ozone layer, and
- EU directives and regulations.

1.1.3 Environmental conditions

Air quality in Finland is generally good and the local impacts of air pollution are fairly limited. During periods when certain atmospheric conditions prevail, however – particularly atmospheric inversions in the winter and spring – concentrations of pollutants in the air in Finnish cities may be compared to those observed in cities of similar size elsewhere in Europe.

Acidifying compounds can reach the ground with rain or snow as wet deposition, or in the form of particles or gases as dry deposition. Ecosystems may eventually lose their neutralising or buffering capacity completely, if acid deposition rates persistently exceed the critical levels. Rainfall is naturally slightly acidic, but certain types of air pollutants can increase its acidity considerably. Combustion gases formed during the use of fossil fuels like oil, coal and peat particularly contain oxides of nitrogen and sulphur that can subsequently react in the atmosphere to produce acids that are dissolved in precipitation.

Acidification problems first became evident in the 1960s, when industrial emissions increased rapidly, and efficient methods for cleaning waste gases had not yet been developed. It took some time for action to be taken, although the threat of "acid rain" was clearly serious, with fish disappearing from some lakes, forests dying, and metal structures being rapidly corroded. Ultimately international agreements were signed to force industry and energy production to curb harmful emissions, and these measures have been particularly successful where sulphur emissions are concerned.

Finland carries out extensive monitoring of air quality/deposition and effects in various sectors. Finland participates in all the international effects programmes (ICPs) of the Working Group on Effects of the UNECE CLRTAP and has carried out extensive air quality/deposition monitoring as part of EMEP. Results from these activities have also been published in several national assessment reports and in papers in scientific journals.

Acidification represents a serious threat to many plants and animals, particularly in sensitive aquatic ecosystems. One of the most harmful impacts of acidification is that in acidic conditions toxic aluminium and heavy metal ions are more easily rinsed out of the soil and absorbed by living organisms. The ecosystems most sensitive to acidification are the nutrient-poor lakes and forests of northern Finland, whose natural buffering capacity is already weak. In more fertile regions, soils and the bedrock typically contain higher concentrations of calcium, which helps to prevent acidification.

The concentrations of sulphur compounds decreased and buffering capacity increased in all types of lakes in Finland during the 1990s, thanks to dramatic reductions in the atmospheric deposition. Some 5,000 smaller lakes in Finland are now considered to be recovering well from serious acidification problems.

Since the early 1990s stocks of perch (Perca fluviatilis) have been increasing in many lakes in forested areas of southern Finland where fish stocks had suffered badly from acidification in the 1970s and 1980s.

Declining atmospheric deposition has also reduced acidification problems in Finland's vital groundwater reserves. It may still take decades for groundwater to recover completely, since sulphur compounds and other acidifying impurities are still widely present in the soil, and are only gradually leached out into water courses.

(Ministry of the Environment 2017 Air Pollution Control, https://www.ymparisto.fi/en/pollution-and-environmental-risks/air-pollution-control and Lyytimäki J. 2014 Environmental protection in Finland, Finnish Environment Institute)

1.2 Institutional arrangements for inventory preparation

Changes in chapter	
February 2024	TF

Responsibilities in the Finnish national system for air emission inventories are divided between Statistics Finland, which is responsible for greenhouse gas inventories under the UNFCCC and the EU Governance Regulation (2018/1999), and the Finnish Environment Institute SYKE, which is responsible for air pollutant emissions under the UNECE CLRTAP and the EU NEC Directive. The task is included in the national legislation and in agreements between the Ministry of the Environment and SYKE.

E-PRTR reporting is under the responsibility of the Development and Administration centre of the Centres for Economic Development, Transport and the Environment (KEHA Centre). Energy Authority is the responsible unit for EU ETS data.

The share of responsibilities between the different organizations in the preparation on air emission inventories is illustrated in Figure 1.5.

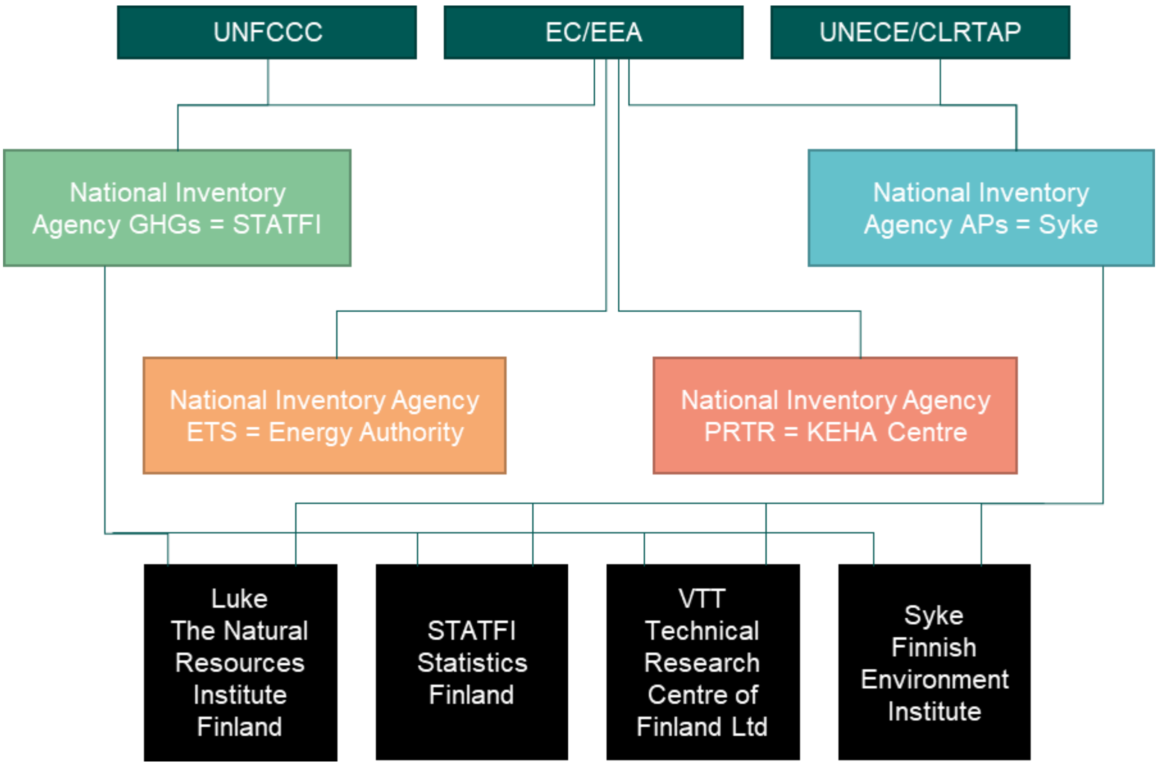


Figure 1.5. National systems for air emission inventories in Finland.

1.3 Brief description of the process of inventory preparation

1.3.1 Organization of the air pollutant inventory

Changes in chapter	
February 2021	KS

The inventory of air pollutant emissions to the UNECE CLRTAP Secretariat is coordinated by, and for the most parts also carried out, at Finnish Environment Institute (SYKE). SYKE also compiles the NFR reporting tables and the Informative Inventory Report (IIR) (Figure 1.6).

In the preparation of the inventory SYKE cooperates with several authorities: Finnish Customs; Finnish Food Authority; Finnish Safety and Chemicals Agency TUKES; Natural Resources Institute Finland LUKE; Ministry of Economic Affairs and Employment; Ministry of the Environment, Ministry of Transport and Communications; Finnish Institute for Health and Welfare THL; National Supervisory Authority for Welfare and Health Valvira; Rescue Services in Finland; Statistics Finland.

Several industrial associations and companies provide data for the preparation of the inventory: Association of Finnish Paint Industry; Chemical Industry Federation of Finland; Confederation of Finnish Construction Industries RT; Finnish Cosmetic, Toiletry and Detergent Association TY; Finnish Energy, Finnish Food and Drinks Industries' Federation ETL; Finnish Forest Industries Federation; Federation of Finnish Technology Industries; First Quantum Minerals Ltd, Lemminkäinen Infra Ltd Asphalt Division; Nynas Ltd (specialty oils); Paulig Ltd (coffee); Suomen Hiiva (yeast), Yara (chemicals) as well as the following research institutes: Natural Resources Institute Finland LUKE and VTT Technical Research Centre of Finland.

In 2020 an agreement was made between SYKE and VTT to transfer the emission inventory of all the remaining transport sector emission sources to VTT (i.e. heavy metals, POPs, particles as well as volatile and abrasion emissions).

Figure 1.6 Organization of the air pollutant emission inventory in Finland

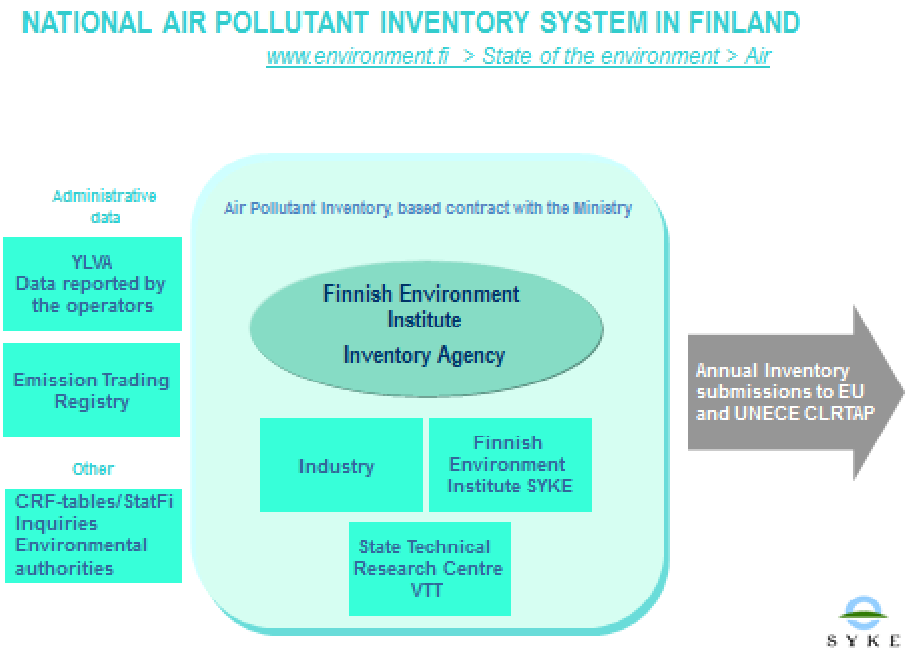


Figure 1.6 Organization of the air pollutant emission inventory in Finland.

1.3.2 Preparation of the inventory

Changes in chapter	
March 2022	KS

Air pollutant inventory agency

The national air pollutant emission inventories under the UNECE CLRTAP and the EU Directives (NECD and LCPD) are carried out at SYKE by the Air Emissions Team. Resources used for the preparation of air pollutant inventories are about 2.5 man years.

The team also participates the national greenhouse gas inventory by carrying out the inventory of F-gases and the waste sector inventory. The team also prepares as the NMVOC emission inventory under the CLRTAP and the NECD to be in the format to be reported under the UNFCCC and EU Governance Regulation (2018/1999). Resources used for contributing the greenhouse gas inventory are about 0.9 man years.

The annual schedule of the inventory work is presented in Figure 1.7.

Other services

The Air Emissions Team develops and maintains national release estimation techniques for air pollutants and maintains this information available on to the operators of industrial installations and to environmental authorities on the environmental administration's website[6]. The Team, in addition, develops tools for estimating greenhouse gases on the level of municipalities.

The Air Emissions Team provides expert services and technical support to the Ministry of the Environment.

Participation in national and international cooperation and research projects with research institutes, universities and industry is an essential tool to further develop the knowledge and expertise.

The Team members also participates in international work under the UNECE TFEIP, IPCC, OECD and the Nordic Council of Ministers as well as in the inventory review programmes under the UNFCCC and CLRTAP/NECD.

Bilateral cooperation and development projects as well as EU Twinning projects are included in the annual work of experts where resources allow.

Annual schedule of air emission inventories

The annual working schedule of air pollutant and greenhouse gas inventories at Finnish Environment Institute SYKE is provided in Figure 1.7.

[6] Information on national emission estimation methods is provided in Finnish and in Swedish on the website https://www.ymparisto.fi/fi/saasteettomuus-ja-ymparistoriskit/ilmansuojelu/ilman-epapuhtauksien-paastot-suomessa/paastotiedon-tuottaminen-ja-ilmoittaminen-paastorekistereihin/kansallista-aineistoa-paastojen-maarittamiseen

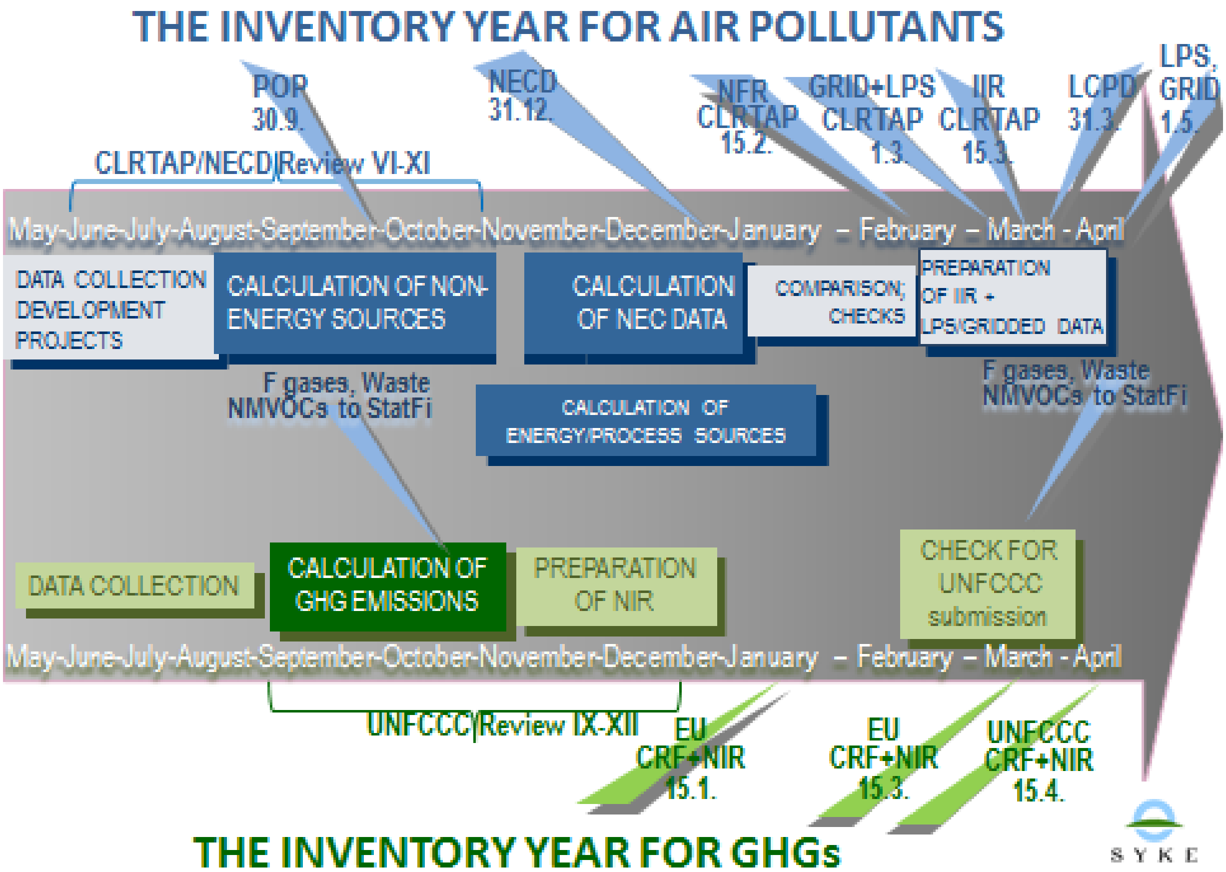


Figure 1.7. Annual schedule of inventory work at SYKE.

1.3.3 Reporting tool IPTJ

Changes in chapter	
February 2024	TF

The air pollutant emission data system IPTJ (Ilmapäästötietojärjestelmä) was built up during 2000 – 2003 as a reporting tool for the inventory. IPTJ currently contains emission data for the years 1990 – 2022 while data for the earlier years are partly based on manual documentation.

During the year 2013 the data compilation system was upgraded and automated using a Microsoft Visual Studio 2008 extension Business Intelligence Development Studio (BIDS). Microsoft Access based queries were extracted and the syntax converted into a format compatible with Microsoft SQL Server Database and most SQL-compatible database management systems and the SQL queries stored as SQL Server Integration Services (SSIS) packages.

Emission data in the IPTJ system is retrievable in different reporting formats: SNAP (Source Nomenclature for Air Pollutants), CRF (Common Reporting Format, IPCC), IPPC (Integrated Pollution Prevention and Control, Council directive 96/61/EC), as well as in IPPC and E-PRTR categories. The structure of IPTJ is presented in Figure 1.8.

Spatial emission data calculated at the level of EMEP grid (0.1° * 0.1°). Spatial emission data can be calculated also for each municipality (309 municipalities in 2022), provinces (19 in 2022) and Centres for Economic Development, Transport and the Environment (sc. ELY Centres, the number of which were 15 in 2022).

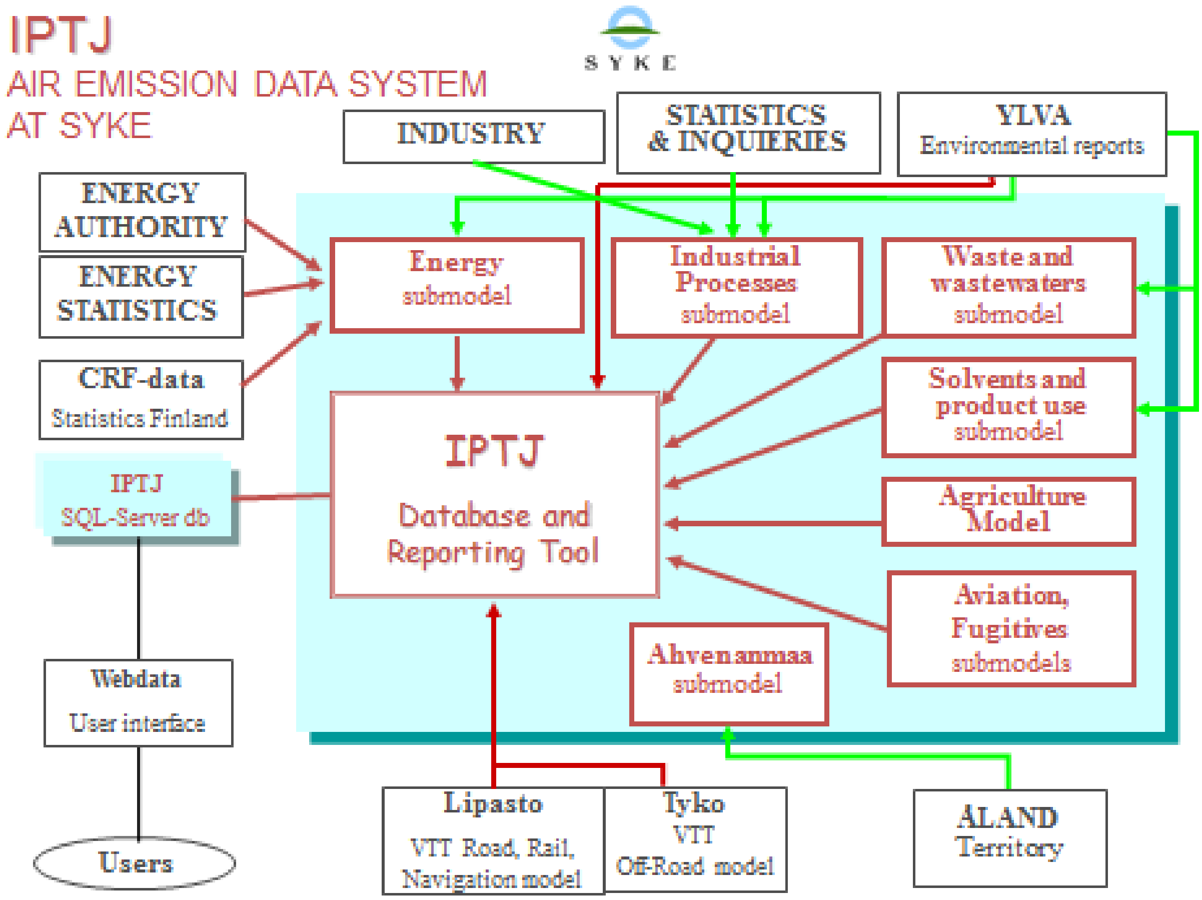


Figure 1.8. Structure of the air pollutant emission data system IPTJ at the Finnish Environment Institute SYKE.

1.3.4 Use of bottom-Up Data in the Emission Inventories

Changes in chapter	
February 2024	TF

The approach

A specific feature of the Finnish emission inventories is the use of data reported by the industrial installations[7]. The installations report their annual emissions to the supervising authorities at the Centres for Economic Development, Transport and the Environment according to the monitoring and reporting obligations determined in their environmental permits. After checking and approving the emission reports by the plants the supervising authorities record the information, including emission data for the supervised period, into their database (YLVA)[8] from where it is available also for emission inventory purposes.

At the Finnish emission inventory agencies (i.e. Finnish Environment Institute for air pollutants and Statistics Finland for greenhouse gases), the data is checked with normal statistical comparisons (e.g. check of magnitude and trend) and according to the IPCC Good Practice Guidelines principles before it is taken into the inventory databases of the inventory agencies. The use of bottom-up data increases the accuracy of the inventory by allowing actually measured emissions to be included into the inventory and covering, for instance, emissions during exceptional situations[9], which otherwise would not easily be captured (Figures 1.9 and 1.10). However, this also brings along additional workload in checking and allocating this information correctly.

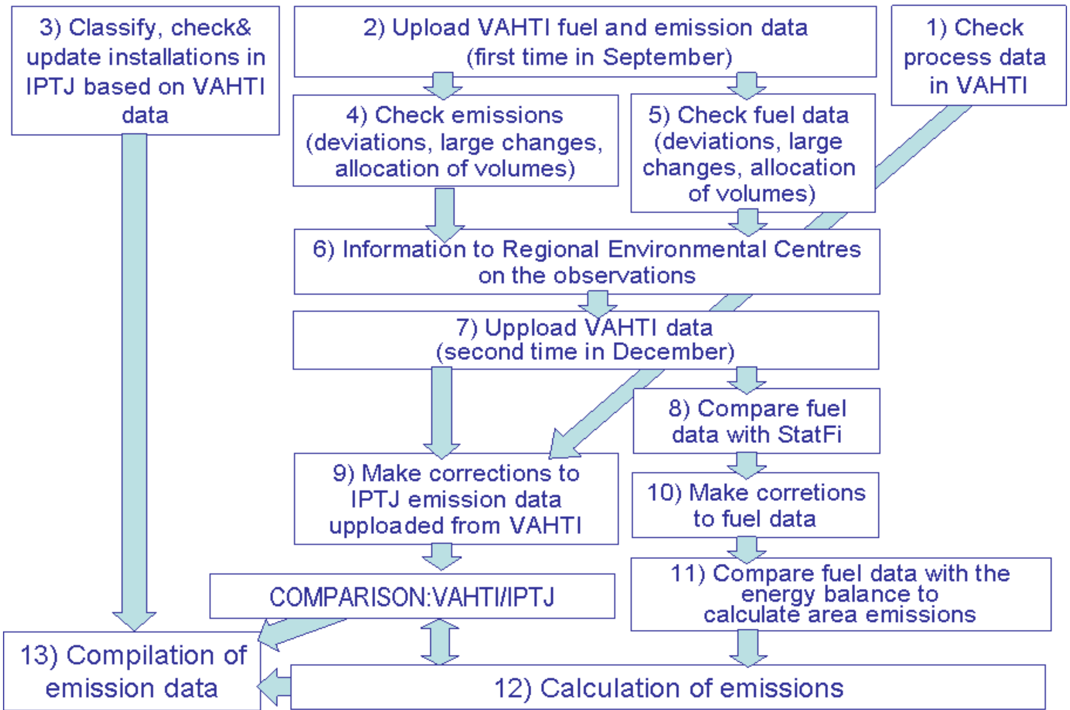


Figure 1.9. Processing of emission data reported by the plants for use in the air pollutant emission inventory, Part 1. (Note; the name of VAHTI has been changed to YLVA in 2018)

[7] This data is reported by the operators according to the reporting obligation in the environmental permit, as described in Chapter 1.3.3 first paragraph.
[8] Database for the supervising authority
[9] Such as malfunctioning of abatement technique, accidental releases due to process failures etc.

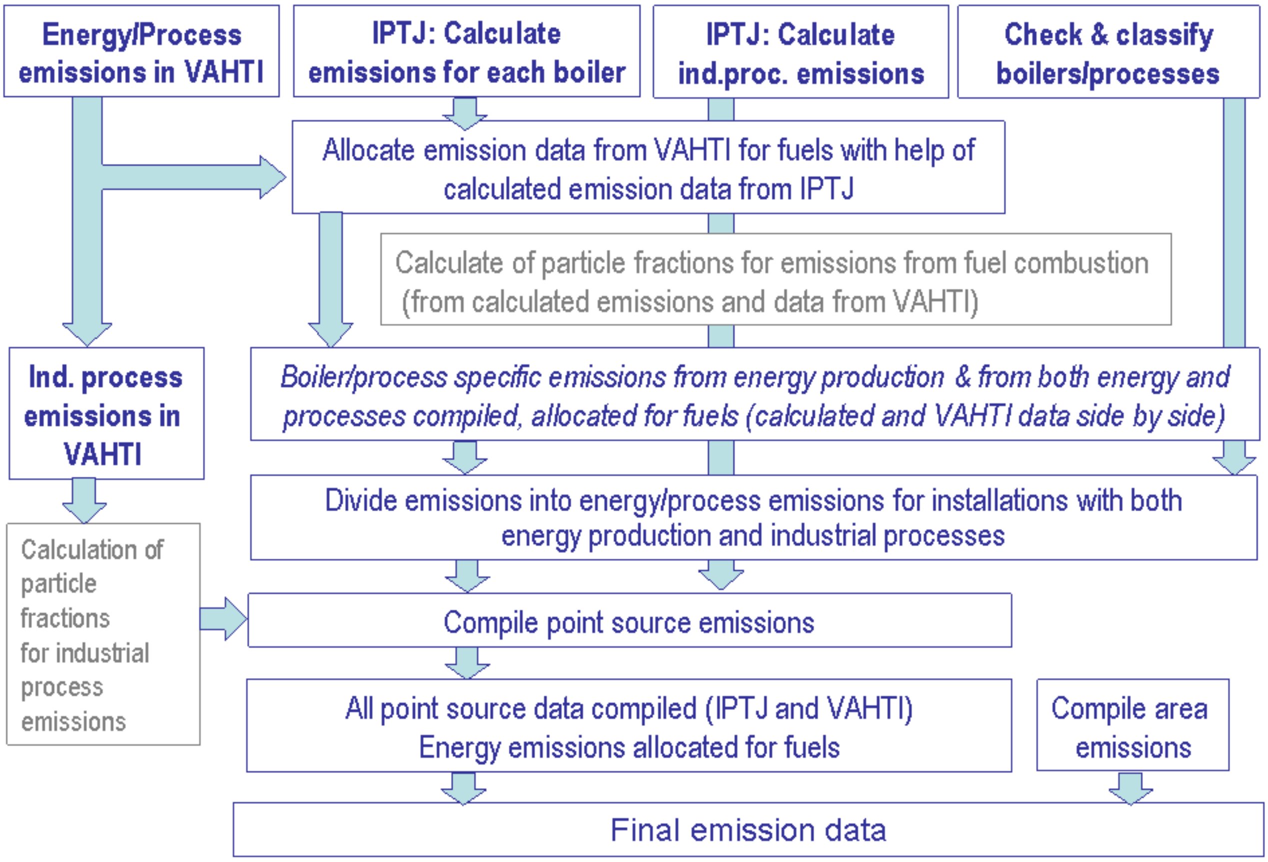


Figure 1.10. Processing of emission data reported by the plants for use in the air pollutant emission inventory, Part 2. (Note; the name of VAHTI has been changed to YLVA in 2018)

YLVA database

The Centres for Economic Development, Transport and the Environment (ELY Centres[10]) process environmental permits and monitor the compliance of activities to the requirements. The operators report data and information according to the monitoring and reporting obligations in their permits. The data is collected into the central YLVA database of the ELY Centres (Figure 1.11 to be updated to the next submission).

YLVA includes information and data on wastes generated, wastewater discharges and emission into the air. This baseline data is used by the ELY Centres in their work for supervising the activities. Emission data is also available to the inventory agencies for the use in emission inventories.

YLVA contains information on how facilities comply with the environmental regulations. A case management tool is incorporated into the system and the user interface makes it possible to add new customers, change or add customer data, retrieve reports from database and write inspection reports. The system includes mapping functions and a calendar to remind the inspector of time limits. Currently, there are 600 active users of the system.

[10] https://www.ely-keskus.fi/en/web/ely-en/

YLVA is a customer information system. The information recorded of the customer (i.e. an industrial plant) include, for example:

- facility identification details
- contact persons at the facility and environmental administration
- environmental permit conditions
- environment insurance information
- discharge points (stacks and sewers)
- information on process techniques and existing
- release control techniques
- information on fuels used
- information on landfills
- information on releases to air, water and wastes as well as related analysis data
- information on energy production and other production
- information on consumption of raw materials and water

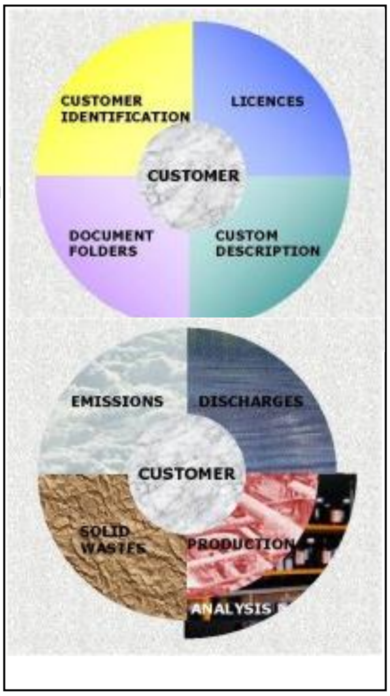


Figure 1.11. Structure of the YLVA database

The operators of installations (i.e. energy producers, industrial installations, fish farmers, peat producers, waste management, wastewater treatment plants) that have an environmental permit report information to the ELY Centres through a centralized data collection system. After checking and approving the data the supervising authorities record the data into the YLVA database from where it is available also for emission inventory purposes.

The coverage of installations in the Finnish environmental legislation is wider than in the European Union's Industrial Emissions Directive (IED). YLVA database includes information of about 31 000 clients out of which about 28 000 are currently in operation and about 3 000 out of operation. Out of these only about 1 000 installations fall under the EU IED. In 2006, 3 401 facilities sent their emission reports to the authorities. The number of facilities that reported information in 2015 on emissions to air, water or on wastes is presented in Table 1.4.

Table 1.4 Facilities reporting information to VAHTI in 2015. (to be updated to the contents of YLVA)

Activity	Water	Air	Waste
Energy production and industrial installations	1 110	623	770
Municipalities	384	6	261
Fish farms	169	0	20
Others	111	421	1 096
Total	1 774	1 050	2 147

Small facilities as well as part of the medium sized facilities, such as small animal shelters and petrol stations, are not yet requested to report to the authorities.

Air pollutant reporting obligations for plant operators

Annual emissions reporting under the environmental permit

In the environmental permit, or in a plant specific emission monitoring and reporting programme annexed to the permit, requirements are determined on what the operator (i.e. a person or a legal person in charge of a facility) must report to the authorities. The annual reporting obligation of an installation concerns emissions for which the installation has an emission limit value (ELV) in the environmental permit. The monitoring system for these substances is stipulated together with the ELV for these compounds. In the environmental permits ELVs are usually given for emissions of sulphur (as SO_2), particles (as TSP or PM_{10}) and nitrogen oxides (as NO_2), in some cases also for heavy metals, NMVOCs, ammonia, POPs and halogens, but not for greenhouse gases (carbon dioxide, methane, nitrous oxide or F-gases).

E-PRTR reporting

Emissions falling under the European Pollutant Release and Transfer Register (E-PRTR)[11] reporting scheme are reported as total emissions for an industrial site. Those air pollutants that are not included in the reporting requirements under the environmental permits may, however, fall under the reporting requirement of the E-PRTR.

Format and procedure of reporting

The plants report the emissions by individual boilers and processes or as total emissions for an industrial site, according to how the data is stipulated to be reported in the environmental permit.

The operators also report on the types, characteristics and consumption of fuels, though this data may not be as complete as emission data. Information on waste amounts, with official classification codes, to solid waste disposal sites, and wastewater handling data are available from YLVA.

The operators may submit emission reports to the supervising authorities as hard copies, electronically by email or through the Internet (Figure 1.12). The larger industrial installations use systems that allow direct information flow from the plant information systems to the supervising authority.

The emission data is always checked by the supervising authority before it is recorded into YLVA.

When the operator chooses to send the data over the Internet using the national authorities' centralized data collection system the data is automatically checked for completeness and only the completed data set will be sent to the authorities for further checking.

[11] According to the Finnish Environmental Protection Act chapter 20 section 223 the Environmental Protection Register contains information about emission reports and monitoring connected to the environmental permits. The ELY Centres and municipal authorities are responsible for collecting the data from the operators. This data, as well as the data reported under the EPER or E-PRTR obligations are recorded into the YLVA data system from where it is available for inventory purposes.

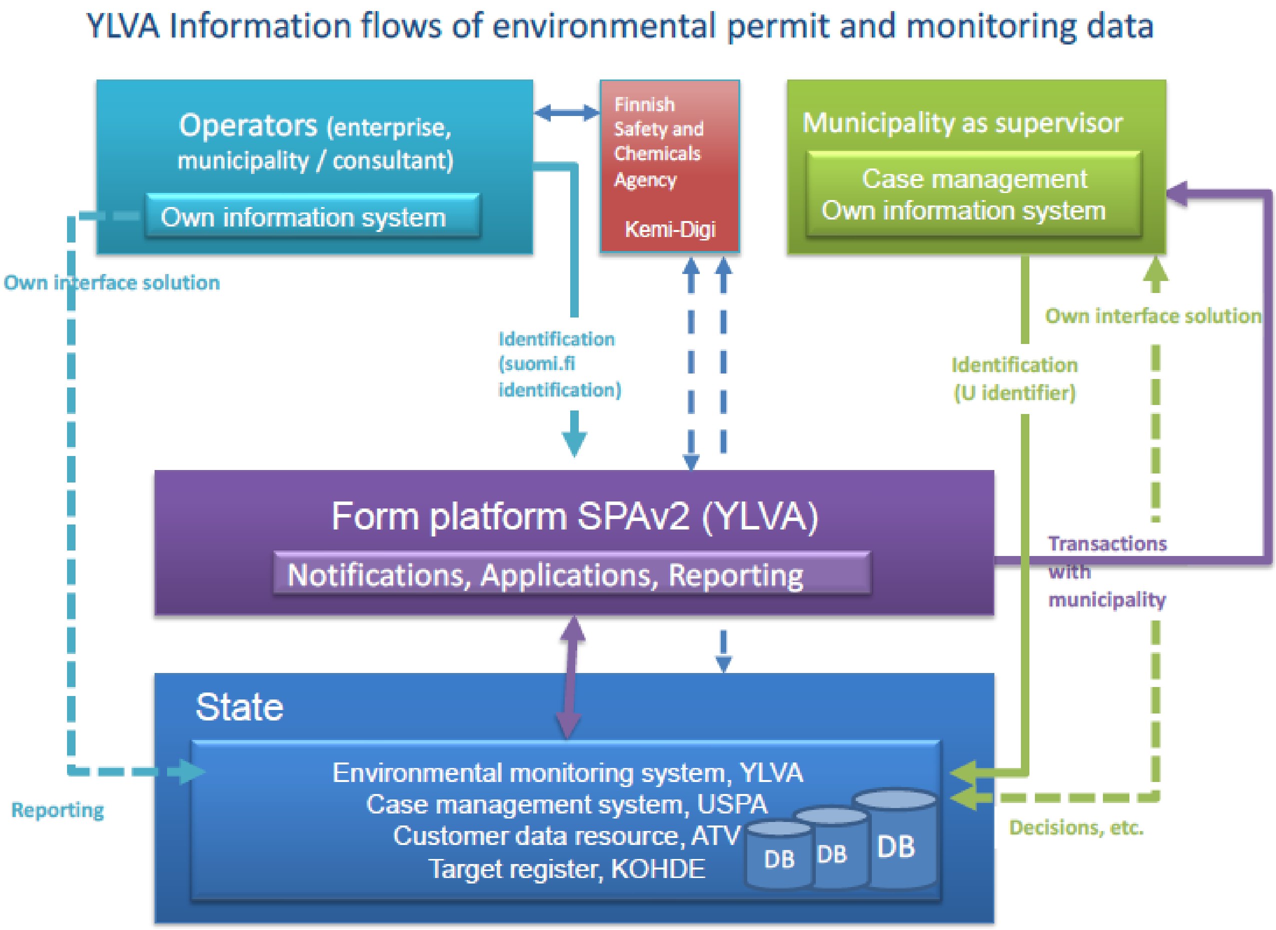


Figure 1.12. Reporting data flows in YLVA system.

QA/QC carried out by the supervising authority

When receiving the emission report from the operator the supervising authority checks the correctness of the data as well whether the data is produced according to the methods agreed upon in the environmental permit or in a separate monitoring programme for the plant. The methods usually include the use of international standards or approved in-house methods. The principles of the EU IED Reference Document on Monitoring of Emissions (Monitoring REF) are also followed.

Programme to improve point source data

In 2011-2013 a project (TIVA2) was running in the environmental administration to integrate the contents of YLVA database with corrected and completed data from air and wastewater databases at SYKE to provide the end-users of data the latest and corrected information through a new interface. This means that cross-checks and corrections made e.g. in the air pollutant emission inventory are included in the data available through the new system. The new interface is planned to serve also the needs of a national PRTR system.

Use of EU ETS data

The operators report emissions of carbon dioxide as well as fuel data to the Energy Authority that keeps the Emission Trading Register. The annual emission data in the EU ETS was earlier reported mainly on process level but recently only on the level of facilities. This data is available for emission inventory purposes for Statistics Finland and the Finnish Environment Institute.

More details of the use of ETS data in the inventory is provided under the Energy sector in Chapter 4.2.4 Source specific QA/QC and verification.

How data reported to authorities is handled in the inventory

For all substances falling under the substances list of the CLRTAP, default emissions in the energy production sector are calculated in the inventory system. These default emissions are used in the preparation of the national inventory. In case the operator reports any emission values, these are compared against the default values calculated in the inventory system and in case found reasonable, included in the inventory in-stead of the default values. In unclear cases, the inventory agency contacts the supervising authorities or the plant operator directly to confirm the correctness of the reported value and the reason behind any deviating values. The comparison between the calculated default values and data reported by the operator can be seen as part of a verification process for both data sets.

In cases where the operator reports only the total emissions of a site, the default emissions calculated for energy production activities (e.g. boilers, turbines etc.) for the site, are used to allocate the total emissions of the site under relevant NFR categories as follows: the default emission value(s) calculated for energy production are subtracted from the total emission of a site and the remainder is reported under the relevant NFR sector (e.g. under an industrial processes sector). These cases mainly relate to TSP emissions reported by a relatively small number of plants.

1.3.5 Inter-comparison with greenhouse gas emission inventory data

The calculation systems for the air emissions inventories under the UNECE CLRTAP and EU NECD are separate from the GHG calculation system but use mostly the same basic data sources for calculating emissions from fuel combustion. The independence of the calculation systems is used as a verification tool for the inventories, and moreover, as a source of additional corrections in point source data. Comparisons between the data in these two calculations systems are performed continuously during the inventory preparation. The annual calculation at Finnish Environment Institute SYKE is performed a bit later than the GHG inventory and, thus, the source data set usually includes more updated data than used in the preliminary EU GHG inventory. The thorough comparison between the Air pollutant and GHG inventories in accordance with the EU Governance Regulation (2018/1999) is performed after 15 February and the differences are either corrected or accounted for by the 15 March submissions.

The inter-comparison between Statistics Finland and the Finnish Environment Institute is carried out with data related to the fuel combustion source categories at the aggregation level allowed for statistical confidentiality as presented in Figure 1.13. The inter-comparison is explained in more details under Energy sector in Chapter 4.2.4 Source-specific QA/QC and verification.

The observed omissions and errors are corrected to both inventories according to the results of the inter-comparison. The remaining differences are explained in Chapter 1.4.3.

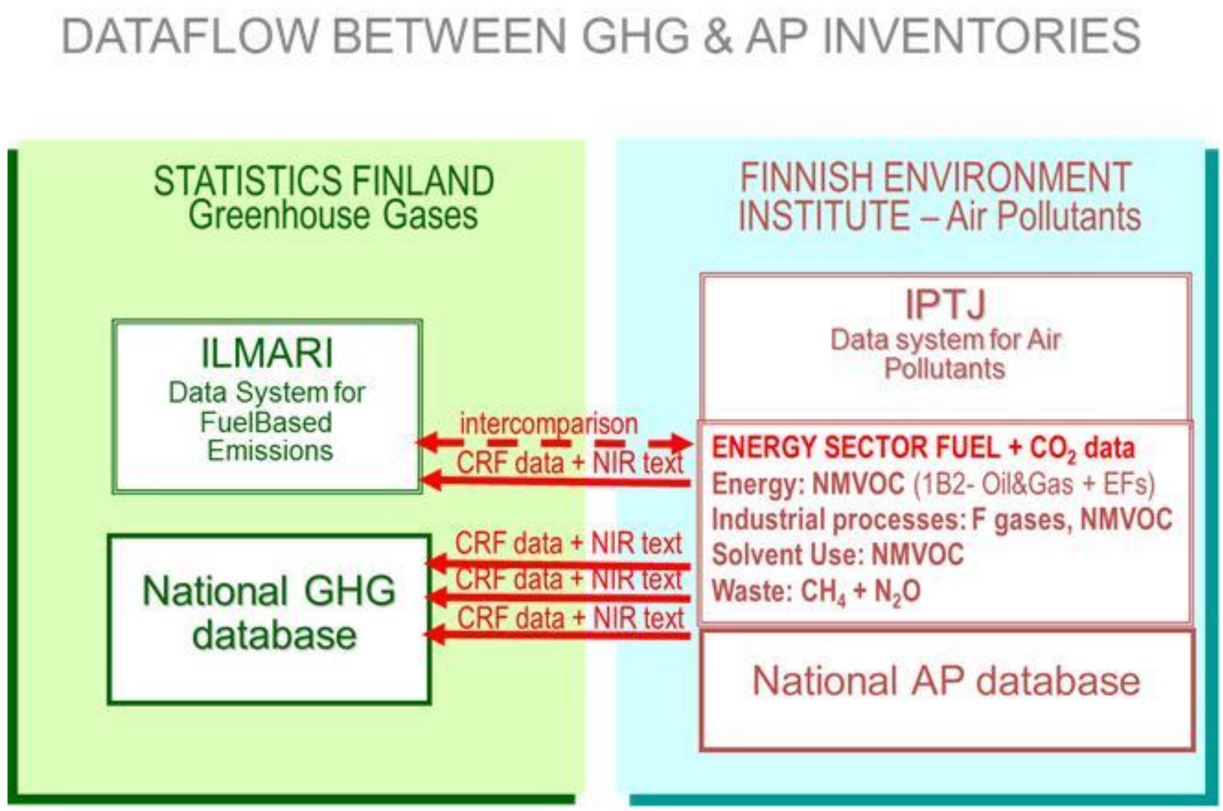


Figure 1.13. Inter-comparison of air emissions inventory data between Statistics Finland and SYKE.

1.4 Methods and data sources

1.4.1 Methodology

Changes in chapter	
February 2021	KS

The EMEP/EEA Emission Inventory Guidebook methodology and national methods are used in the preparation of air pollutant emission inventories. Country specific emission factors and compliance data reported by the operators or emissions estimated by the industrial associations are used whenever they provide better estimates of the national circumstances than the default values. The latest version of the EMEP/EEA Emission Inventory Guidebook was published in October 2023. Due to the relatively late publication date in relation to the 2024 submissions under the UNECE CLRTAP and the EU NECD, the new emission factors and new or revised methodologies introduced in the new version of the Guidebook have not yet thoroughly been implemented in all sectors. Detailed descriptions of the implementation of the 2023 Guidebook are provided in the sector specific parts of the IIR.

The Nomenclature for Reporting (NFR) tables are used in reporting the emission figures under the UNECE CLRTAP and the EU NECD.

In this report, compilation of emission data for 2022 is described in detail while the compilation of the data for the earlier years is presented at a more general level.

1.4.2 Differences in the methods between the submissions in 2022 and in 2023

Changes in chapter
March 2023 KS

There are no major differences in methods used in the previous inventories and the one submitted in 2022. Some updates and improvements are made as detailed in the sector specific chapters 4-9 and summarised in Chapter 14.

1.4.3 Differences in emission data reported under different reporting obligations and cooperation between inventory agencies

Changes in chapter	
March 2024	TF

This chapter explains differences between the submissions to the UNECE CLRTAP Secretariat and to the EU NECD to the UNFCCC Secretariat and to the Commission under the EU Governance Regulation (2018/1999).

A quantification of differences in the 2024 submissions to the UNFCCC, CLRTAP and NECD regarding data for 2022 are presented in Table 1.5.

Table 1.5 Differences between 2021 emissions in UNFCCC/EC (2023)-CLRTAP (2023)-NECD(2023) submissions

Submissions				Difference %		
2022	UNFCCC	CLRTAP	NECD	CLRTAP-UNFCCC	NECD-UNFCCC	CLRTAP-NECD
SOx	22.692	23.374	23.374	-2.9	-2.9	0
NOx	90.979	99.292	99.292	-8.4	-8.4	0
NMVOC	75.464	75.375	75.375	0.1	0.1	0
CO	310.209	305.508	305.508	1.5	1.5	0

The differences for NO_x emissions are due to the use of different versions of the agriculture calculation model in the air pollutant and the greenhouse gas inventories. For NMVOC and CO, additional differences originate from the method used to calculate emissions from small scale wood combustion, where the greenhouse gas inventory not yet has updated the emission factors.

Some minor differences generally exist for SO_2, NO_x, NMVOC and CO emissions, due to the following reasons:

(1) Energy sector emission data in Finland is calculated in two different calculation systems:

- The data submitted to the UNFCCC Secretariat and to the EU Commission under EU Governance Regulation (2018/1999) is calculated at Statistics Finland, which is the National Inventory Agency for Greenhouse Gas Inventories.
- The data submitted to the UNECE CLRTAP Secretariat and the EU Commission under the EU NECD is calculated at the Finnish Environment Institute, which is responsible for the national inventory of air pollutants.

(2) Allocation of data in the CRF and NFR tables: harmonization of the allocation of emissions has some inherent challenges due to the different reporting formats (CRF and NFR). For instance, it is not always possible to report the same activities under the corresponding CRF/NFR source

categories because certain sources fall under a CFR category in the greenhouse gas inventory, while air pollutants generated from the same activity are not related to the given CRF/NFR category and are therefore reported under the main activity of the plant.

(3) The allocation of point sources in the CRF and NFR inventory categories may differ somewhat in the data systems of the two institutes and checks on the allocation are regularly made between StatFi and SYKE.

(4) Currently in the time series of the inventories there are certain differences, some of which are related to a different timing of uploading point source data from the compliance reporting database YLVA (Chapter 2.3.3), as the contents of YLVA is being improved by completing and correcting the data throughout the year, for both the current and the historical years. In cases where deficient data is not corrected in YLVA database, the inventory agencies cooperate to use corrected data in their inventories. Some differences between the two energy sector inventories may also be related to errors and omissions in the inventory databases at Finnish Environment Institute or Statistics Finland. Efforts are made to ensure consistency of the data.

The annual inter-comparisons between Statistics Finland and Finnish Environment Institute are explained in Chapter 2.3.4.

Benefits of the cooperation

Due to intensive cooperation of energy experts at Statistics Finland and SYKE, the two inventory approaches in calculation of energy sector emissions can be regarded as an efficient QA/QC tool because errors and omissions are efficiently identified and corrected where found.

NMVOC emissions

NMVOC emission data for other sources than energy are calculated at Finnish Environment Institute and integrated into the CRF tables reported under the UNFCCC and EU Governance Regulation. Thus, the emission data, activity data and methodologies are the same in all of these inventories. Energy sector NMVOC emissions are calculated in both Statistics Finland and SYKE's calculation systems using the same emission factors. Since the 2017 reporting emissions for small scale combustion sources are calculated by the new technology specific model under the CLRTAP and NECD while not yet included in the UNFCCC reporting, where adoption of the new model is underway.

Nitrogen/NH_3 emissions

Nitrogen emissions used as input data in the greenhouse gas inventory are calculated at LUKE (Agrifood Finland) for the use of agriculture sector greenhouse gas emission inventory. The emissions are calculated in the same model (see IIR Part 5 Agriculture for details) as ammonia emissions in the air pollutant emission inventory. The model is accessible for both institutes through the Internet. This guarantees that the source data and emissions are the same in both inventories.

1.4.4 Possible differences between the emission inventory reports under the UNECE CLRTAP and the EU NECD

Changes in chapter
February 2021 KS

Since the revision of the NECD and adoption of the same reporting requirements than the CLRTAP, no differences will be in the reported emissions because a copy of the data submitted under the CLRTAP is reported under the NECD.

The inventories under the UNECE CLRTAP and under the EU NECD are both calculated in the same inventory system at Finnish Environment Institute.

1.5 Key categories

Changes in chapter	
February 2024	TF

According to the EMEP/EEA Emission Inventory Guidebook 2023, "a key category is one that is prioritised within the national inventory system because it is significantly important for one or a number of air pollutants in a country's national inventory of air pollutants in terms of the absolute level, the trend, or the uncertainty in emissions".

The results of the key category analysis are used in prioritizing the inventory improvements. For the Finnish 2024 submission inventory, the Approach 1 methodology presented in the EMEP/EEA emission inventory guidebook 2023, including the level and the trend assessment, has been used to identify key categories for each pollutant. Key source categories are sources that together contribute with either 80 % of the level or 80 % of the overall trend of reported emissions.

The combined results of the level and trend analysis for the latest submission are presented in Annex 7.

1.6 QA/QC, verification and treatment of confidentiality issues

Changes in chapter	
May 2018	KS, JM

1.6.1 Quality system

A quality management system is used to support the preparation of the air pollutant emissions inventory. QA/QC procedures have been implemented in the inventory work since the inventory of the year 2003 emissions carried out in 2005 they follow the principles carried out in the Finnish greenhouse gas emission inventory[12].

[12] See https://stat.fi/en/statistics/documentation/khki and https://www.stat.fi/org/periaatteet/laadunhallinta_en.html

1.6.2 Quality plan and QA/QC procedures

Quality plan

The QA/QC plan covers quality objectives and the planned general quality control and quality assurance procedures regarding all sectors. The checklist in Table 1.7 specifies the actions, schedules and responsibilities in order to attain the quality objectives and to provide confidence in the preparation of high-quality inventories.

The QC procedures comply with those set in the EMEP/EEA Emission Inventory Guidebook 2009. General inventory QC procedures include routine checks of the integrity, correctness and completeness of the data, identification of errors and deficiencies, documentation and archiving of the inventory data as well as quality control actions.

*Table 1.7 Quality objectives (* means restricted applications due to availability of resources)*

Inventory principle	**Quality objectives**
1.Continuous improvement	1.1. Treatment of review feedback is systematic 1.2. Improvements are indicated in Informative Inventory Report and carried out* 1.3. Improvement of the inventory is systematic * 1.4. Inventory quality control procedures meet the requirements * 1.5. Inventory quality assurance is appropriate and sufficient*
2. Transparency	2.1. Archiving of the inventory is systematic and complete 2.2. Internal documentation of calculations supports emission and removal estimates 2.3. NFR tables and Informative Inventory Report include transparent and appropriate descriptions of emission estimates and of their preparation
3. Consistency	3.1. The time series are consistent * 3.2. Data have been used in a consistent manner in the inventory *
4. Comparability	4.1. The methodologies and formats used in the inventory meet comparability requirements
5. Completeness	5.1. The inventory covers all emission sources, pollutants and geographic areas
6. Accuracy	6.1. Estimates are systematically neither higher nor lower than the true emissions or removals 6.2. Calculations are performed correctly 6.3. Inventory uncertainties are estimated
7. Timeliness	7.1. Inventory reports submitted within the set time

Applied QA/QC procedures

<u>Internal review</u>

Normal statistical quality checks and comparisons to the previous years' data are implemented in the preparation of the inventory.

For the energy and industrial processes sectors compliance data reported by the plants have been used where applicable. The quality checks performed to the compliance data are explained in Chapter 1.3.

Category-specific QC checks including technical reviews of the source categories, activity data, emission factors and methods are applied on a case-by-case basis focusing on key categories and on categories where significant methodological and data revisions have taken place.

QA reviews performed after the implementation of QC procedures concerning the finalised inventory comprise comparisons and checks to assess procedures already taken and to identify areas where improvements could be made. Specific QA actions include basic reviews of the draft report, data verification with other available datasets and information sources. The data and documentation are cross-checked by several experts not involved in the area where they do the checks.

QA/QC tools

In 2017-2018 a series of tools was developed to manage the data in the IPTJ and to compile, analyse and correct the NFR output data. The tools were applied in the recalculation of the time series 1990-2016 reported on 13th April 2018.

The tools consist of a variation of solutions, techniques and manual routines to manage the content of over two million rows or air emission data. The tools connect directly to the IPTJ and allow the latest information to be always available in a comprehensive format. The embedded check-ups find inconsistent notation keys, strongly deviating values, gaps in emission data and trend progression analysis (remark on sudden decrease or increase) and general value validity. Also notation key management tools are included.

The tools enable comparisons between datasets by highlighting emission rates that increase or decrease over a selected tolerance. It also highlights cells to which IPTJ contains updated values. In such cases, the changes can be exported to the NFR reporting sheet instantaneously for the selected year, range of years or all years. This enables agile and adjustable control over the whole time series.

The time series for national totals or individual NFR-categories can be evaluated with an index value that is constructed by analysing the standard deviation of the series and the count of points of discontinuity. The indexing helps in directing focus into the most relevant subjects. All values are also visually enhanced to create a visual overview of series consistency. A more detailed description of the tools is presented in Annex 6.

Inter-comparisons

Close cooperation is carried out with the Finnish Greenhouse Gas Inventory Unit at Statistics Finland, to maintain comparability and to discuss improvements and their impacts on both air pollutant and greenhouse gas inventories. Annual inventories are compared and possible differences discussed and corrective actions made in both inventories where relevant.

External review

CLRTAP S1 and S2 review results by the review conducted by the CEIP are used to identify deficiencies and errors in the data.

CLRTAP S3 review results as well as NECD Technical Reviews' results have been addressed in the sector specific chapters of the IIR (under Recalculations).

1.6.3 Implementation of the QA/QC plan in the preparation of the data

The leading principle has been that certain source categories or certain types of quality measures to solve systematic errors are taken under work during one inventory year.

QA/QC measures are carried out separately for each of the boxes illustrated in Figure 1.14 as follows:

1. dark blue boxes cover calculation in MSExcel sheets where data checking and comparison is mostly visual but rather straight forward, and the data used comes from statistics, industrial organizations or research
2. light blue boxes cover database tables within the IPTJ data system with inbuilt check operations; these data are also compared, where possible, against environmental reports by

plants and E-PRTR data, both of which are also used in the inventory, as well as statistics and expert institutes
3. light red boxes include data, which is cross-checked between Statistics Finland data sets for fuels and emissions at CRF classification level, as well as comparisons to EU ETS data, which is also used in the inventory
4. the final results are manually compiled for 1980-1989 into the NFR table; for 1990-2022 the IPTJ QA/QC tool is used both to compile the NFR tables and to check the data.
5. Manual comparison against CRF data is carried out before the reporting, deviations are explained in the IIR Chapter 1.4.3.

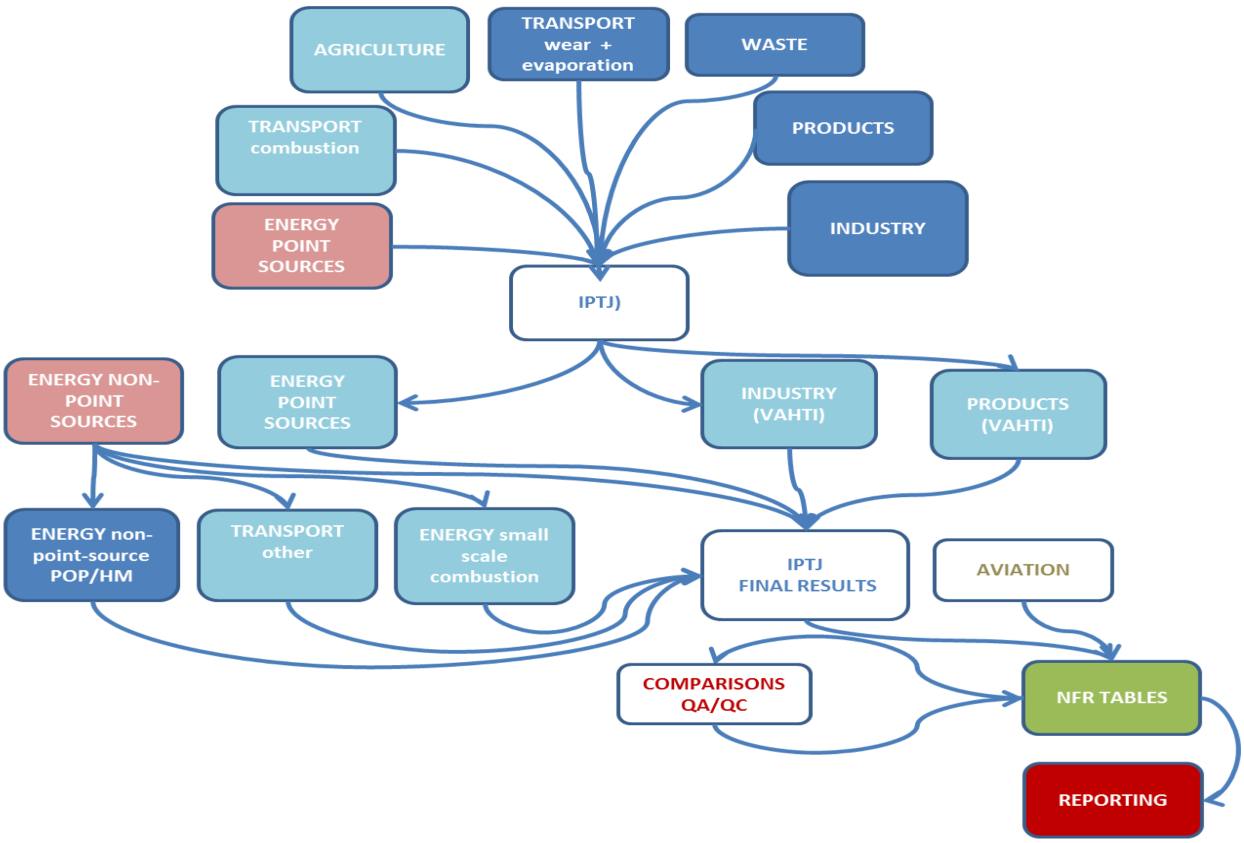


Figure 1.14 The process of data compilation for reporting

1.6.4 Documentation

Documentation of the calculation methods is updated whenever there are changes in the methods or new sources are included in the inventory. The documentation is carried out in the working guidelines available for each source sector (in Finnish). Notes and explanations for deviating values are recorded in the calculation sheets.

A summary of improvements made in the inventory is presented in Chapter 14.

1.6.5 Archiving of the inventory

The annually reported NFR tables, calculation sheets and documentation of the methods together with the records of the original data are archived at the Finnish Environment Institute. The original data sets and calculation results are stored in databases on a SQL server.

1.6.6 Verification

The inter-comparison explained in Chapter 1.4 is carried out annually. The inventory has not yet been verified by a third party.

1.6.7 Treatment of confidential issues

When confidential information is used for the preparation of the inventory, this data is handled and stored in a way that ensures the confidentiality to remain. When confidential data is included in the reported emissions, the emissions are aggregated so that disclosure of confidential information is not possible.

1.7 Uncertainties

Changes in chapter	
March 2021	TF

1.7.1 Methodology

The uncertainty analysis for emission data is carried out following the Approach 1 methodology presented in the EMEP/EEA emission inventory guidebook 2019. The Approach 1 comprise estimation of uncertainties using the error propagation equations, and simple combination of uncertainties by source category to estimate overall uncertainty for one year and the uncertainty in the trend. The uncertainties of the input parameters (activity data and emission factors) are estimated by experts compiling the inventories and those of the measured emissions by the competent authorities that supervise emission monitoring carried out at the individual plants. In the case of emissions reported by the plants, the total uncertainty of the reported emission is determined instead of separate uncertainties for AD and EF. The fuel use uncertainties are the same that Statistics Finland uses in the UC analysis for the Finnish greenhouse gas inventory. The emissions of some pollutants from certain sources are poorly understood, for instance some POP compounds from fuel combustion and industrial processes, and therefore estimation of their uncertainty is found to be very challenging at the moment. The uncertainty analysis will be further developed to the next submission by re-evaluating the input parameters.

The uncertainty analysis covers all emission sources included in the inventory and represents thus the uncertainty of the reported emission data. The possible lack of completeness of emission sources is, however, not reflected in the uncertainty analysis. Information of the completeness of the inventory is presented in Chapter 1.8.

The uncertainty analysis is carried out at the country-level, i.e. uncertainties in emissions by region are not assessed.

The complete results of the uncertainty analysis are presented in Annex 6. The uncertainty for the total emissions together with the uncertainty for the trend for all pollutants are presented in Table 1.8. The year 1990 has been used as a base year for all pollutants in the uncertainty analysis.

The latest uncertainty analysis has been carried out in in submission 2023 for the 2021 emissions and for the trend 1990-2021. The uncertainty analysis will be updated again in the 2025 submission.

Table 1.8. Summary of uncertainties in total inventory by pollutant in 2021 and trend uncertainties 1990-2021.

Pollutant	Uncertainty in total inventory 2021 (%)	Uncertainty introduced into the trend 1990-2021 (%)	Pollutant	Uncertainty in total inventory 2021 (%)	Uncertainty introduced into the trend 1990-2021 (%)
NO_x	13.2	6.4	Hg	46.6	31.8
NMVOC	41.1	20.4	As	28.1	2.4
SO_x	5.5	0.7	Cr	26.1	11.1
NH_3	66.0	80.7	Cu	75.3	26.5
$PM_{2.5}$	48.0	20.5	Ni	20.3	3.7
PM_{10}	44.6	23.7	Zn	31.2	9.0
TSP	31.2	19.3	PCDD/F	279.5	288.8
BC	59.2	28.0	PAH-4	187.2	292.7
CO	35.0	21.8	HCB	285.0	260.4
Pb	31.1	1.8	PCB	269.0	309.5
Cd	33.5	6.0			

1.8 General assessment of completeness

Changes in chapter	
March 2022	JMP, ks

The completeness by emission sources and the geographical and timely coverage of the inventory is explained in this chapter.

The annual submissions of LPS data are presented in Chapter 11 and of projected emissions in Chapter 13.

The figures in the NFR tables are given with an accuracy of three decimals from the inventory calculations.

1.8.1 Completeness by emission sources

The inventory is almost complete regarding the emission sources and substances and it can be estimated that the total emission levels are representative to the actual emissions. However, there are still a few cases where either the lack of methodology or activity data has prevented quantifying the emissions, for instance, in the product use sector.

Sources that are reported as not estimated (NE) are listed in Table 1.9

Table 1.9 Explanation of the use of the Notation key NE in NFR Tables submitted in 2023.

NFR14	Substance	Reason for not estimated
1A1a 1A1b 1A2a-f 1A2gviii 1B1b 2C1 2C2 2G	Se	A comprehensive inventory of all sources of Se is not yet available, however, bottom-up data reported by the plants is included in the inventory

Allocation of emissions reported as included elsewhere (IE) is provided in Table 1.10 and explanation of sources reported under categories Other in Table 1.11.

Table 1.10 Explanation of the use of the Notation key IE in NFR tables submitted in 2023.

NFR14	Substance	Included in
1A2a-f, gviii	NOx, SOx 1980-1989*	1A1a
1A1c	NOx, NMVOC, Sox, PCDD/PCDF, HCB	IE depending on the year reported (use of NA/IE will be checked when the recalculation is finalized)
1A2f	NH3	USE of notation keys and allocation will be checked when the
1A3ei	NOx, SOx 1980-1989*	1A1a
1A4ai, bi, ci	NOx, SOx 1980-1989*	1A1a
1A5a	NOx, SOx 1980-1989*	1A1a
1B1a	Particles	2A5c
1B1b	NOx, CO	1A2a
1B2ai	NMVOC 1990-2019	1A3ei
1B2aiv	NOx, SOx, NH3, BC, CO, heavy metals, PCDD/PCDF	See IIR Part2Energy on page 27
1B2c	NOx, NMVOC, SOx, particles, heavy metals	1A1a
2A1	NOx, SOx, PM2.5, PM10, TSP, BC	1A2f
2A2	SOx	1A2f/1A2gviii
2A3	NOx	1A2f
2C1	NOx	1A2a, 1A2b or 1A2gviii
2C2	NMVOC 1990-2002, SOx 1990-2012	1A2a
2C3	NMVOC 1992-1996, 1998, 2001-2002, 2014-2019	1A2b or 1A2gviii
2C6	Hg 1990-1994, Cu 1990-2001, Ni 1990-1991	1A2b or 1A2c
2C6	PM2.5, PM10, TSP 2016-2017, 2019	1A2b
2C7a	NMVOC 1990-1995	1A2b
2C7b	PM2.5, PM10, TSP	1A2a
2D3f	NMVOC	2D3e
5C1bii	all	1A1a or 1A2gviii
5C1biii	NOx, NMVOC, SOx, NH3, particles, CO, Cr, Ni	1A1a or 1A2gviii
5C1biv	NOx, NMVOC, SOx, CO	1A1a or 1A2gviii

*will be verified to the next submissions

Table 1.11 Sub-categories reported under "Other" in the 2023 submission (updated every 5 yrs).

NFR14	Substance	SNAP	Sub-source description
1 A 2 g viii	all	030101 030102 030103a 030103b	Combustion plants in - manufacturing of fishing equipment - dry cleaners - rock wool manufacturing - concrete production - limestone production - car production - testing of engines - shipyards - quarrying and crushing - manufacturing of textiles - reparation of railway vehicles - starch modification - pellet production - manufacturing of zip production machines - light gravel manufacturing - manufacturing of gypsium products - manufacturing of tiles

NFR14	Substance	SNAP	Sub-source description
			- glass production - talc manufacturing
1 A 2 g viii	all	030105	Stationary engines in crushing
1 A 2 g viii	all	030204	Gas turbines in manufacturing of gypsium products
1 A 2 gviii	all	030205	Other furnaces, crushing
		030326	Other, boiler plants in food industry, mines tc
2C1		040210	Other metal production, -foundries
2C7c		040306 040307	allied metal manufacturing galvanizing
2C7c		040309z	smelteries, surface treatment plants
2C7d		040211	ferrous metals storage and handling
2 B10 a	all	040401	Sulfuric acid
2 B 10 a	all	040406	Ammonium phosphate
2 B 10 a	all	040407	NPK fertilisers
2 B 10 a	all	040413	Chlorine production
2 B 10 a	all	040414	Phosphate fertilizers
2 B 10 a	all	040416	Calcium Carbonate manufacturing
2 B 10 a	all	040416	Silicon wafer manufacturing
2 B 10 a	all	040416	Production of oxygen, nitrogen and hydrogen
2 B 10 a	all	040416	Al- and Fe-chemicals manufacturing
2 B 10 a	all	040416	Manufacturing of ion exchange and chromatographic resins and special polymers
2 B 10 a	all	040416	Pigments manufacturing
2 B 10 a	all	040416	Manufacturing of explosives
2 B 10 a	all	040416	Fertilizer manufacturing
2 B 10 a	all	040416	Manufacturing of cobolt based special chemicals
2 B 10 a	all	040416	Hydrogen peroxide plant
2 B 10 a	all	040416	Manufacturing of natrium silicate
2 B 10 a	all	040416	Potassium sulphate manufacturing
2 B 10 a	all	040416	Formic acid and hydrogen peroxide manufacturing
2 B 10 a	all	040416	Manufacturing of viscose staple fibres and by-products
2 B 10 a	all	040501	Ethylene
2 B 10 a	all	040506	Polyethylene Low Density
2 B 10 a	all	040507	Polyethylene High Density
2 B 10 a	all	040509	Polypropylene
2 B 10 a	all	040511	Polystyrene
2 B 10 a	all	040512	Styrene butadiene
2 B 10 a	all	040513	Styrene-butadiene latex
2 B 10 a	all	040527	Enzyme production
2 B 10 a	all	040527	Manufacturing of techno-chemical products
2 B 10 a	all	040527	Manufacturing of benzene, cumene and phenols
2 B 10 a	all	040527	Drag reducing additive production
2 B 10 a	all	040527	Manufacturing of prganic base chemicals
2 B 10 a	all	040527	Manufacturing of tall oil
2 B 10 a	all	040527	Manufacturing of organic fine chemicals
2 B 10 a	all	040527	Manufacturing of pharmaceuticals
2 B 10 a	all	040527	Manufacturing of titanium dioxide pigments
2 B 10 a	all	040527	Manufacturing of lignosulphonate products
2 B 10 a	all	040527	Cleaning of solvents and manufacturing of solvent mixtures
2 B 10 a	all	040527	Manufacturing of biocides and other 47gricultural chemicals
2 B 10 a	all	040527	Manufacturing of carboxymethylcellulose
2 A 6		040618	Limestone and Dolomite use
2 B 10 b	all	040522	Storage and handling of organic products
2 B 10 b	all	040415	Storage and handling of inorganic chemical products
2 L	all	040617	Light gravel manufacturing
2 L	all	040617	Talc manufacturing
2 L	all	040617	Ceramic household and decorative products manufacturing
2 L	all	040617	Tile manufacturing

NFR14	Substance	SNAP	Sub-source description
2 L	all	040617	Gypsium product manufacturing
2 L	all	040617	Quarrying and crushing
2 L	all	040617	Manufacturing of electricity distribution and monitoring devices
2 L	all	040617	Starch modification
3 B 4 h	all	100510	Fur animals and reindeer
3 B 4 g iv	all	100509z	other poultry
5 E	all	091101	Unintentional house fires
5 E	all	091102	Unintentional car fires
5 E	all	091103	Unintentional landfill fires
5 E	all	091007	Latrines

1.8.2 Completeness by geographical coverage

The inventory includes emissions from the autonomic territory of Åland (Ahvenanmaa). Information on national emissions allocated for the territory of Åland is underway and will be available later at the website *http://www.environment.fi > Maps and statistics Air pollutant emissions in Finland* >.

The gridded emissions data over the national territory are illustrated by maps for each substance in Chapter 2.3.

As a result from the project to prepare geographical presentation of emission data in 1 km *1 km resolution, Finland reported in May 2015 gridded data in the new 0.1^{O} * 0.1^{O} EMEP grid. The new EMEP grid equals approximately 7 km * 7 km resolution in Finland. The submissions of gridded data (Table 1.12) are available in the EIONET CDR.

Table 1.12 Finnish submissions of gridded data.

Pollutants	For the year	Comments
SO_X	1999 – 2022	
NO_X	1999 – 2022	
NH_3	1999 – 2022	
CO	1999 – 2022	
NMVOC	1999 – 2022	Gridded data for earlier years has been submitted year by year by their due dates. Updated gridded data will be sent when recalculation of time-series is finalized
PCDD/F	1999 – 2022	
PAH-4	1999 – 2022	
HCB	1999 – 2022	
PCB	1999 – 2022	
PCP	1999 – 2007*	
SCCP	-*	
TSP	1999 – 2022	*excluded from NFR tables since the 2009 submission
PM10	1999 – 2022	
PM2.5	1999 – 2022	
As	1999 – 2022	** inventory not complete, Se not one of the obligatory heavy metals
BC	2018-2022	
Cd	1999 – 2022	
Cr	1999 – 2022	
Cu	1999 – 2022	
Hg	1999 – 2022	
Pb	1999 – 2022	
Ni	1999 – 2022	
Se	-**	
Zn	1999 - 2022	

1.8.3. Completeness by coverage of years

The annual inventory submissions under the UNECE CLRTAP include emission estimates since 1980 as presented in Tables 1.9 and 1.10.

Complete emission data sets for all substances have been reported for the years 1980-2022 with the following exceptions:

SO_x, NO_x, NH_3 and CO: Emission data has been reported for the years 1980-2022 and is complete in the details for the years 1990-2022.

Heavy metals: Emission data has been reported for the years 1980/1990 –2022. The reporting requirement starts from the year 1990, the data is complete in details since 1990.

NMVOC: Emission data has been reported for the years 1988 –2022. The reporting requirement starts from the base year of NMVOCs for Finland 1988.

Particles: Emission data has been reported for the years 1990 –2022. The reporting requirement for particles starts from the year 2000.

Table 1.13 and 1.14 present Finland's official submissions of emissions and projections data.

Table 1.13 Finnish official submissions of emission data – the years indicate the year of emissions (not the submission).

Pollutants	Data per sector	National Totals	Comments
SO_X	1990-2022	1980-2022	National totals available for only those pollutants and Tiers for which reporting requirements existed
NO_X	1990-2022	1980-2022	
NH_3	1990-2022	1980-2022	The reporting requirement starts from 1990
CO	1990-2022	1980-2022	
NMVOCs	1990-2022	1980-2022	The reporting requirement starts from the base year for Finland 1988
PCDD/F	1990-2022	1980-2022	The reporting requirement starts from 1990
PAH-4 and indicator substances	1990-2022	1980-2022	The reporting requirement starts from 1990
HCB	1990-2022	1980-2022	The reporting requirement starts from 1990
PCB	1990-2022	1980-2022	The reporting requirement starts from 1990
PCP	1990-2007	1980-2022	Available separately and in the old submissions
SCCP	1990-2007	1980-2022	Available separately and in the old submissions
As	1990-2022	1980-2022	The reporting requirement starts from 1990
Cd			
Cr			
Cu			
Hg			
Ni			
Pb			
Zn			
Se	1990-2022	(inventory is not complete)	

Table 1.14 Finnish projected data (submitted annually).

Pollutants	Per sector for years	National totals for years	Based on
SO_X	2025, 2030, 2040*, 2050*	2025, 2030	WM
NO_X	2025, 2030, 2040*, 2050*	2025, 2030	WM
NH_3	2025, 2030, 2040*, 2050*	2025, 2030	WM
NMVOCs	2025, 2030, 2040*, 2050*	2025, 2030	WM
PM2.5	2025, 2030, 2040*, 2050*	2025, 2030	WM
BC	2025, 2030, 2040*, 2050*	2025, 2030	WM

**Depending on the sector.*

1.8.4 Completeness of information reported

In addition to emissions and projections data presented in Chapter 2.13.4. Finland reports gridded data as presented in Table 1.15 and data for large point sources (LPSs) as presented in Table 1.16.

Table 1.15 Finnish submissions of gridded data – the years indicate the year of emissions (not the submission).

Gridded data submissions	Format
1999-2013	EMEP Grid 50 km * 50 km
1990, 1995, 2000, 2005, 2010, 2015, 2020 and 2022	EMEP Grid 0.1 º * 0.1 º

Table 1.16 Finnish submissions of LPS data - the years indicate the year of emissions (not the submission).

Main Pollutants	LPS data submitted
SO_X	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
NO_X	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
NH_3	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
CO	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
NMVOCs	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
PCDD/F	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
PAHs	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
HCB	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
PCBs	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
Cd	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
Pb	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
Hg	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022
PM_{10}, $PM_{2.5}$	1990, 1995, 2000, 2005, 2010 , 2015, 2020, 2022

1.8.5 Use of Notation Keys

Changes in chapter	
March 2023	KS JMP

The application of notation keys is reported on Reporting Table IV extension sheet. Notation keys are used and understood in the Finnish inventory as follows:

IE Included elsewhere – Emissions for this source are estimated and included in the inventory but not presented separately for this source (the source where included is indicated in 0).

In the Finnish inventory IE is used when it is not possible to give disaggregated values.

NA Not applicable – The source exists but relevant emissions are considered never to occur.

In certain cases, mainly in the Energy and Industrial Processes sectors, ***instead of using NA, the actual emissions*** are presented for categories where both the sources and their emissions are well-known due to availability of bottom-up data. When pointing the value "0.000" with the cursor, the actual emissions can be seen. The value "0.000" is shown in the NFR table due to the rounding of data to three significant decimals. Summing up of these below 0.000 values often results in emissions of > 1 reporting unit and would thus cause inaccuracies in the sums as well as when compared to e.g. gridded or LPS data.

NE Not estimated – Emissions occur but have not been estimated or reported.

NE is used when the source exists and it can be assumed that emissions occur, but the emissions have not been estimated.

NO Not occurring – A source or process does not exist within the country.

The source does not exist in Finland.

C Confidential information – Emissions are aggregated and included elsewhere in the inventory because reporting at a disaggregated level could lead to the disclosure of confidential information.

NR Not relevant - According to paragraph 9 in the Emission Reporting Guidelines, emission inventory reporting should cover all years from 1980 onwards if data are available. However, “NR” (not relevant) is introduced to ease the reporting where emissions are not strictly required by the different protocols, e.g. for some Parties emissions of NMVOCs prior to 1988.

NR is not in use in the Finnish inventory report.

1.8.6 Basis for estimating emissions from mobile sources

The basis for estimating emissions from mobile sources is presented in Table 1.17 Fuel statistics for mobile sources is providing in the NRF reporting tables.

Table 1.17 Basis for estimating emissions from mobile sources.

NFR09	Description	Fuel sold	Fuel used
1 A 3 a i (i)	International aviation (LTO)	*x*	
1 A 3 a i (ii)	International aviation (Cruise)	*x*	
1 A 3 a ii (i)	1 A 3 a ii Civil aviation (Domestic, LTO)	x	
1 A 3 a ii (ii)	1 A 3 a ii Civil Aviation (Domestic, Cruise)	x	
1A3b	Road transport	x	
1A3c	Railways	*x*	

1A3di (i)	International maritime navigation	x	
1A3di (ii)	International inland waterways	x	
1A3dii	National navigation	x	
1A4ci	Agriculture	x	
1A4cii	Off-road vehicles and other machinery	x	
1A4ciii	National fishing	x	
1 A 5 b	Other mobile (Including military)	x	

2 KEY EMISSION TRENDS

Changes in chapter	
February 2024	TF

2.1 Description and interpretation of emission trends for air pollutants emissions

2.1.1 Overview of factors having impact on the emission trends

Fluctuations in the economic and climatic conditions are reflected in the different emission source sectors. For instance, changes in electricity imports and production of fossil fuel based condensing power cause annual variation in the energy sector emissions and emissions from industrial processes are influenced each year by the economic situation. The main industrial sectors in Finland are energy intensive. In addition, weather conditions and the volumes of energy produced with renewable energy sources vary annually.

Information by individual air pollutants is provided under Chapter 2.3 and by emission sources under the sector specific parts of the IIR.

2.1.2 Air pollutant emission time-series

The air pollutant emission inventory includes estimates of the so-called main pollutants, i.e. sulphur dioxide, nitrogen oxides, carbon monoxide and ammonia since the year 1980 and non-methane volatile organic compounds (NMVOC) since 1988.

Heavy metal emissions have been estimated since 1990 for lead, cadmium, mercury, arsenic, chromium, copper, nickel, vanadium and zinc. There is not yet a comprehensive emission inventory covering all sources of selene. Vanadium is not included in the international reporting obligations, but an annual inventory is prepared for domestic purposes. Information on cobolt emissions from point sources is collected annually but a comprehensive inventory has not been established.

Persistent organic pollutants (POPs) are estimated since 1990 and include PCDD/F, PAH-4, HCB, HCH, PCB. In addition, PCP and SCCP which no more are included in the reporting obligations are covered by annual inventories for domestic purposes. In addition, studies were carried out in 1990-2006 on emissions of the following POP compounds: HBCD, HBCDD, HCBD, DeBDE, OBDE, PeBDE PeCB, PCN, PFAS/PFOS.

Particulate matter emissions have been estimated since year 2000 for total particles and particle sizes smaller than 10 μm and 2.5 μm as well as for black carbon (BC).

Air pollutant emission trends by pollutant are discussed in Chapter 2.3. In general, the emission levels are decreasing. The annual variations mainly depend on economic trends for the energy intensive sectors, the production level of hydropower, the level of imported electricity and the availability of alternative non-carbon energy sources. In Finland, the level of imported electricity is highly affected by the annual rainfall situation in the neighboring countries, Sweden and Norway, which have significant hydropower capacities.

Future emissions of air pollutants have been estimated by using national integrated models and scenarios as explained in detail in Chapter 8.2.

2.1.3 Meeting of reduction targets

Changes in chapter	
March 2024	KS, TF

2010 Ceilings

According to the National Air Pollution Control Programme 2010 (Ministry of the Environment, 2002) the reduction targets adopted in the EU Directive on national emission ceilings as well as in the Gothenburg Protocol were anticipated to be met by 2010 by applying already adopted national and international measures to reduce emissions from both stationary and mobile sources. However, when approaching the year 2010 it become clear that the national emission ceiling for ammonia (31 kt in 2010) would not be met.

To meet the best science practise inventories and to show more compliance towards the reduction targets of ammonia emissions, Finland applied for adjustments for (1) manure management, (2) small scale combustion and (3) transport sector emissions. The adjustment application is presented as Appendix 3 to the Finnish IIR 2015.

The Adjustments Expert Review Team in 2015 accepted two of the applied adjustments (small scale combustion and transport) but rejected the application for manure management. Finland disagreed with the conclusions of the ERT and continued to discuss the justifications rejected by the ERT.

Finland changed the calculation in the national agriculture emissions calculation model in 2015-2016 to closer follow the method presented in the Guidebook. As a result, ammonia emissions decreased to a level which allowed Finland to meet the 2010 ceiling with the help of the granted adjustments already in 2015.

2020 and 2030 ceilings

The 2020 reduction targets for all air pollutants were achieved without additional measures (Suoheimo et al. 2015) with the exception of NH_3 for which the adjustments procedure was used for the years 2010-2019. Since the submission in 2022, the reduction targets for ammonia emissions have been achieved. Further information on the preparation of national emission projections is presented in Chapter 8.2.

2.1.4 Progress in meeting the reduction targets set in the CLRTAP Protocols, especially in the Gothenburg Protocol

Tracking of achieving the reduction targets set out in the old and new Gothenburg Protocols and the respective emission levels are presented in Table 1.18.

Sulphur dioxide
The old Gothenburg protocol reduction target for sulphur dioxide was achieved already in 1995, when the emissions were 105 kt. The new reduction target was achieved in 2013.

Nitrogen oxides
The Sophia Protocol target to reduce nitrogen oxides below the 1987 level, and the emission ceiling in the old Gothenburg protocol were met in 2012. The new reduction target of the Gothenburg protocol was achieved in 2016.

Non-methane volatile organic compounds
For NMVOC emissions the reduction target of 30 per cent from the year 1988 and the emission ceiling in the old Gothenburg protocol have been met since 2008.

Ammonia
Ammonia emissions have been reduced since 1990 but not as rapidly as expected. Between 2010-2019 Finland complied with the old Gothenburg ceiling of 31 kt with the adjustment procedure (for details see Finland's IIR 2021). Since the submission 2022, the ammonia emissions since 2020 have been below the ceiling. In the 2024 submission, the ammonia emissions for 2020 and 2021 were -20% below the base year 2005 and in 2022 -25% below the base year.

Heavy metals
Reduction targets set for the three priority heavy metals lead, cadmium and mercury, to reduce the emissions below 1990 level have all been achieved since 1991.

PCDD/F
The PCDD/F reduction target to decrease the emission level below the 1994 level has been met since 1995.

PAH-4
The PAH-4 reduction target to decrease the emission level below the 1994 level has been met in 2020 and 2022 in addition to 1995-1997 and 1999-2000. During the time of setting the reduction target, PAH-4 emissions were quantified using a different method from that currently applied, thus the increase of wood use in combustion was not foreseen problematic regarding PAH-4 emission levels. Currently, small-scale wood combustion is the main source of PAH emissions. In 2020 a research project was carried out to verify the national methodology, to check the results of data collection to the national wood use statistics and to verify the development of combustion technologies. The project resulted in a considerable increase in the emission level throughout the time series as explained in detail under the Energy Sector. The foreseen decrease in PAH emissions due to the verified technology development as well as and a milder winters in 2020 and 2022 resulted in reaching the target in 2020 and 2022 (Figure 1.16).

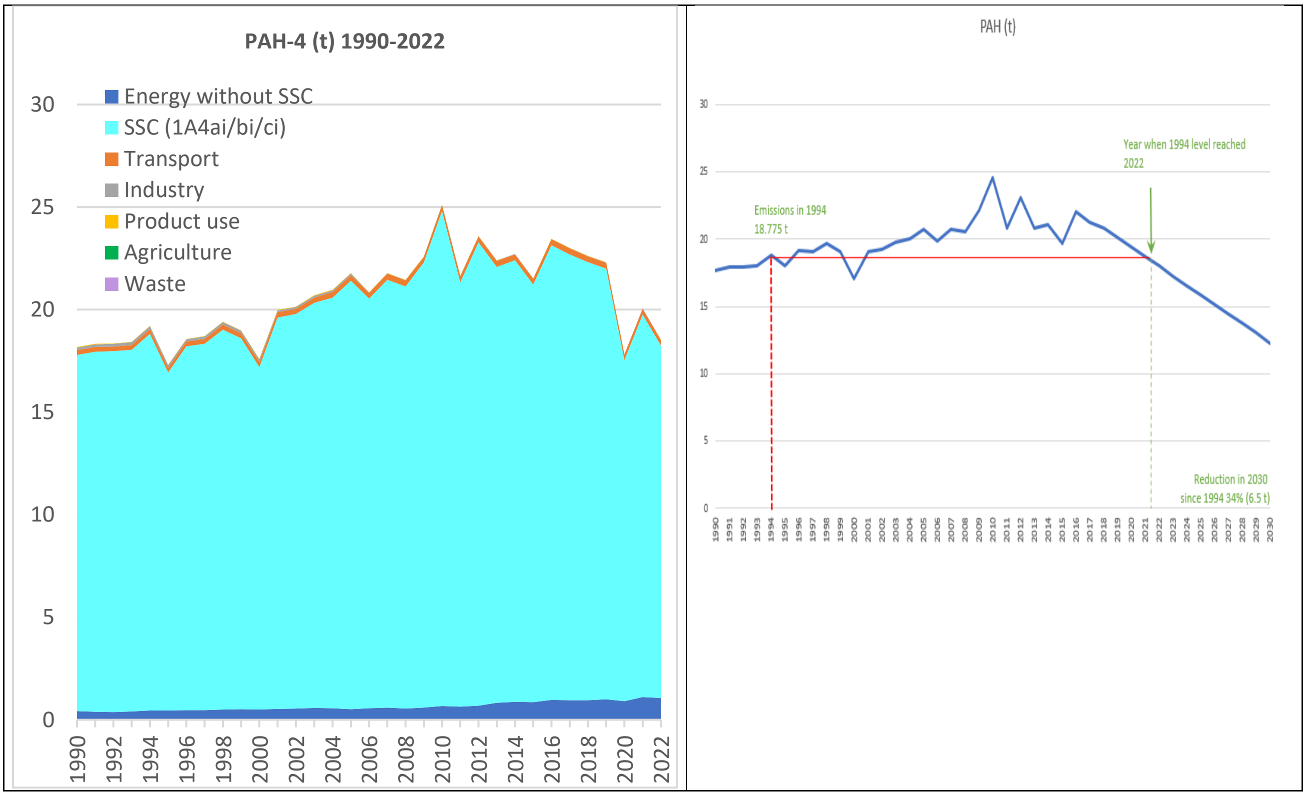


Figure 1.16. PAH-4 emissions scenario up to 2030. SSC stands for small scale wood combustion.

HCB
The targets to reduce HCB emissions below the level in 1994 have been met in 1995, in 2001-2005, 2008-2015 and since 2017.

PCBs
The targets to reduce emissions of PCBs below the level in 1994 have been met in 1996 and since 2008.

2.1.5 Progress in meeting the reduction targets set in the National emission ceilings Directive (2016) (EU NECD) in 2020-2029

Finland is currently meeting all its emission ceilings as presented in Table 1.18. Annual variations in the emission levels occur depending on economic and climatic conditions.

Sulphur dioxide
The SO_x emission ceiling of the old NECD directive for the year 2010 was met in 1996. The emissions have also been under the revised reduction target of -30% of the 2005 emissions levels for 2020-2029 of the revised NECD since 2013. In addition, the reduction target of -34% from 2030 was achieved in 2014.

Nitrogen oxides
The NO_x emission ceiling in the old NECD for the year 2010 has been met since 2012. New sources have recently been added to the inventory for the whole time series while annual variations in emissions are common due to variations in both economic and climatic conditions. The revised NECD emission reduction targets of -35% for 2020-2029 and -47% from 2030 are already achieved in 2016 and 2020, respectively.

Non-methane volatile organic compounds
The NMVOC emission ceiling in the old NECD for the year 2010 was met in 2005. Slight variations in the emissions are possible depending on economic and climatic conditions. Finland has implemented and fulfilled the requirements on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations (EU Solvents Emissions Directive (1999/13/EC) and Paint Directive (2004/42/EC) and reports regularly on the environmental permits and registrations under this directive. Due to the revised calculation of small-scale wood combustion, the level of emissions decreased by 10%. New sources have been added to the NMVOC emissions inventory and slight variations in emissions are possible depending on the climatic conditions. The revised NECD emission reduction targets (where agriculture emissions are excluded) of -35% for 2020-2029 and -48% from 2030 are already achieved in 2013 and 2022, respectively.

Ammonia
Ammonia emission reductions since the 1990 level were more challenging than expected mainly due to the changes in animal husbandry when moving from small farms to large installations. Finland revised the agriculture sector emissions calculation model in 2015-2016 to more closely follow the guidance provided in the EMEP EEA Guidebook and used adjustments in the small-scale combustion and transport sector to compensate the previously unknown challenges in decreasing ammonia emissions from agriculture. The adjustments are explained in detail in Finland’s IIR 2021. Since 2020 ammonia emissions have been below the ceiling set for 2020 and 2029. The ammonia emissions for 2020 and 2021 were -20% below the base year 2005 and in 2022 -25% below the base year.

$PM_{2.5}$
$PM_{2.5}$ emissions have been reduced since the base year of 2000 and are under the 2020-2029 NECD reduction target as well as the 2030 reduction target.

Table 1.18 Emission ceilings, reduction targets and emissions in the 2024 submission

NECD	2022	NECD Old	NECD 2016 (Base year 2005)				
		Ceiling 2010-2020		Ceiling 2020-2029		Ceiling from 2030	
		(kt)	Emissions in 2005 (kt)	(%)	(kt)	(%)	(kt)
NO_x	99.292	**170**	208	-35	**135**	-47	**110**
Nox agriculture excl.	89.539						
SO_2	22.692	**110**	70	-30	**49**	-34	**46**
NMVOC	75.464	**130**	147	-35	**96**	-48	**77**
NMVOC agriculture excl.	60.622						
$PM_{2,5}$	13.384		26	-30	**18**	-34	**17**
NH_3	31.583	**31**	42	-20	**33**	-20	**33**
NH_3 adj	*NA*						
Compliance NH_3	*NA*						

CLRTAP Gothenburg Protocol	2022	Base year 1990	Emission (kt) in the base year	Old Target (kt)	Year when target reached	Revised target from 2005 emission levels from 2020 (%)	(kt)
NO_x	99.292	1987	300.504	170	2012	-35	135
SO_2	22.692	1980	585.029	116	1995	-30	49
NMVOC	75.464	1988	240.494	130	2005	-35	96
NH_3	31.583	1990	41.402	31	-	-20	33
TSP		2000	56.854	*na*			
PM_{10}		2000	42.931	*na*			
$PM_{2.5}$		2000	25.991	*na*		-30	18

CLRTAP HM Protocol	2022	Emissions (t) in the base year 1990	Target reached (below the level of the base year)
Pb	12.516	321.435	1991
Cd	0.779	6.686	1991
Hg	0.505	1.087	1991
As	1.920	34.817	1991
Cr	14.905	47.670	1992
Cu	38.391	156.894	1991
Ni	9.917	78.439	1991
Zn	131.533	682.839	1991

CLRTAP POP Protocol	2022	Emissions in the base year 1994	Target reached (below the level of the base year)
PCDD/F	9.497	**18.372**	since 1995
HCB	29.245	**36.054**	1991, 1995, 2001-2005, 2008-2015, 2017-2022
PCB	19.922	**28.654**	1996, 2009-2022
PAH-4	18.531	**18.174**	2020, 2022

2.3 Description and interpretation of emissions in 2023 and the trends by pollutant

Changes in chapter	
February 2024	TF

This section describes the sources of air pollutants, emission trends and their spatial distribution. The maps are based on the new EMEP 0.1°* 0.1° grid and the intensity of the colouring is pollutant specific.

2.3.1 Main pollutants

The time series of the main pollutants SO_x, NO_x, NH_3, NMVOC and CO for 1980-2022 are presented in Figure 1.17.

- *Sulphur oxides* trend since 1980 has been strongly declining.
- *Nitrogen oxides* trend since 1980 is declining. New sources have been included in the inventory over the years.
- *NMVOC* emissions have been continuously decreasing since the base year of 1988. New sources have been included in the inventory over the years.
- *Ammonia* emissions have been slightly decreasing since 1980. There was an unexpected change in the emission levels regarding especially dairy cows when the animal-specific emissions started gradually grow in the 1990's with the increased animal size and productivity while the number of animals decreased drastically. New sources have been included in the inventory over the years.
- The annual fluctuations in the *carbon monoxide* emissions are related to fluctuations in the energy use in fuel combustion and transport sectors, but the trend is generally declining. Full emission inventories have been carried out since 1990.

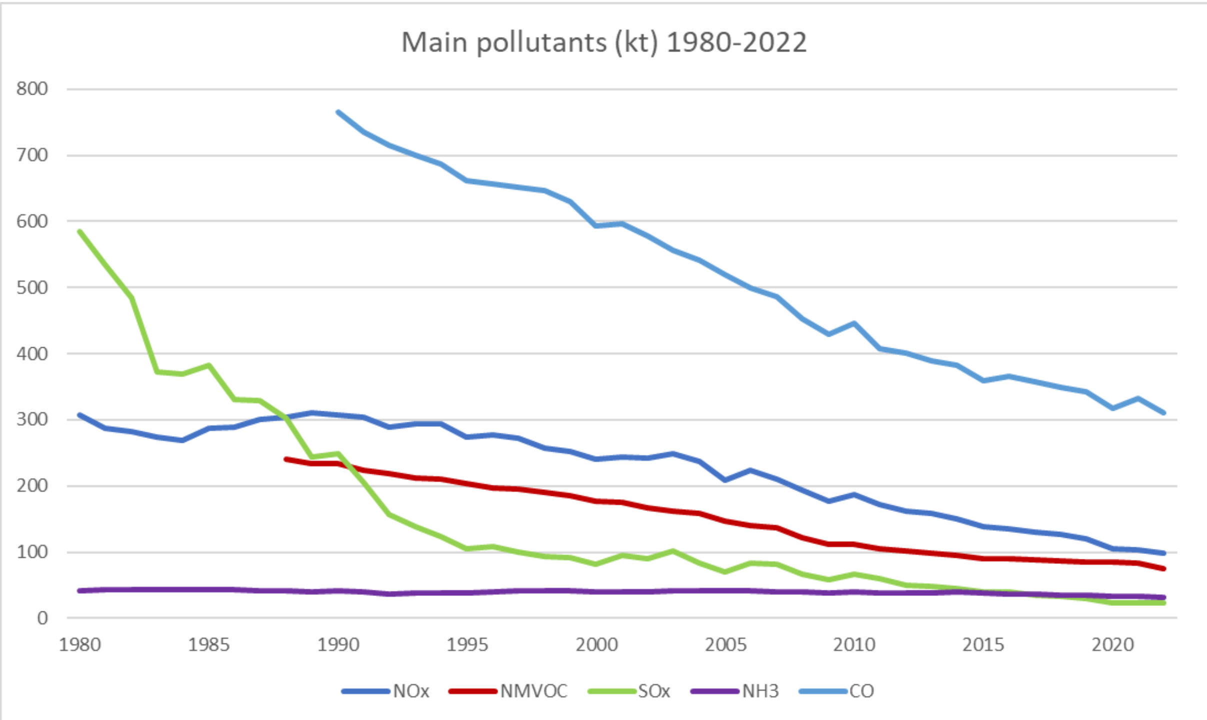


Figure 1.17. Emissions of main pollutants SO_2, NO_2, NH_3, NMVOC and CO in 1990–2022.

2.3.2 Nitrogen oxide emissions reported as nitrogen dioxide NO_2

Emission trend

Nitrogen oxides have been reduced from the base year 1987 emissions and all the emission reduction targets have been met.

The Finnish inventory covers all nitrogen oxide emissions converted into nitrogen dioxide (NO_2). Other nitrogen compounds include, for instance, nitric acid (HNO_3), nitrogen oxide (NO) and nitrogen trioxide (NO_3). The main sources of NO_2 in Finland are energy production and transport.

Nitrogen oxide emissions have constantly decreased since the 1980's. In 1991 the government issued general guidelines restricting emissions from boilers and gas turbines, and, in 1988 a resolution on the reduction of emissions from road transport. New petrol-engine vehicles were required to be equipped with three-way catalytic converters since 1991 and emissions from diesel-engine vehicles were to be reduced through new engine construction and after-treatment equipment. Follow-up of how Finland has met the reduction targets under the UN and EU legislation is presented in Chapters 2.1.3 – 2.1.5.

The NO_x emissions trend 1980-2022 is presented in Figure 1.18. Time series fluctuations are mostly driven by changes in fuel combustion. Emission data reported by the plants according to their monitoring programmes in their environmental permits is used in the inventory, therefore energy and industry sector emissions are considered quite accurate.

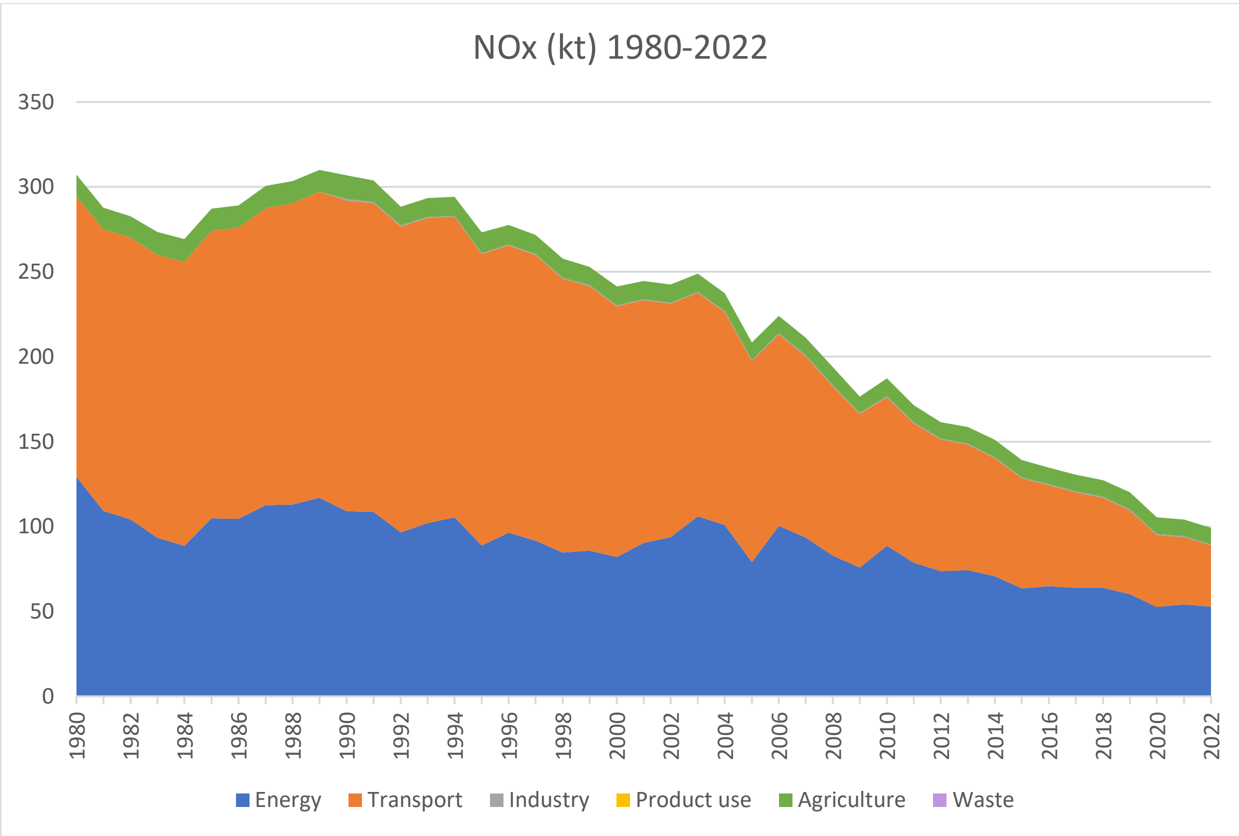
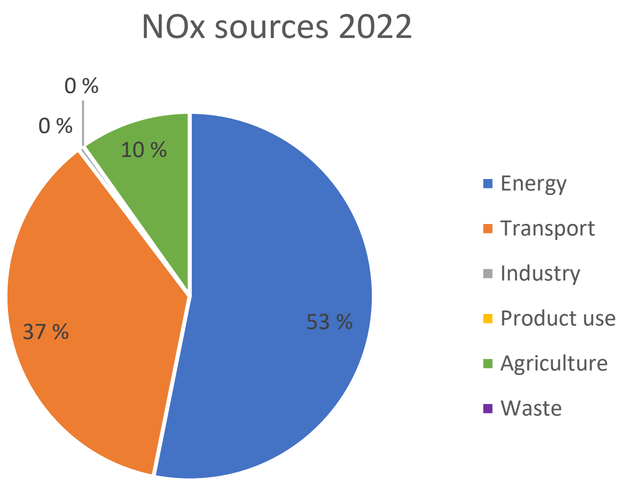


Figure 1.18 Emissions of nitrogen oxide (Gg) in 1980-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.19.



Shares of data reported by the plants of total NOx emissions in 2022							
NFR	**Percentage of national total**	**Total release [Gg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [Gg]**	**Percentage reported by the plants**
1A1a	17.3	17.171	94.2	1A4ci	1.0	0.955	1
1A1b	1.6	1.586	99.8	1A4cii	1.9	1.877	0
1A2a	3.0	2.968	100	1A4ciii	1.7	1.684	0
1A2b	0.2	0.163	90.1	1A5a	5.6	5.573	0
1A2c	1.2	1.183	97.9	2B10a	0.2	0.150	20.3
1A2d	13.0	12.93	97.4	2B2	0.4	0.350	100
1A2e	0.3	0.280	91.8	2G	<0.1	0.004	0
1A2f	2.1	2.113	95.3	3B1a	<0.1	0.043	0
1A2gvii	4.6	4.521	0	3B1b	0.1	0.144	0
1A2gviii	2.2	2.209	69.3	3B2	<0.1	0.008	0
1A3ai(i)	0.6	0.557	0	3B3	<0.1	0.005	0
1A3aii(i)	0.1	0.124	0	3B4d	<0.1	<0.001	0
1A3bi	8.8	8.785	0	3B4e	<0.1	0.030	0
1A3bii	3.5	3.507	0	3B4gi	<0.1	0.042	0
1A3biii	7.0	6.926	0	3B4gii	<0.1	0.095	0
1A3biv	0.2	0.158	0	3B4giii	<0.1	0.009	0
1A3c	1.3	1.327	0	3B4giv	<0.1	0.004	0
1A3dii	4.9	4.877	0	3B4h	<0.1	0.023	0
1A3ei	<0.1	0.001	100	3Da1	5.9	5.835	0
1A4ai	1.2	1.199	4	3Da2a	2.6	2.542	0
1A4aii	1.0	1.004	0	3Da2b	0.1	0.109	0
1A4bi	4.5	4.444	0	3Da2c	0.3	0.285	0
1A4bii	0.9	0.912	0	3Da3	0.6	0.579	0

	Total	100	99.292	39.1

Figure 1.19. The contribution of different sources to NOx emissions and data reported by the plants.

2.3.3 Non-methane organic compounds emissions (NMVOC)

Emission trend

NMVOC emissions have been successfully reduced from the base year 1988 (Figure 1.20).

NMVOC emissions originate in energy production, transport, product use and agriculture. In its time, the CLRTAP VOC protocol requirement to reduce emissions by 30% from the 1988 level by 1999 proved to be difficult, because emissions in the transport sector did not decrease as expected, particularly concerning non-road machinery and equipment, as vehicles had not been replaced at the rate that was earlier foreseen. Strict emission limits have been applied to new vehicles since 1990 and their impact on emissions can be seen through the gradual renewal of the passenger car fleet. With the aid of differential taxes, there was a transition in the 1990s toward reformulated traffic fuels, which helped reduce evaporative emissions from petrol engine vehicles as well as CO and VOC emissions from vehicle flue gases.

Finland has implemented EU Directives on the control of volatile organic compound emissions from storage and distribution of petrol and from industrial solvents. Decreased NMVOC content in paints and the introduction of better abatement techniques in several industrial processes have contributed emission reductions in addition to the economic depression resulting in lower production volumes. The most important emission sources for the decreased NMVOC emissions after 2007 are paint application and printing industry. Low-NMVOC containing and waterborne paint products were introduced during the 1990s and their market-share rapidly increased, typically in indoor paints and road marking paints, leading to source specific emission reductions of 20–50%. At the same time, also the sales of thinners for paint products decreased, printing processes were improved and new abatement technologies as well as substitution and recovery of NMVOC containing substances took place.

Follow-up of how Finland has met the reduction targets under the UN and EU legislation is presented in Chapters 2.1.3 – 2.1.5.

The time series is not consistent for the years 1980-1987 for which not all sources are included.

The uncertainties of emission data are included in Annex 6 of the IIR.

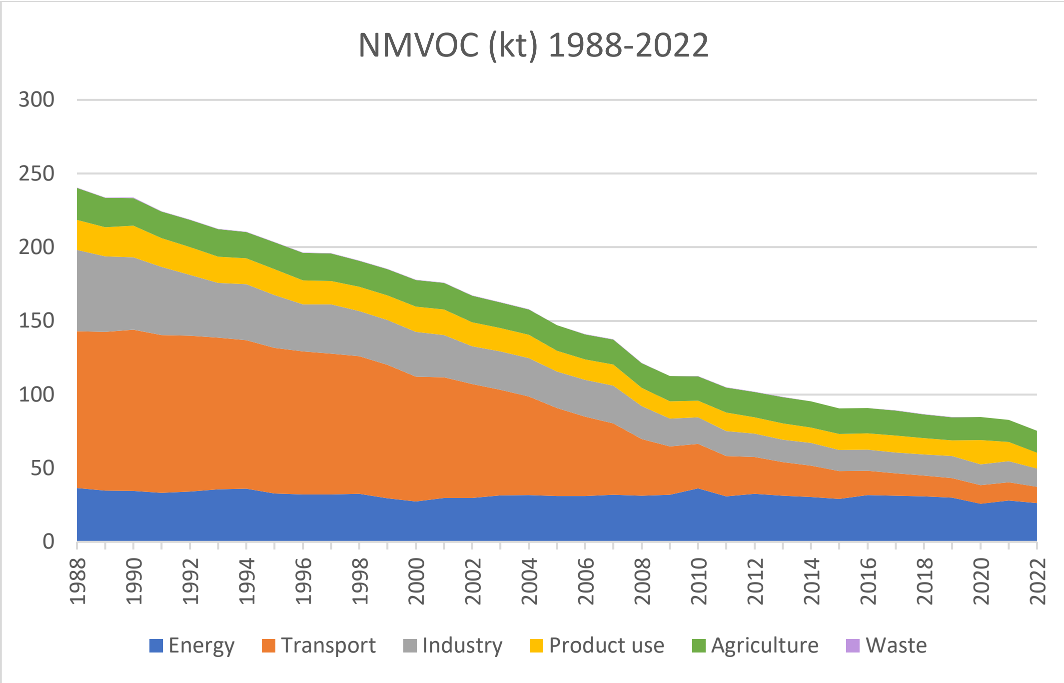
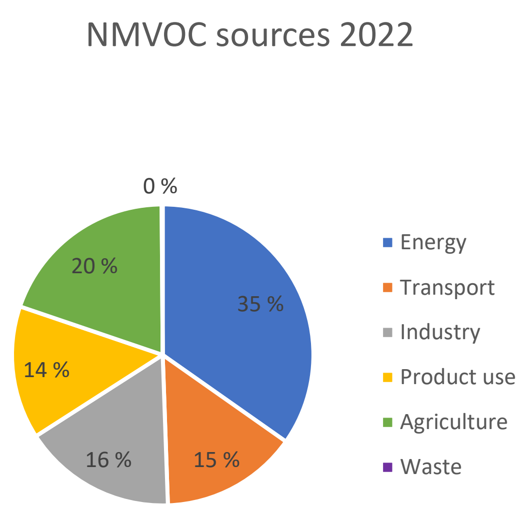


Figure 1.20. NMVOC emissions (Gg) in 1988-2022.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.21.



Shares of data reported by the plants of total NMVOC emissions in 2022							
NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants
1A1a	2.6	1.963	14.3	2C1	0.3	0.208	86.6
1A1b	<0.1	0.071	48.0	2C2	<0.1	0.001	100
1A2a	<0.1	0.014	0	2C3	<0.1	0.001	100

1A2b	<0.1	0.001	28.9	2C7a	<0.1	<0.001	0
1A2c	<0.1	0.008	5.0	2C7b	<0.1	0.026	100
1A2d	0.4	0.293	3.9	2C7c	<0.1	0.002	100
1A2e	<0.1	0.014	0	2D3a	8.9	6.692	0
1A2f	<0.1	0.017	0	2D3b	0.3	0.234	0
1A2gvii	1.3	0.968	0	2D3c	<0.1	0.027	0
1A2gviii	0.2	0.161	4.3	2D3d	7.8	5.871	15.6
1A3ai(i)	<0.1	0.059	0	2D3e	0.8	0.598	3.5
1A3aii(i)	<0.1	0.017	0	2D3g	1.9	1.465	81.3
1A3bi	1.3	0.955	0	2D3h	0.5	0.367	68.7
1A3bii	0.3	0.192	0	2D3i	1.9	1.419	4.9
1A3biii	0.3	0.202	0	2G	<0.1	0.015	0
1A3biv	1.1	0.801	0	2H1	1.2	0.932	9.1
1A3bv	1.6	1.205	0	2H2	2.5	1.885	8.7
1A3c	<0.1	0.074	0	2I	1.5	1.153	39.6
1A3dii	3.9	2.919	0	2L	<0.1	0.002	100
1A3ei	<0.1	<0.001	0	3B1a	7.6	5.702	0
1A4ai	0.1	0.083	0	3B1b	5.1	3.824	0
1A4aii	0.5	0.410	0	3B2	0.2	0.143	0
1A4bi	24.1	18.181	0	3B3	0.3	0.227	0
1A4bii	2.7	2.055	0	3B4d	<0.1	0.005	0
1A4ci	0.3	0.261	0	3B4e	0.3	0.231	0
1A4cii	1.5	1.141	0	3B4gi	0.3	0.258	0
1A4ciii	0.1	0.079	0	3B4gii	1.1	0.803	0
1A5a	0.7	0.506	0	3B4giii	<0.1	0.031	0
1B1b	<0.1	0.062	0	3B4giv	<0.1	0.021	0
1B2aiv	2.5	1.876	100	3B4h	0.7	0.493	0
1B2av	3.3	2.473	4.4	3Da2a	2.8	2.101	0
1B2b	0.3	0.250	0	3Da3	<0.1	0.069	0
2A1	<0.1	0.035	40.3	3De	1.2	0.935	0
2A3	<0.1	0.002	99.3	5A	<0.1	0.067	0
2B10a	3.0	2.230	100	5D1	<0.1	0.007	0
2B10b	<0.1	0.053	100	5D2	<0.1	0.012	0
				Total	**100**	**75.464**	**10.6**

Figure 1.21. The contribution of different sources to NMVOC emissions and data reported by the plants.

2.3.4 Sulphur emissions as sulphur dioxide SO_2

Emission trend

Sulphur oxides emissions have been reduced from the base year 1980 (Figure 1.22).

The main sources of sulphur emissions are energy production and industrial processes. All sulphur compounds converted into sulphur dioxide (SO_2) are included in the inventory, i.e. emissions of reduced sulphur compounds are also covered: sulphur trioxide (SO_3), sulphuric acid (H_2SO_4), and reduced sulphur compounds, e.g. hydrogen sulphide (H_2S), mercaptans and dimethyl sulphides.

Emissions of reduced sulphur compounds originate, for instance, from petroleum refineries, tank farms for unrefined petroleum products, natural gas plants, petrochemical plants, oil sands plants, sewage treatment facilities, kraft pulp and paper plants and animal feedlots.

Sulphur emissions have been dramatically decreased since the beginning of the 1980s due to successful national programmes to reduce emissions. A Government resolution was issued in 1986 for a 50% reduction of emissions from the 1980 level, and in 1990, the aim was set at an 80% reduction over the next ten years. Emissions from energy production, pulp mills, sulphur acid plants and refineries were limited as was the sulphur content of coal and oil products. The industry branch specific reduction targets were regularly followed and re-examined. Investments, including desulphurization units for existing coal-fired power stations, were made in the beginning of the 1990s to implement these decisions. Follow-up on how Finland meets the reduction targets under the UN and EU legislation is presented in Chapters 2.1.3 – 2.1.5.

SO_x emissions are regarded rather accurate as emission data reported by the plants according to their monitoring programmes in environmental permits is used in the inventory. Fluctuations in annual emission levels are related to economic conditions and changes in energy production.

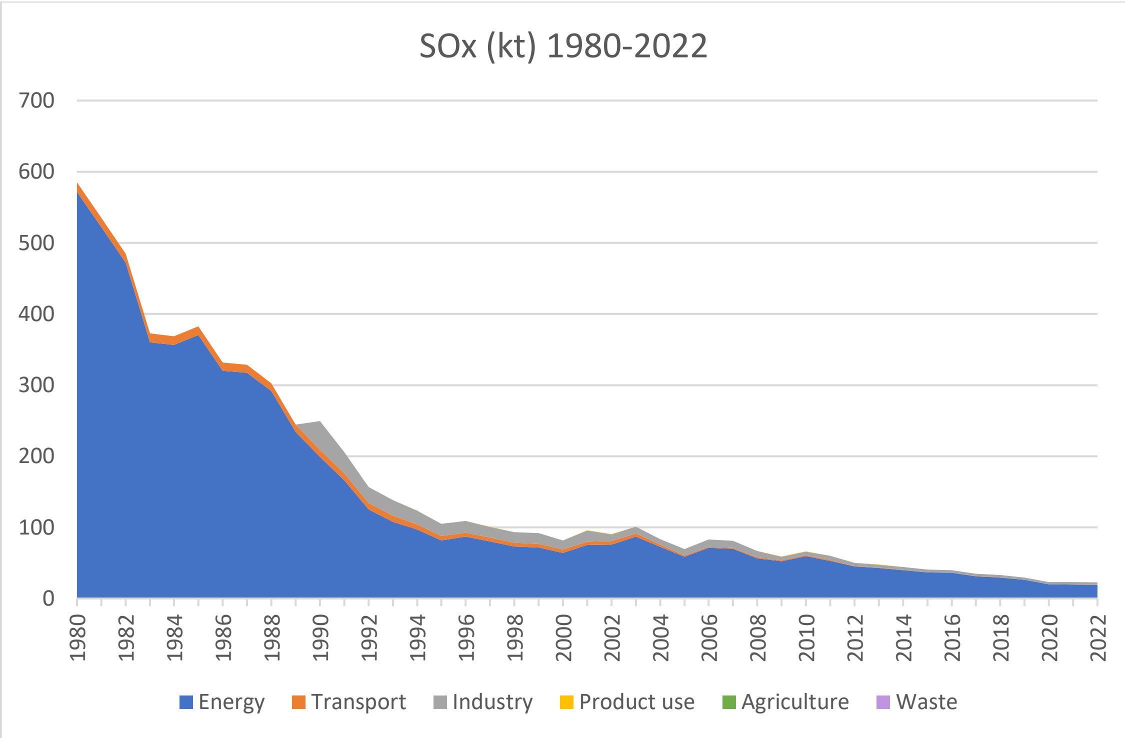
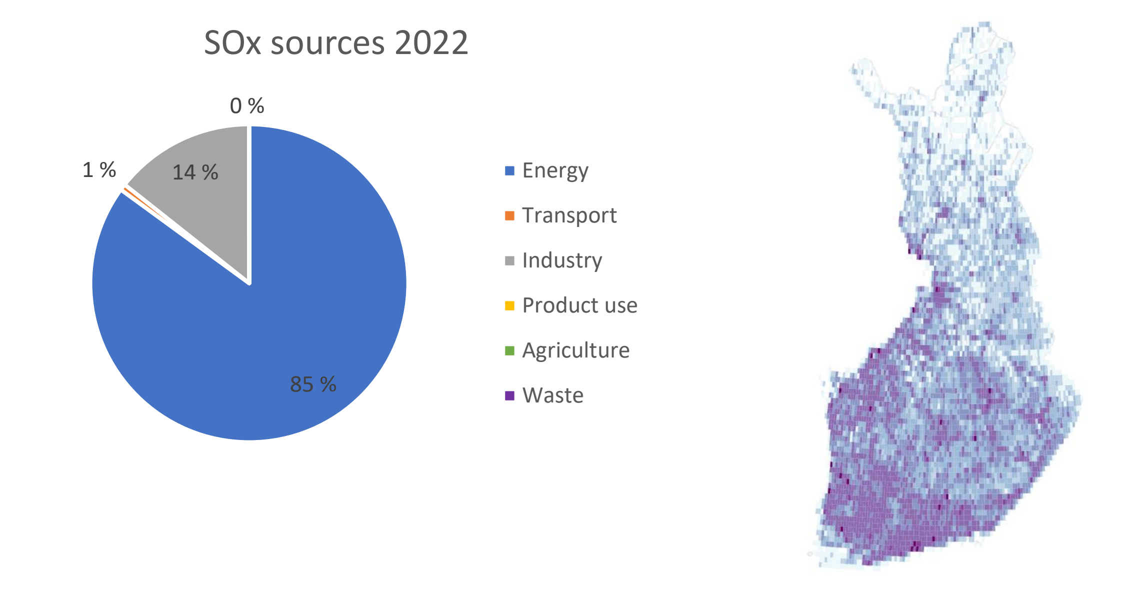


Figure 1.22. Emissions of sulphur dioxide (Gg) in 1980-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.23.



Shares of data reported by the plants of total SOx emissions in 2022							
NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants
1A1a	33.2	7.535	89.9	1A4aii	<0.1	0.001	0
1A1b	11.0	2.500	99.8	1A4bi	2.4	0.534	0
1A2a	1.0	0.224	99.8	1A4bii	<0.1	<0.001	0
1A2b	10.9	2.468	99.5	1A4ci	2.1	0.481	0.2
1A2c	1.9	0.430	79.9	1A4cii	<0.1	0.003	0
1A2d	7.3	1.645	73.7	1A4ciii	<0.1	<0.001	0
1A2e	1.0	0.233	86.3	1A5a	5.4	1.220	0
1A2f	1.9	0.432	90.1	1B1b	0.9	0.195	100
1A2gvii	<0.1	0.004	0	2B10a	5.3	1.201	99.2
1A2gviii	1.4	0.318	58.5	2C1	3.7	0.848	100
1A3ai(i)	0.2	0.035	0	2C2	<0.1	0.003	100
1A3aii(i)	<0.1	0.009	0	2C7a	0.5	0.113	3.6
1A3bi	<0.1	0.022	0	2C7b	0.4	0.083	100
1A3bii	<0.1	0.003	0	2C7c	<0.1	<0.001	100
1A3biii	<0.1	0.015	0	2D3g	<0.1	<0.001	100
1A3biv	<0.1	<0.001	0	2D3i	<0.1	<0.001	100
1A3c	<0.1	<0.001	0	2G	<0.1	0.004	0
1A3dii	0.2	0.051	0	2H1	4.4	1.001	98.1
1A3ei	<0.1	<0.001	0	2L	<0.1	<0.001	100
1A4ai	4.8	1.079	0	**Total**	**100**	**22.692**	**77.5**

Figure 1.23 The contribution of different sources to SOx emissions and data reported by the plants.

2.3.5 Ammonia emissions

Emission trend

Ammonia emissions have been reduced from the 1990 level of 41 kt and 42 kt in 2005 to 32 kt in 2022. The main ammonia source is agriculture, while energy, transport, industrial processes and waste together contribute to 10% of emissions. The emissions decreased from early 1980s by 1990, however, after that the emission trend has been rather consistent. In the most recent years the emissions have turned into decrease. Ammonia emission trend is presented in Figure 1.24.

According to the current understanding, the emissions are expected to follow a slight decreasing trend. Follow-up of how Finland has met the reduction targets under the UN and EU legislation is presented in Chapters 2.1.3 – 2.1.5.

Understanding of ammonia emission sources and levels has gradually been improved during the 2000s. Still in 2002 not all sources of ammonia emissions were identified and the emissions from the major source, agriculture, were underestimated. While the Gothenburg protocol which limits NH_3 emissions had not yet entered into force, it was understood that further assessment of the inventory was necessary. A new calculation model to improve the agriculture sector inventory was developed in 2006-2008. Based on the results of this work, it was concluded that the earlier estimates, especially for dairy cows, did not take into account the increased specific emissions following the growth of the animals while the number of the animals had significantly decreased. The time series has been revised several times since, while a comprehensive recalculation in 2016. After that, minor corrections and inclusion of minor new sources have been carried out. A detailed description of ammonia emissions is presented in IIR Part 5 Agriculture.

In 2014 new sources were identified (residential combustion, leather tanning, coke production and use of latrines) and ammonia emissions from the new sources were included in the inventories from the year 1990 onward. Earlier, ammonia emissions had been estimated as national totals only for 1980, 1985-1988, 1990, 1995 and 1997-1999 and in NFR format only from 2000 onwards. The recalculated time series is available in NFR format since 1980.

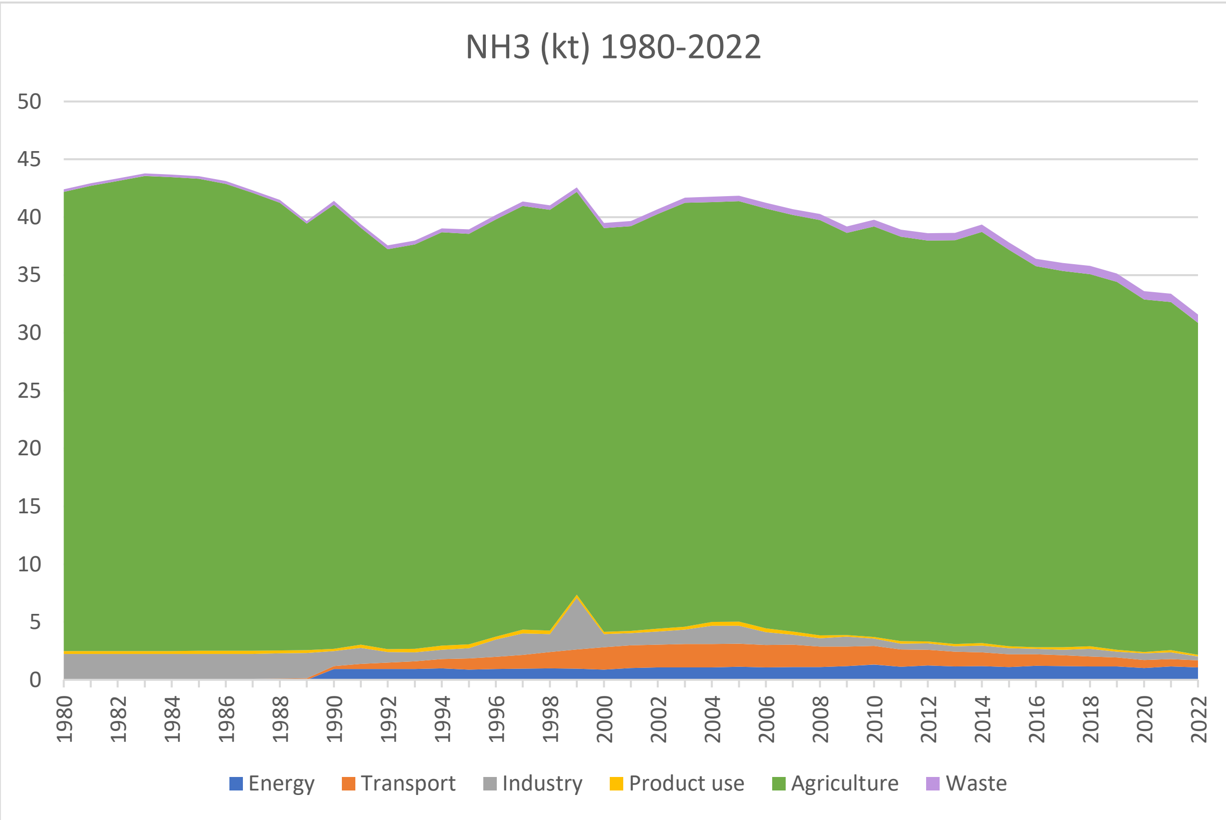
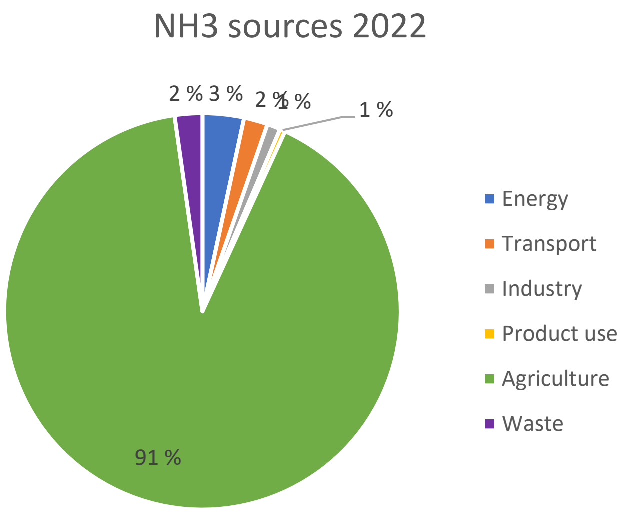


Figure 1.24. Ammonia emissions (Gg) in 1980-2022. Note, the peak NFR2 (Industry) in 1999 is due to an accidental emission reported by the plant to the environmental authorities.

The uncertainties of emission data in 2022 are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.25.



Shares of data reported by the plants of total NH_3 emissions in 2022

NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants
1A1a	<0.1	0.016	100	2D3i	0.4	0.121	100
1A2gvii	<0.1	0.003	0	2G	<0.1	0.008	0
1A2gviii	<0.1	0.010	100	2H1	0.2	0.056	96.6
1A3bi	1.8	0.564	0	2L	<0.1	0.007	2.9
1A3bii	<0.1	0.011	0	3B1a	17.3	5.460	0
1A3biii	<0.1	0.031	0	3B1b	16.4	5.194	0
1A3biv	<0.1	0.002	0	3B2	0.4	0.124	0
1A3c	<0.1	<0.001	0	3B3	7.5	2.372	0
1A3dii	<0.1	<0.001	0	3B4d	<0.1	0.008	0
1A4ai	<0.1	0.005	0	3B4e	2.2	0.685	0
1A4aii	<0.1	<0.001	0	3B4gi	0.8	0.250	0
1A4bi	3.2	1.022	0	3B4gii	2.0	0.631	0
1A4bii	<0.1	<0.001	0	3B4giii	0.3	0.087	0
1A4ci	<0.1	0.010	0	3B4giv	<0.1	0.030	0
1A4cii	<0.1	0.002	0	3B4h	3.3	1.027	0
1A4ciii	<0.1	<0.001	0	3Da1	11.2	3.536	0
1A5a	<0.1	<0.001	0	3Da2a	20.6	6.521	0
1B1b	<0.1	0.003	0	3Da2b	0.2	0.074	0
2B10a	0.7	0.212	100	3Da2c	1.8	0.570	0
2C1	0.1	0.036	100	3Da3	4.5	1.435	0
2C7b	0.1	0.033	100	5B1	0.3	0.087	0
2C7c	<0.1	<0.001	100	5B2	0.8	0.242	0
2D3e	<0.1	0.004	0	5D1	1.2	0.384	1

2D3g	<0.1	0.002	39.6	6A	2.2	0.706	0
				Total	**100**	**31.583**	**1.5**

Figure 1.25 The contribution of different sources to NH_3 emissions and data reported by the plants.

2.3.6 Carbon monoxide emissions

Emission trend

Carbon monoxide emissions have been reduced from the 1990 level. The carbon monoxide emission trend is presented in Figure 1.26. The main sources of CO emissions are fuel combustion in the energy production and transport. Emissions from transport have decreased heavily while emissions from energy production have stayed rather constant. CO emission data reported by the plants is used in the inventory. CO emission levels are well known due to the use of CO as process parameter.

CO emission data is available as national totals since the year 1980 and in NFR format since the year 1990. For the 1980s several subcategories have been included in the recent years.

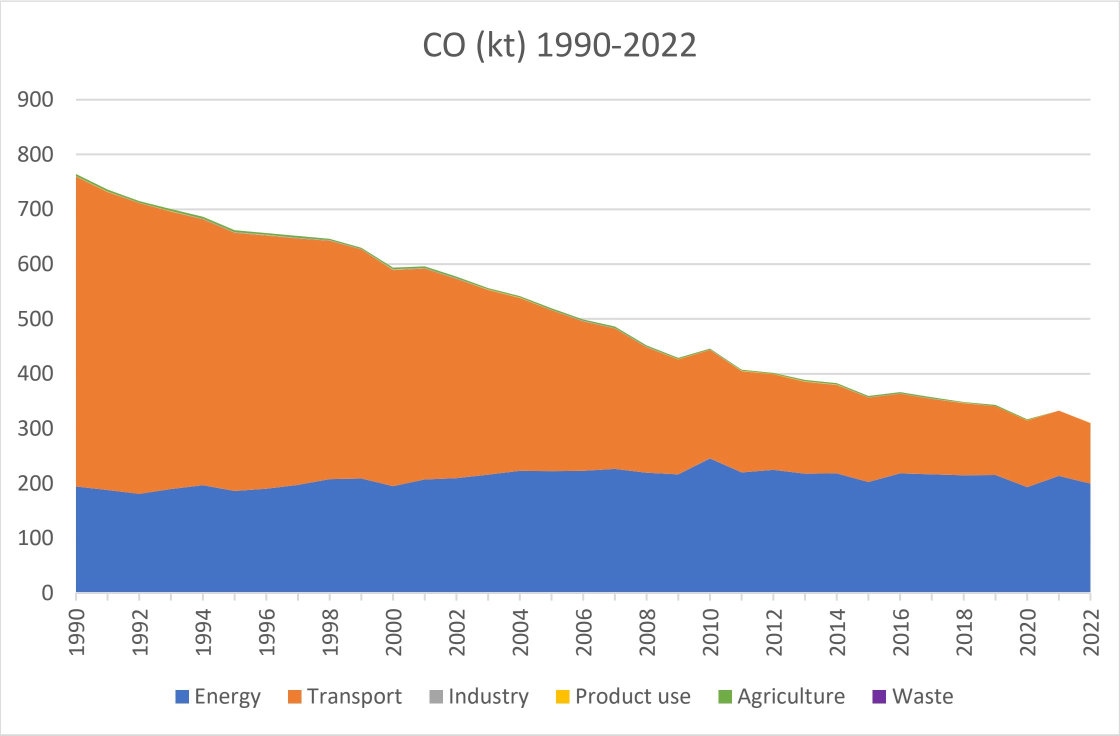
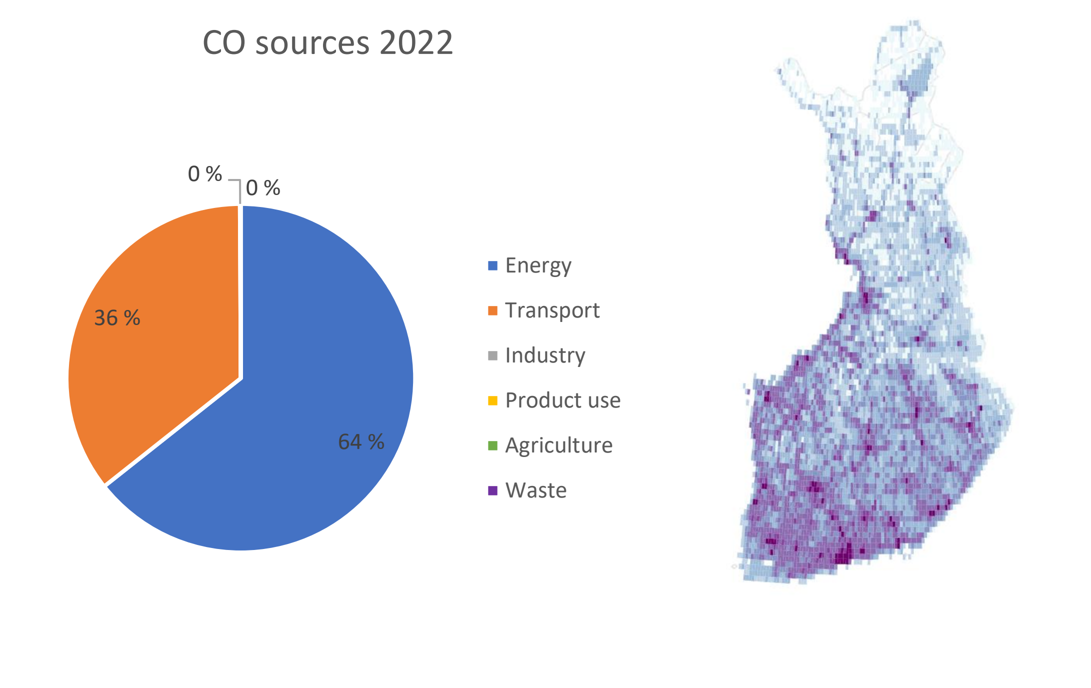


Figure 1.26. Emissions of carbon monoxide (Gg) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.27.



Shares of data reported by the plants of total CO emissions in 2022							
NFR	**Percentage of national total**	**Total release [Gg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [Gg]**	**Percentage reported by the plants**
1A1a	5.2	15.992	17.9	1A3biv	0.9	2.853	0
1A1b	0.2	0.761	0	1A3c	<0.1	0.181	0
1A2a	0.2	0.668	0.2	1A3dii	6.8	20.958	0
1A2b	<0.1	0.087	76.2	1A3ei	<0.1	<0.001	0
1A2c	<0.1	0.284	9.8	1A4ai	0.3	1.018	0.3
1A2d	4.3	13.452	12.1	1A4aii	4.8	14.955	0
1A2e	<0.1	0.252	0.2	1A4bi	45.2	140.223	0
1A2f	1.0	2.998	8.8	1A4bii	11.2	34.885	0
1A2gvii	2.2	6.777	0	1A4ci	0.6	1.771	0
1A2gviii	0.9	2.775	12.7	1A4cii	2.6	7.936	0
1A3ai(i)	0.2	0.568	0	1A4ciii	<0.1	0.263	0
1A3aii(i)	<0.1	0.259	0	1A5a	6.2	19.296	0
1A3bi	5.7	17.615	0	2C1	<0.1	0.134	100
1A3bii	0.4	1.242	0	2C7a	<0.1	0.008	100
1A3biii	0.6	1.875	0	2G	<0.1	0.122	0
				Total	**100**	**310.209**	**1.7**

Figure 1.27. The contribution of different sources to CO emissions and data reported by the plants.

2.3.7 Particulate matter emissions

Particulate matter emissions have been estimated since 1990 and the trends are decreasing. Data for earlier years are available for most of the categories. The reporting obligation for particles starts from the year 2000. The main sources for particle emissions are energy, road transport and industrial processes sectors. The emission trend is presented in Figure 1.28.

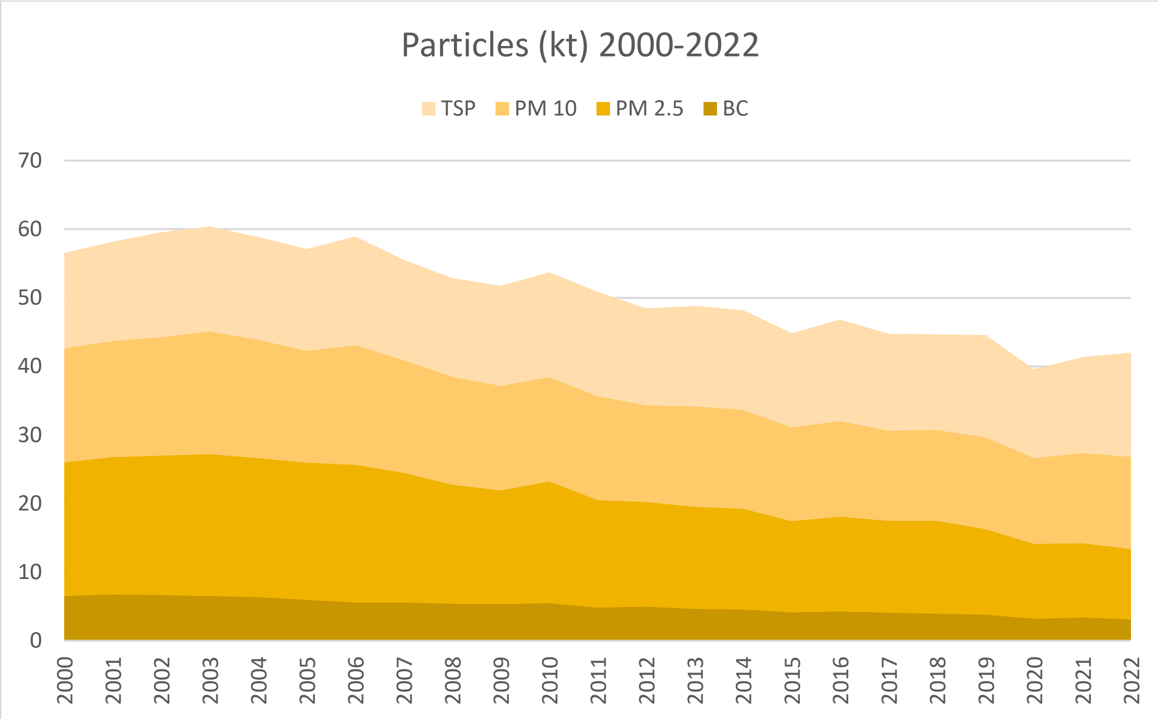


Figure 1.28 Particle emissions (TSP, PM_{10}, $PM_{2.5}$ and BC) in 2000-2022.

Particulate matter emissions fluctuate largely from year to year due to changes in energy consumption, which is affected by the level of annually imported electricity and fossil fuel based condensing power in annual energy production. Energy consumption reflects the energy intensity of the Finnish industry (forest industry, chemical industry and manufacture of basic metals), extensive consumption during the long heating period, as well as energy consumption in the transport sector due to long distances in the sparsely inhabited country. During the last decades large decreases in specific emissions have been achieved through implementation of abatement techniques especially in peat and oil combustion. The especially high peat production volumes in summer 2006 can be seen in the peak in the emission trend.

Reporting of TSP emissions is traditionally included in the monitoring programs of environmental permits and emission data for LCPs can therefore be regarded quite accurate. This data is used in the inventory. Particle emissions from energy production are efficiently abated in the centralized electricity and power production using electrostatic precipitators and scrubbers.

The time series are strongly affected by smaller boilers, where the inventory does not currently reflect implemented abatement technology and the emissions are calculated as unabated due to the fact that information is not available of the implemented abatement technology in smaller district heating plants. The issue will be solved in the next submissions.

Note that the sources for $PM_{2.5}$ and BC are not equal: peat production (NFR 1.B.1.c) is a significant source for $PM_{2.5}$ but is not a source of BC. In the black carbon emission inventory, the main sources are transport (road transport and off-road machinery) and energy production, mainly residential combustion.

2.3.7.1 Particles TSP

Emission trend

The trend of TSP emissions is presented in Figure 1.29.

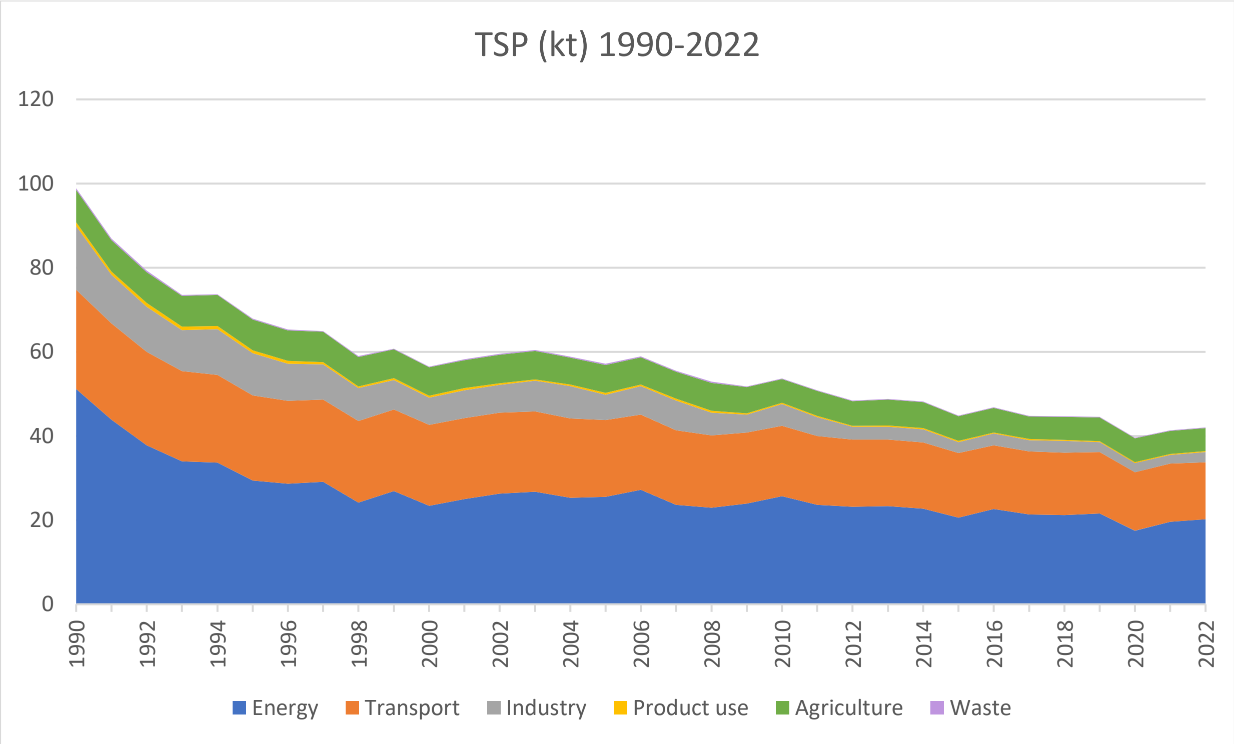
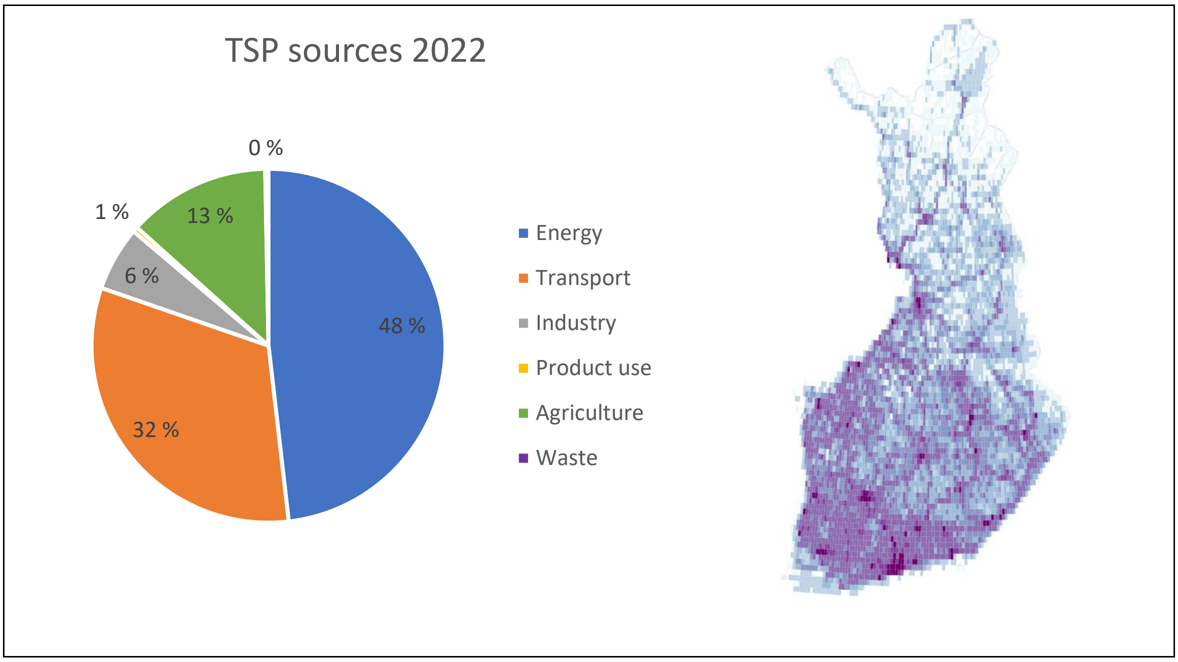


Figure 1.29. TSP emissions (kt) 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.30.



Shares of data reported by the plants of total TSP emissions in 2022							
NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants
1A1a	3.9	1.639	32.8	2A5c	1.6	0.678	0
1A1b	0.2	0.081	99.0	2B10a	1.0	0.429	100
1A2a	<0.1	0.014	98.9	2B10b	<0.1	0.035	0
1A2b	<0.1	0.009	74.5	2B6	<0.1	0.001	0
1A2c	0.2	0.064	75.5	2C1	0.6	0.260	85.7
1A2d	3.3	1.380	95.8	2C2	0.3	0.127	100
1A2e	<0.1	0.019	60.0	2C3	<0.1	<0.001	93.9
1A2f	0.2	0.073	87.3	2C6	<0.1	<0.001	100
1A2gvii	0.5	0.228	0	2C7a	<0.1	<0.001	13
1A2gviii	1.0	0.412	43.9	2C7c	<0.1	0.010	100
1A3ai(i)	<0.1	0.004	0	2C7d	<0.1	0.011	0
1A3aii(i)	<0.1	0.001	0	2D3b	0.2	0.08	0
1A3bi	0.4	0.174	0	2D3d	<0.1	0.001	100
1A3bii	0.4	0.147	0	2D3g	<0.1	0.001	100
1A3biii	0.2	0.099	0	2D3i	0.1	0.059	95.3
1A3biv	<0.1	0.015	0	2G	0.1	0.055	0
1A3bvi	3.5	1.485	0	2H1	0.8	0.323	100
1A3bvii	25.3	10.646	0	2H2	1.0	0.431	11.9
1A3c	<0.1	0.028	0	2I	0.3	0.111	98.3
1A3dii	0.7	0.295	0	2L	<0.1	0.017	100
1A4ai	0.7	0.288	0.1	3B1a	0.4	0.177	0
1A4aii	0.2	0.069	0	3B1b	0.4	0.154	0
1A4bi	18.9	7.931	0	3B2	<0.1	0.009	0
1A4bii	0.3	0.122	0	3B3	0.6	0.262	0
1A4ci	1.4	0.588	0.9	3B4d	<0.1	<0.001	0
1A4cii	0.3	0.141	0	3B4e	<0.1	0.021	0
1A4ciii	0.1	0.044	0	3B4gi	1.7	0.698	0
1A5a	17.3	7.253	0	3B4gii	0.5	0.190	0
1B1b	0.1	0.043	100	3B4giii	<0.1	0.016	0
1B1c	1.1	0.444	0	3B4giv	0.2	0.079	0
1B2aiv	<0.1	<0.001	0	3B4h	<0.1	0.024	0
1B2av	<0.1	<0.001	100	3Dc	9.2	3.850	0
2A2	<0.1	0.002	100	5A	<0.1	<0.001	0
2A3	<0.1	0.006	100	5C1bv	<0.1	0.002	0
2A5a	<0.1	0.004	97.0	5E	0.3	0.122	0
2A5b	<0.1	0.028	1.7	**Total**	**100**	**42.014**	**8.7**

Figure 1.30 The contribution of different sources to TSP emissions and data reported by the plants.

2.3.7.2 Particles PM_{10}

Emission Trend

The trend of PM_{10} emissions is presented in Figure 1.31.

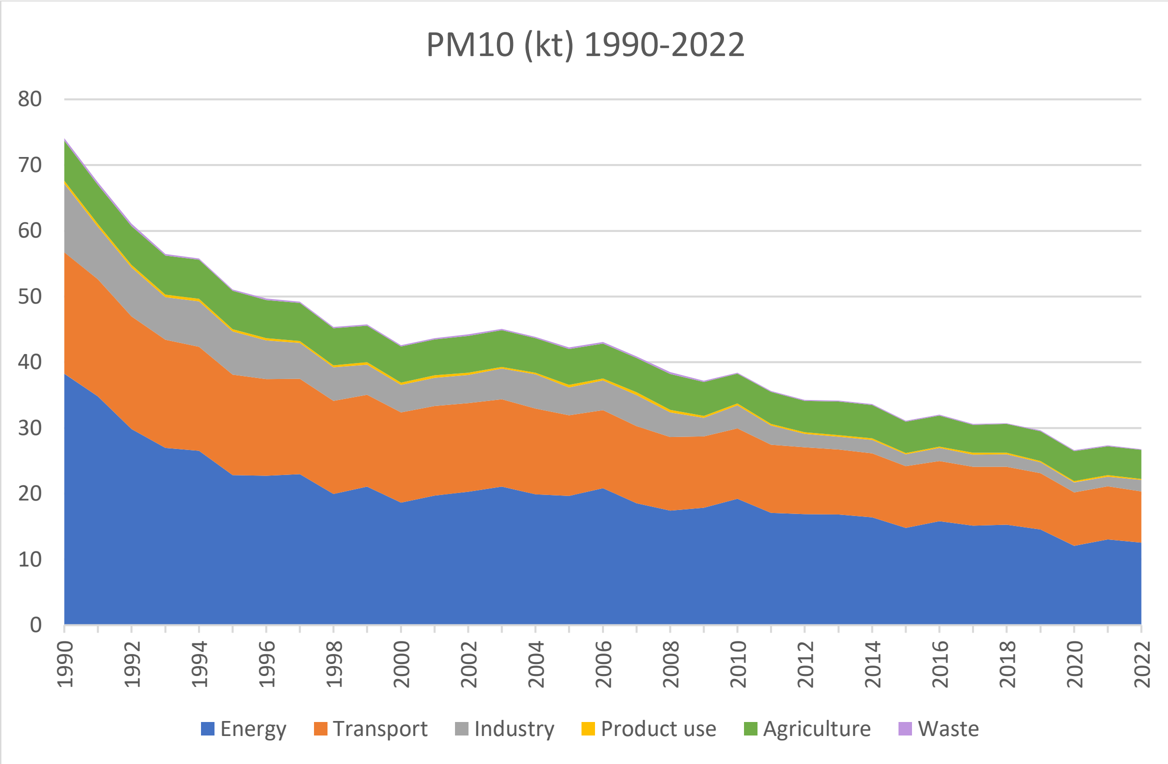
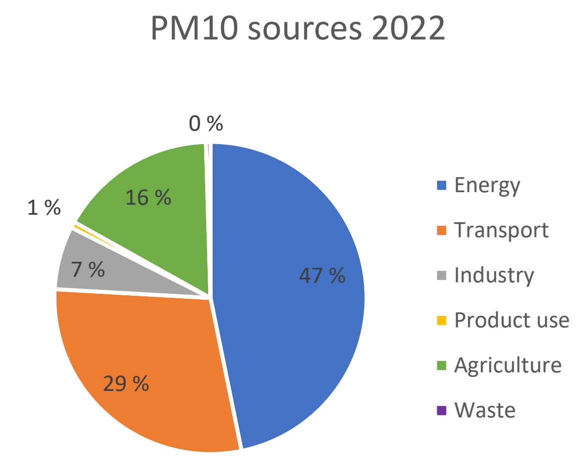


Figure 1.31. PM_{10} emissions (kt) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.32.



Shares of data reported by the plants of total PM_{10} emissions in 2022							
NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants
1A1a	2.5	0.672	0	2A5c	1.0	0.265	0
1A1b	<0.1	0.022	0	2B10a	1.4	0.371	0
1A2a	<0.1	0.005	0	2B10b	<0.1	0.011	0
1A2b	<0.1	0.006	0	2B6	<0.1	<0.001	0
1A2c	0.2	0.054	0	2C1	0.8	0.214	0
1A2d	4.5	1.204	0	2C2	0.4	0.108	0
1A2e	<0.1	0.011	0	2C3	<0.1	<0.001	0
1A2f	0.1	0.034	0	2C6	<0.1	<0.001	0
1A2gvii	0.9	0.228	0	2C7a	<0.1	<0.001	0
1A2gviii	0.9	0.246	0	2C7c	<0.1	0.006	0
1A3ai(i)	<0.1	0.004	0	2C7d	<0.1	0.006	0
1A3aii(i)	<0.1	0.001	0	2D3b	0.2	0.060	0
1A3bi	0.6	0.174	0	2D3d	<0.1	0.001	0
1A3bii	0.5	0.147	0	2D3g	<0.1	0.001	0
1A3biii	0.4	0.099	0	2D3i	0.2	0.055	0
1A3biv	<0.1	0.015	0	2G	0.2	0.055	0
1A3bvi	4.1	1.102	0	2H1	1.2	0.310	0
1A3bvii	19.9	5.323	0	2H2	1.5	0.414	0
1A3c	<0.1	0.026	0	2I	<0.1	0.021	0
1A3dii	1.1	0.295	0	2L	<0.1	0.013	0
1A4ai	0.8	0.209	0	3B1a	0.3	0.081	0
1A4aii	0.3	0.069	0	3B1b	0.3	0.071	0
1A4bi	28.4	7.608	0	3B2	<0.1	0.004	0
1A4bii	0.5	0.122	0	3B3	0.2	0.041	0
1A4ci	0.9	0.237	0	3B4d	<0.1	<0.001	0
1A4cii	0.5	0.141	0	3B4e	<0.1	0.009	0
1A4ciii	0.2	0.044	0	3B4gi	0.5	0.147	0
1A5a	7.2	1.917	0	3B4gii	0.4	0.095	0

1B1b	<0.1	0.018	0	3B4giii	<0.1	0.016	0
1B1c	1.1	0.290	0	3B4giv	0.3	0.076	0
1B2aiv	<0.1	<0.001	0	3B4h	<0.1	0.010	0
1B2av	<0.1	<0.001	0	3Dc	14.4	3.850	0
2A2	<0.1	<0.001	0	5A	<0.1	<0.001	0
2A3	<0.1	0.005	0	5C1bv	<0.1	0.001	0
2A5a	<0.1	0.002	0	5E	0.5	0.122	0
2A5b	<0.1	0.009	0	**Total**	**100**	**26.778**	**0**

Figure 1.32. The contribution of different sources to PM_{10} emissions and data reported by the plants.

2.3.7.3 Particles $PM_{2.5}$

Emission trend

The trend of $PM_{2.5}$ emissions is presented in Figure 1.33.

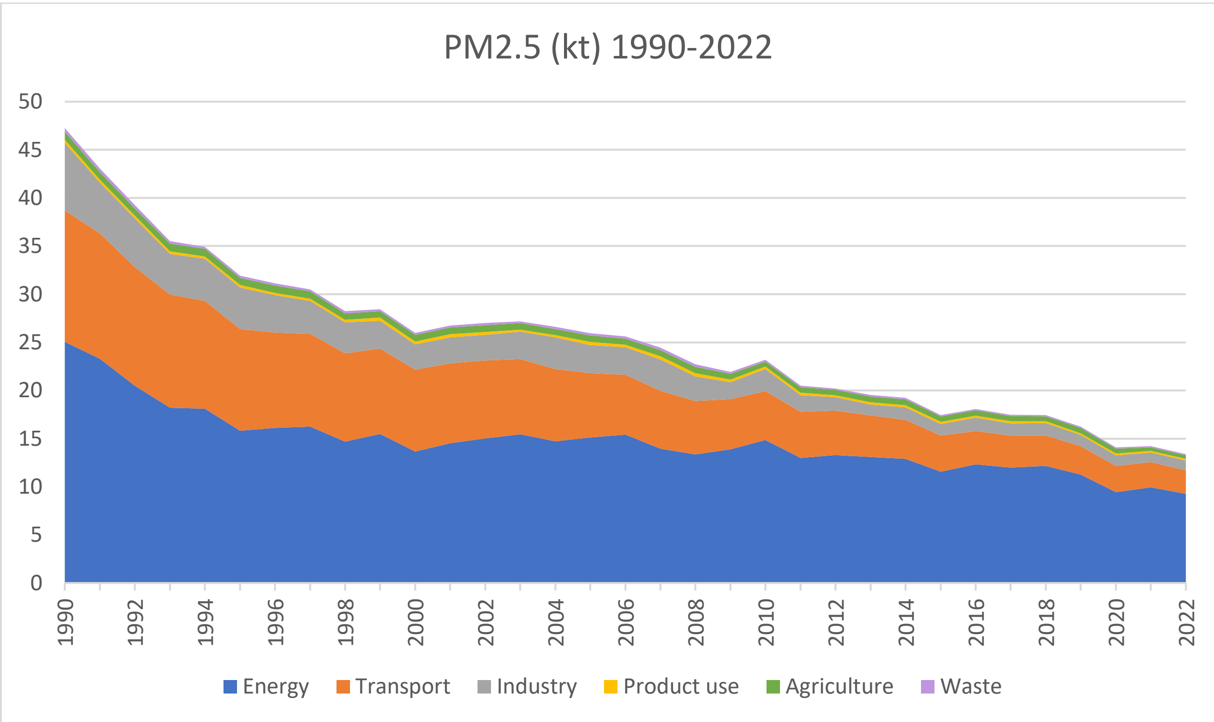
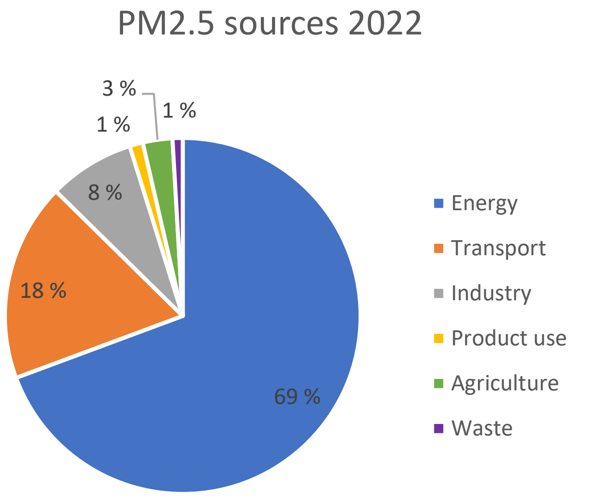


Figure 1.33. $PM_{2.5}$ emissions in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to $PM_{2.5}$ emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in in Figure 1.34.



Shares of data reported by the plants of total $PM_{2.5}$ emissions in 2022							
NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [Gg]	Percentage reported by the plants
1A1a	1.2	0.166	0	2A5c	0.2	0.027	0
1A1b	0.1	0.016	0	2B10a	1.1	0.148	0
1A2a	<0.1	0.001	0	2B10b	<0.1	0.001	0
1A2b	<0.1	0.003	0	2B6	<0.1	<0.001	0
1A2c	0.2	0.024	0	2C1	1.5	0.197	0
1A2d	5.5	0.734	0	2C2	0.6	0.076	0
1A2e	<0.1	0.004	0	2C3	<0.1	<0.001	0
1A2f	<0.1	0.011	0	2C6	<0.1	<0.001	0
1A2gvii	1.7	0.228	0	2C7a	<0.1	<0.001	0
1A2gviii	0.8	0.103	0	2C7c	<0.1	0.005	0
1A3ai(i)	<0.1	0.004	0	2C7d	<0.1	<0.001	0
1A3aii(i)	<0.1	0.001	0	2D3b	0.4	0.055	0
1A3bi	1.3	0.174	0	2D3d	<0.1	<0.001	0
1A3bii	1.1	0.147	0	2D3g	<0.1	<0.001	0
1A3biii	0.7	0.099	0	2D3i	0.4	0.051	0
1A3biv	0.1	0.015	0	2G	0.4	0.055	0
1A3bvi	4.5	0.607	0	2H1	1.3	0.176	0
1A3bvii	3.4	0.450	0	2H2	3.0	0.399	0
1A3c	0.2	0.025	0	2I	<0.1	<0.001	0
1A3dii	2.2	0.289	0	2L	<0.1	0.008	0
1A4ai	1.0	0.136	0	3B1a	0.4	0.053	0
1A4aii	0.5	0.069	0	3B1b	0.3	0.046	0
1A4bi	55.0	7.359	0	3B2	<0.1	0.001	0
1A4bii	0.9	0.122	0	3B3	<0.1	0.002	0
1A4ci	0.9	0.124	0	3B4d	<0.1	<0.001	0
1A4cii	1.1	0.141	0	3B4e	<0.1	0.006	0
1A4ciii	0.3	0.041	0	3B4gi	<0.1	0.011	0

1A5a	2.9	0.390	0	3B4gii	<0.1	0.009	0
1B1b	<0.1	0.008	0	3B4giii	<0.1	0.003	0
1B1c	1.5	0.204	0	3B4giv	<0.1	0.011	0
1B2aiv	<0.1	<0.001	0	3B4h	<0.1	0.005	0
1B2av	<0.1	<0.001	0	3Dc	1.6	0.213	0
2A2	<0.1	<0.001	0	5A	<0.1	<0.001	0
2A3	<0.1	0.005	0	5C1bv	<0.1	0.001	0
2A5a	<0.1	<0.001	0	5E	0.9	0.122	0
2A5b	<0.1	0.001	0	**Total**	**100**	**13.384**	**0**

Figure 1.34. The contribution of different sources to $PM_{2.5}$ emissions and data reported by the plants.

2.3.7.4 Black carbon (BC)

Emission trend

The trend of black carbon emissions is presented in Figure 1.35.

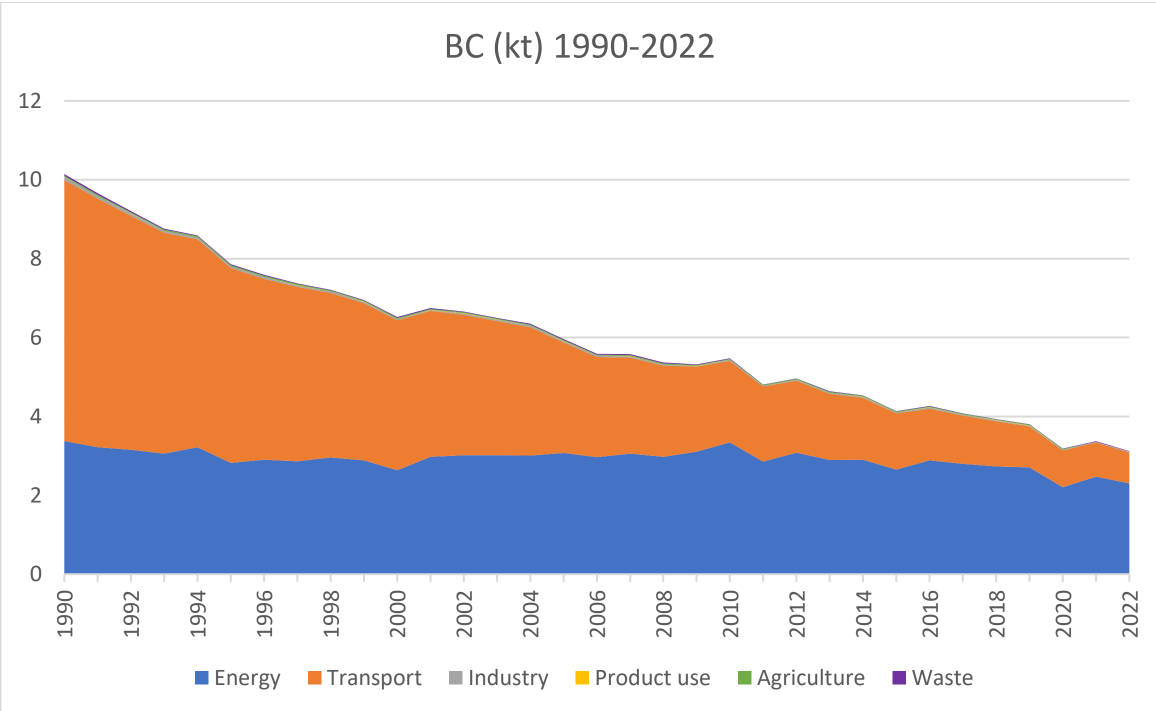
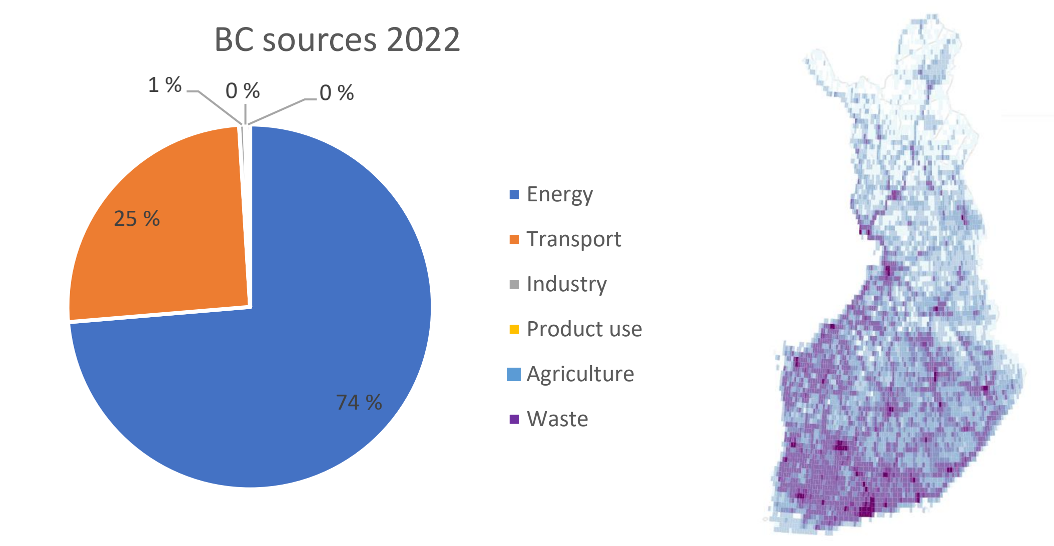


Figure 1.35. BC emissions (kt) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.36.



Shares of data reported by the plants of total BC emissions in 2022							
NFR	**Percentage of national total**	**Total release [Gg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [Gg]**	**Percentage reported by the plants**
1A1a	0.3	0.008	0	1A4bi	67.7	2.113	0
1A1b	<0.1	<0.001	0	1A4bii	0.7	0.023	0
1A2a	<0.1	<0.001	0	1A4ci	0.2	0.006	0
1A2b	<0.1	<0.001	0	1A4cii	1.9	0.061	0
1A2c	0.2	0.005	0	1A4ciii	0.4	0.014	0
1A2d	0.4	0.013	0	1A5a	3.6	0.113	0
1A2e	<0.1	<0.001	0	1B1b	0.1	0.004	0
1A2f	<0.1	0.002	0	2A2	<0.1	<0.001	0
1A2gvii	4.5	0.139	0	2A3	<0.1	<0.001	0
1A2gviii	0.2	0.006	0	2B10a	<0.1	0.003	0
1A3ai(i)	<0.1	0.002	0	2B6	<0.1	<0.001	0
1A3aii(i)	<0.1	<0.001	0	2C1	<0.1	<0.001	0
1A3bi	2.7	0.084	0	2C2	0.2	0.008	0
1A3bii	2.6	0.081	0	2C3	<0.1	<0.001	0
1A3biii	1.7	0.053	0	2C7a	<0.1	<0.001	0
1A3biv	0.1	0.004	0	2D3b	0.1	0.003	0
1A3bvi	5.0	0.157	0	2D3i	<0.1	<0.001	0
1A3bvii	2.8	0.088	0	2G	<0.1	<0.001	0
1A3c	0.5	0.016	0	2H1	0.1	0.005	0
1A3dii	1.7	0.052	0	5C1bv	<0.1	<0.001	0
1A4ai	0.9	0.027	0	5E	0.3	0.011	0
1A4aii	0.6	0.018	0	**Total**	**100**	**3.121**	**0**

Figure 1.36. The contribution of different sources to BC emissions and data reported by the plants.

2.3.8 Heavy metals

The following heavy metals are included in the Finnish inventory: primary heavy metals, lead, cadmium and mercury, and in addition, arsenic, chromium, copper, nickel and zinc. The time series 1990-2022 are presented in Figure 1.37.

Selene is one of the non-obligatory heavy metals for reporting and as a full inventory has not yet been performed for selene, the national total is reported as NE although sector specific values exist and are reported. The same applies also to all other heavy metals prior to the year 1990 when the obligation for inventories starts.

The inventory includes bottom-up data, i.e. data reported by the plants on basis of reporting obligations in their environmental permits. Although a thorough recalculation of the time series has been carried out, there still is need to check the correct abatement techniques used especially for small boilers, currently part of these emissions are calculated as unabated. In addition, a project funded by the Nordic Council of Ministers is running in 2016-2023 to study emissions in the Nordic countries and to develop methodologies that better reflect the real emission levels.

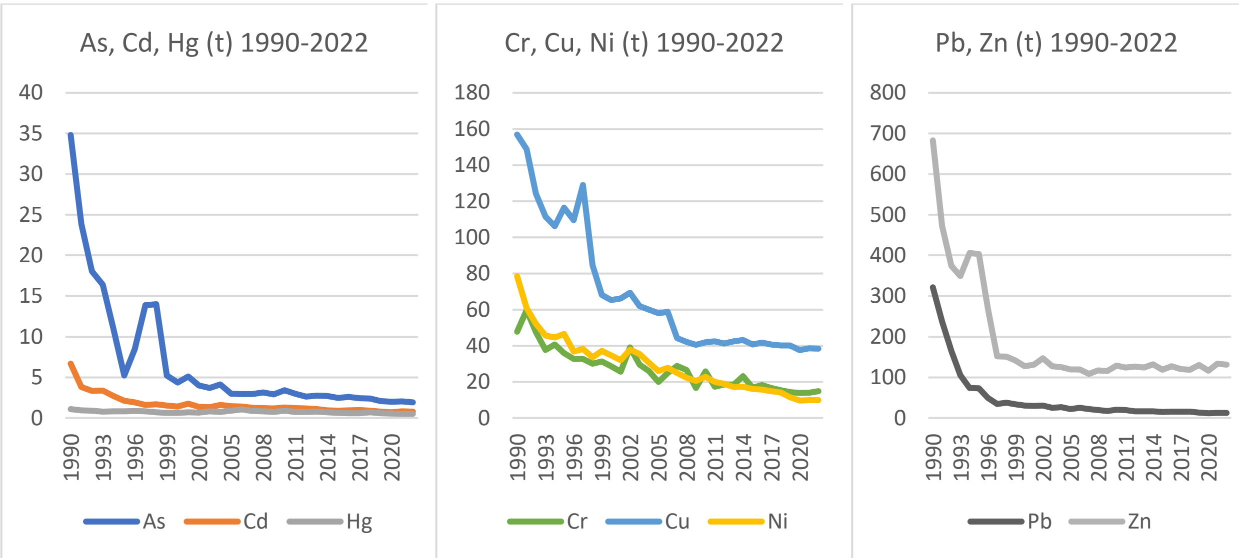


Figure 1.37. Heavy metal emission trends

The emission trends have been strongly decreasing (Figure 1.37) after the first reporting year 1990:

The main sources of heavy metal emissions in Finland are industrial processes and energy production. In both sources there can be large annual variations. For industrial processes the variations are due to changes in the production capacities and in the energy sector, the energy supply structure causes fluctuations. In the integrated Nordic electricity market, the annual rainfall and accordingly the availability of cheap hydropower decreased the Finnish emissions in the early 1990's as well as in the turn of the millennium. After that, in years with limited availability of Nordic hydropower, coal and peat fuelled condensing power generation has increased and impacted emission levels.

Annual variations in the emissions are mainly due to fluctuations in the production of non-ferrous metals. In the energy sector, emissions are more stable though affected by the variations in energy production.

2.3.8.1 Arsenic emissions

Emission trend

Arsenic emissions have been reduced from the base year of 1990. The main source in the beginning of the 1990's was industrial processes (mainly non-ferrous metals), where the emissions have dropped considerably. The largest source at the moment is energy production where the energy supply structure causes fluctuations. The main source currently is combustion of wood in the residential sector (Figure 1.38).

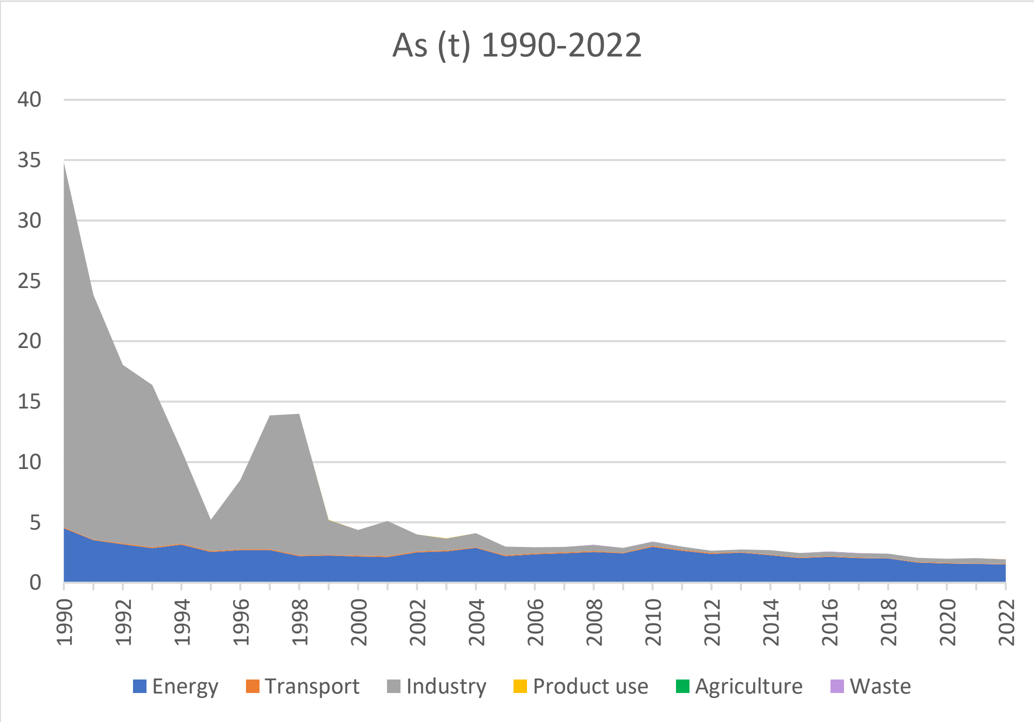
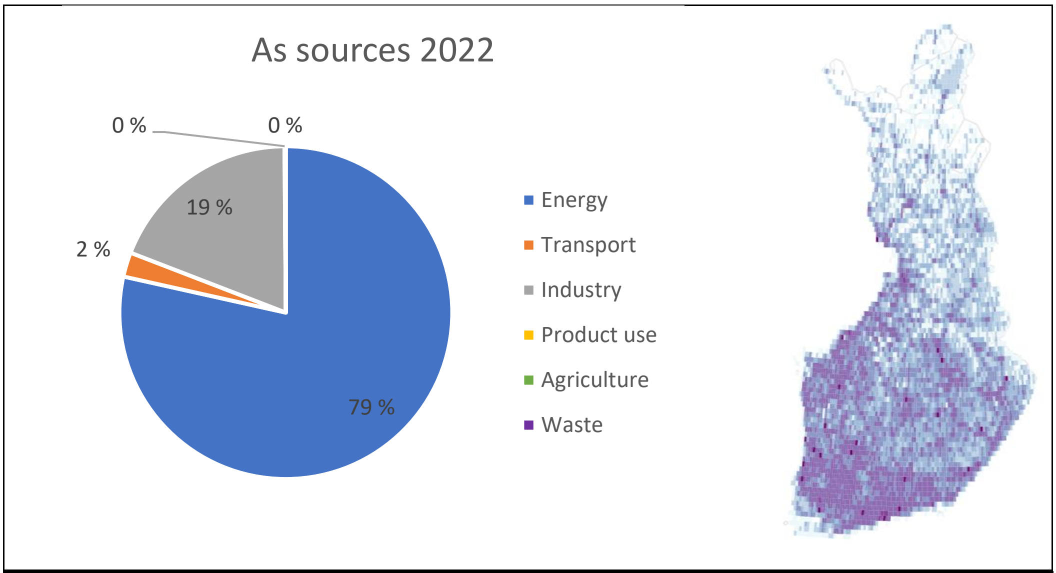


Figure 1.38. Arsenic emissions (t) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.39.



Shares of data reported by the plants of total As emissions in 2022							
NFR	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**
1A1a	27.5	0.528	11.6	1A4ai	0.8	0.014	0
1A1b	26.8	0.514	0	1A4bi	3.1	0.060	0
1A2a	<0.1	<0.001	0	1A4ci	5.1	0.097	0
1A2b	<0.1	<0.001	0	1A4ciii	<0.1	0.001	0
1A2c	0.1	0.002	0	1A5a	2.0	0.039	0
1A2d	5.4	0.104	15.9	1B1b	<0.1	0.001	100
1A2e	2.2	0.042	3.9	2C1	3.0	0.058	100
1A2f	5.2	0.099	1.2	2C2	0.1	0.002	100
1A2gviii	0.3	0.005	26.9	2C3	<0.1	<0.001	100
1A3bi	<0.1	<0.001	0	2C6	2.2	0.042	100
1A3bii	<0.1	<0.001	0	2C7a	6.2	0.119	90.9
1A3biii	<0.1	<0.001	0	2C7c	7.5	0.143	100
1A3biv	<0.1	<0.001	0	2G	<0.1	<0.001	0
1A3bvi	2.1	0.041	0	5C1bv	<0.1	<0.001	0
1A3dii	0.1	0.003	0	5E	<0.1	0.001	0
				Total	**100**	**1.920**	**22.8**

Figure 1.39 The contribution of different sources to AS emissions and data reported by the plants.

2.3.8.2 Cadmium emissions

Emission trend

Cadmium emissions have been reduced from the base year of 1990. The main sources of cadmium are industrial processes and energy production. The emissions fluctuate annually depending on the consumption of fossil fuels and production rates in manufacturing industries. (Figure 1.40).

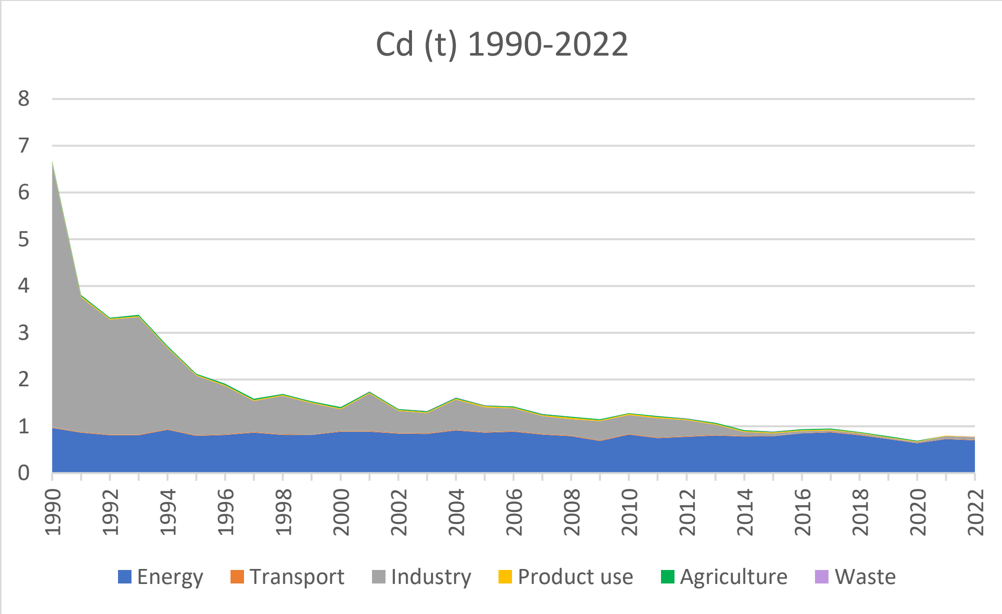
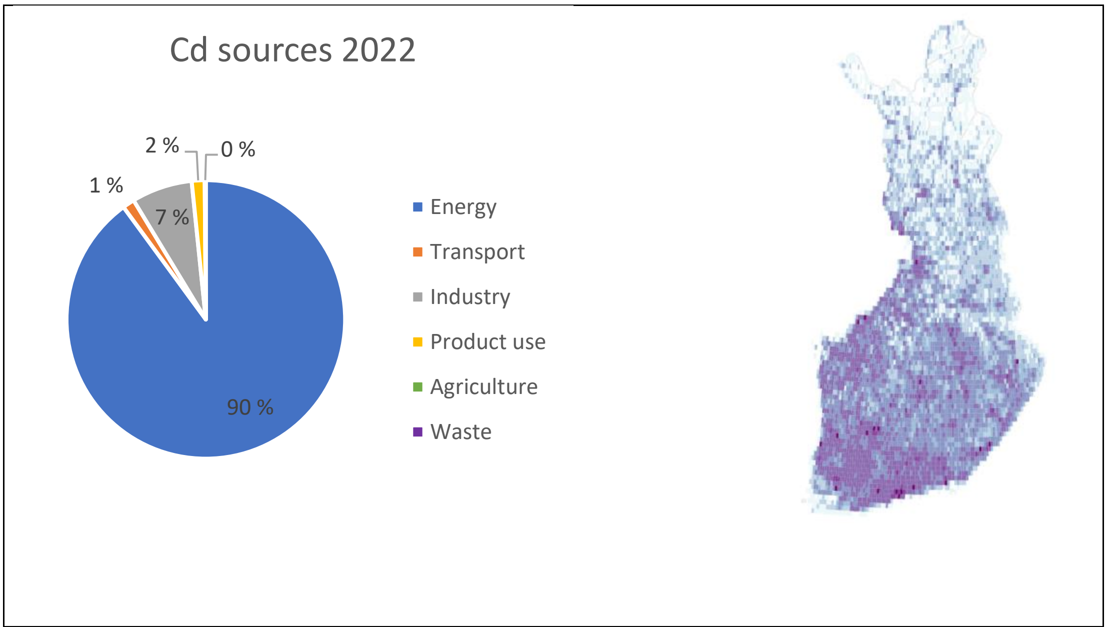


Figure 1.40. Emissions of cadmium (t) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.41.



Shares of data reported by the plants of total Cd emissions in 2022							
NFR	Percentage of national total	Total release [Mg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [Mg]	Percentage reported by the plants
1A1a	15.3	0.119	18.0	1A4aii	0.1	<0.001	0
1A1b	9.1	0.071	0	1A4bi	18.8	0.147	0
1A2a	<0.1	<0.001	0	1A4bii	<0.1	<0.001	0
1A2b	<0.1	<0.001	0	1A4ci	2.8	0.022	0
1A2c	<0.1	<0.001	0	1A4cii	0.3	0.002	0

1A2d	15.3	0.119	6.0	1A4ciii	<0.1	<0.001	0
1A2e	0.3	0.002	3.1	1A5a	23.1	0.180	0
1A2f	2.1	0.017	17.6	1B1b	<0.1	<0.001	100
1A2gvii	0.5	0.004	0	2C1	0.8	0.006	100
1A2gviii	1.7	0.013	8.1	2C2	<0.1	<0.001	100
1A3bi	<0.1	<0.001	0	2C3	<0.1	<0.001	100
1A3bii	<0.1	<0.001	0	2C6	1.3	0.010	100
1A3biii	<0.1	<0.001	0	2C7a	<0.1	<0.001	100
1A3biv	<0.1	<0.001	0	2C7c	4.9	0.038	100
1A3bvi	0.2	0.002	0	2G	1.5	0.012	0
1A3c	<0.1	<0.001	0	5C1bv	<0.1	<0.001	0
1A3dii	<0.1	<0.001	0	5E	<0.1	<0.001	0
1A4ai	1.3	0.010	0	**Total**	**100**	**0.779**	**11.3**

Figure 1.41. The contribution of different sources to Cd emissions and data reported by the plants.

2.3.8.3 Chromium emissions

Emission trend

Chromium emissions have been reduced from the base year 1990. Both energy production and industrial processes contribute to the annual releases. Emissions from industrial processes have large annual variations due to variations in the production volumes, also the energy supply structure causes fluctuations. (Figure 1.42).

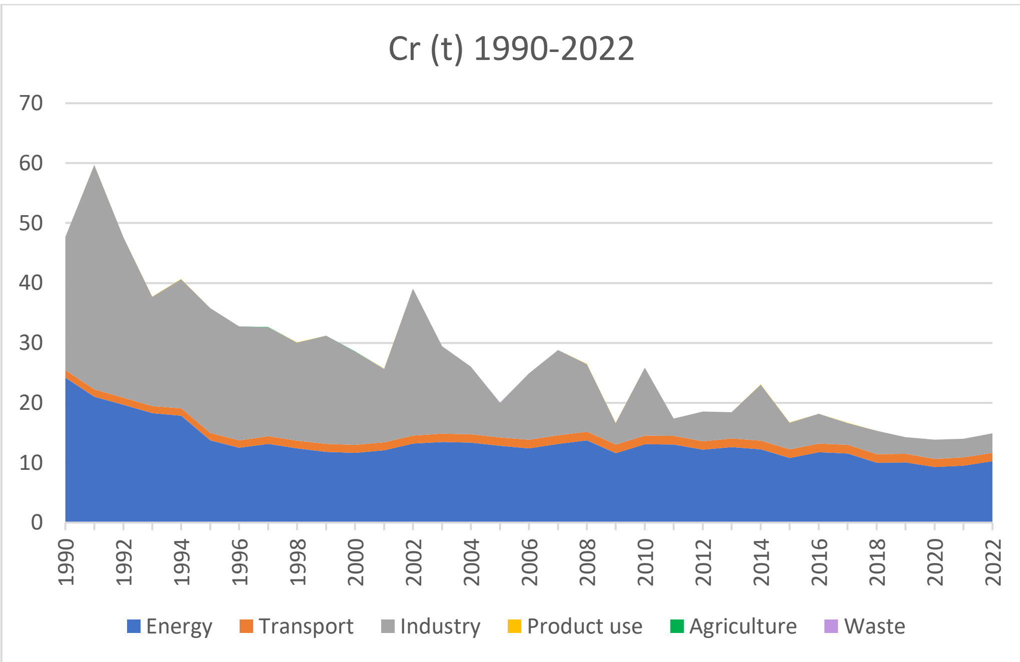
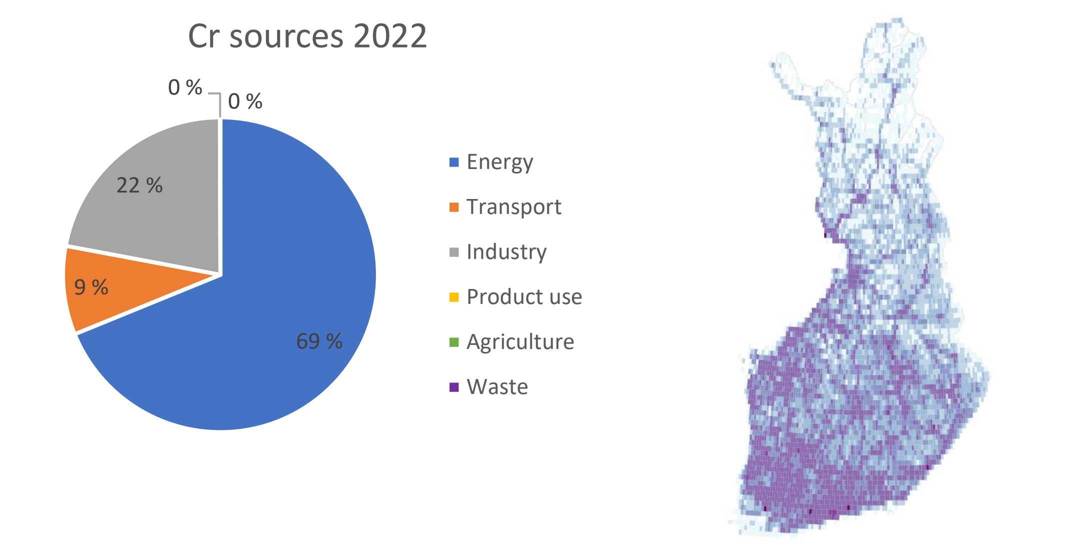


Figure 1.42. Emissions of chromium (t) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.43.



Shares of data reported by the plants of total Cr emissions in 2022							
NFR	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**
1A1a	9.4	1.404	12.6	1A4ai	0.9	0.129	0
1A1b	26.5	3.956	0	1A4aii	<0.1	0.005	0
1A2a	<0.1	<0.001	0	1A4bi	11.6	1.728	0
1A2b	0.8	0.123	0	1A4bii	<0.1	0.003	0
1A2c	<0.1	0.001	0	1A4ci	2.5	0.371	0
1A2d	1.0	0.145	80.0	1A4cii	<0.1	0.012	0
1A2e	0.6	0.084	1.2	1A4ciii	<0.1	0.002	0
1A2f	5.2	0.768	1.8	1A5a	8.4	1.258	0
1A2gvii	0.1	0.018	0	1B1b	<0.1	0.009	100
1A2gviii	1.9	0.285	72.1	2C1	13.9	2.069	100
1A3bi	<0.1	0.012	0	2C2	8.1	1.203	100
1A3bii	<0.1	0.002	0	2C7a	<0.1	<0.001	100
1A3biii	<0.1	0.012	0	2C7c	<0.1	0.006	100
1A3biv	<0.1	<0.001	0	2G	<0.1	0.007	0
1A3bvi	8.6	1.284	0	5C1bv	<0.1	<0.001	0
1A3c	<0.1	<0.001	0	5E	<0.1	0.001	0
1A3dii	<0.1	0.006	0	**Total**	**100**	**14.905**	**25.5**

Figure 1.43. The contribution of different sources to Cr emissions and data reported by the plants.

2.3.8.4 Copper emissions

Emission trend

Copper emissions have been reduced from from the base year of 1990. The main sources of copper emissions are transport, energy production and industrial processes. In the transport sector, emissions originate mainly from brake wear. Emissions from brake wear have stayed rather constant. In the industrial processes sector, emissions have decreased significantly from the base year. Metal industry is the largest contributor and the emissions vary depending on the annual production rates. Also, the national energy supply structure causes slight fluctuations to emissions. Emissions from the industry sector have been decreased due to improvements in processes and abatement technology. (Figure 1.44)

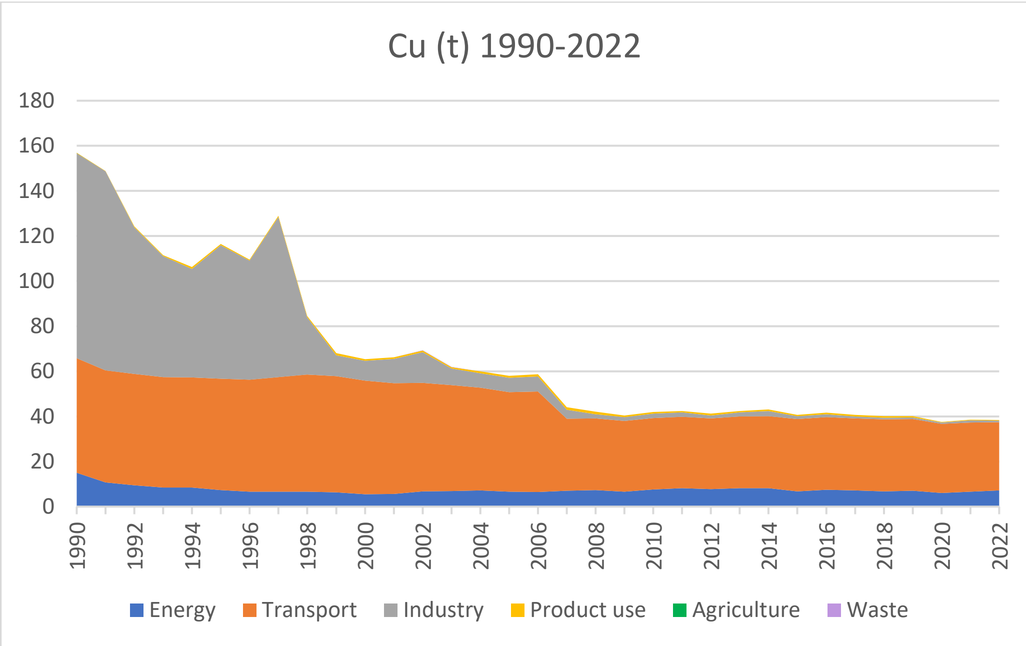
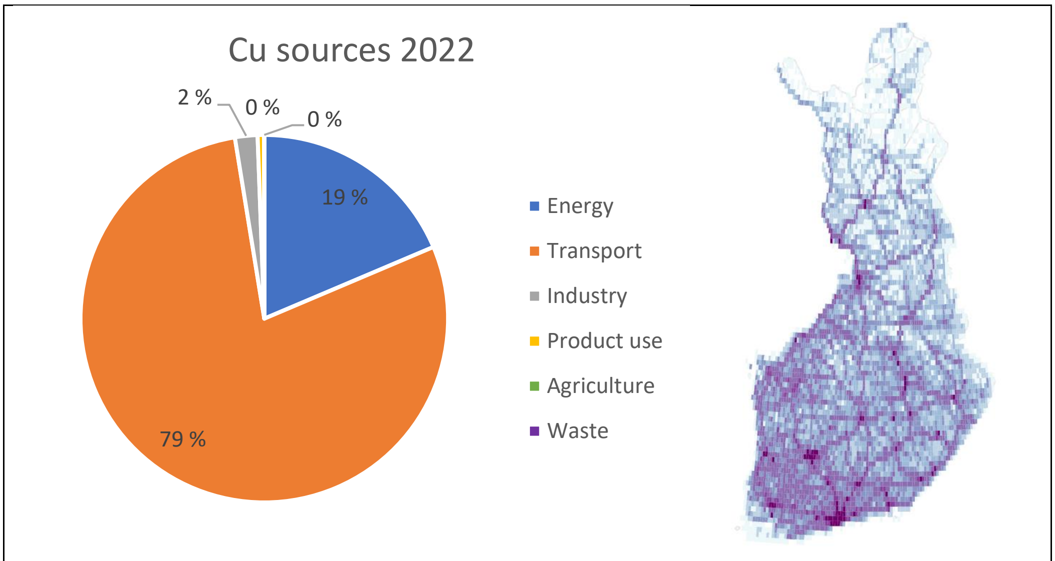


Figure 1.44. Emissions of copper (t) 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.45.



Shares of data reported by the plants of total Cu emissions in 2022

NFR	Percentage of national total	Total release [Mg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [Mg]	Percentage reported by the plants
1A1a	6.1	2.328	14.4	1A4aii	0.4	0.162	0
1A1b	3.6	1.385	0	1A4bi	0.8	0.324	0
1A2a	<0.1	<0.001	0	1A4bii	0.3	0.096	0
1A2b	<0.1	<0.001	0	1A4ci	0.7	0.284	0
1A2c	<0.1	0.003	0	1A4cii	1.0	0.396	0
1A2d	1.0	0.402	88.7	1A4ciii	<0.1	0.006	0
1A2e	0.3	0.115	0.8	1A5a	4.8	1.838	0
1A2f	0.7	0.273	2.7	1B1b	<0.1	0.010	100
1A2gvii	1.6	0.627	0	2B10a	<0.1	0.008	100
1A2gviii	0.4	0.139	10	2C1	0.9	0.365	100
1A3bi	<0.1	0.009	0	2C2	<0.1	0.025	100
1A3bii	<0.1	0.002	0	2C6	<0.1	0.013	100
1A3biii	<0.1	0.008	0	2C7a	<0.1	0.002	100
1A3biv	<0.1	<0.001	0	2C7c	0.9	0.349	100
1A3bvi	75.3	28.906	0	2G	0.6	0.221	0
1A3c	<0.1	0.033	0	5C1bv	<0.1	<0.001	0
1A3dii	<0.1	0.014	0	5E	<0.1	0.003	0
1A4ai	0.1	0.045	0	**Total**	**100**	**38.391**	**3.9**

Figure 1.45. The contribution of different sources to Cu emissions and data reported by the plants.

2.3.8.5 Lead emissions

Emission trend

Lead emissions have been reduced from the base year of 1990. The main source of lead in the beginning of the 1990s was the use of lead added to gasoline being 1211 tonnes in 1980 and 192 tonnes in 1990 and coming down to 0 tonnes in 1994. In the transport sector, lead is still emitted from lubricant use in vehicles. Lead emissions from industrial processes (metal industry) have been significantly decreased since the mid-1990s. The largest source of lead at the moment is combustion of fuels and the emissions vary annually depending on changes in the annual energy supply structure.

The time series is presented in Figure 1.46.

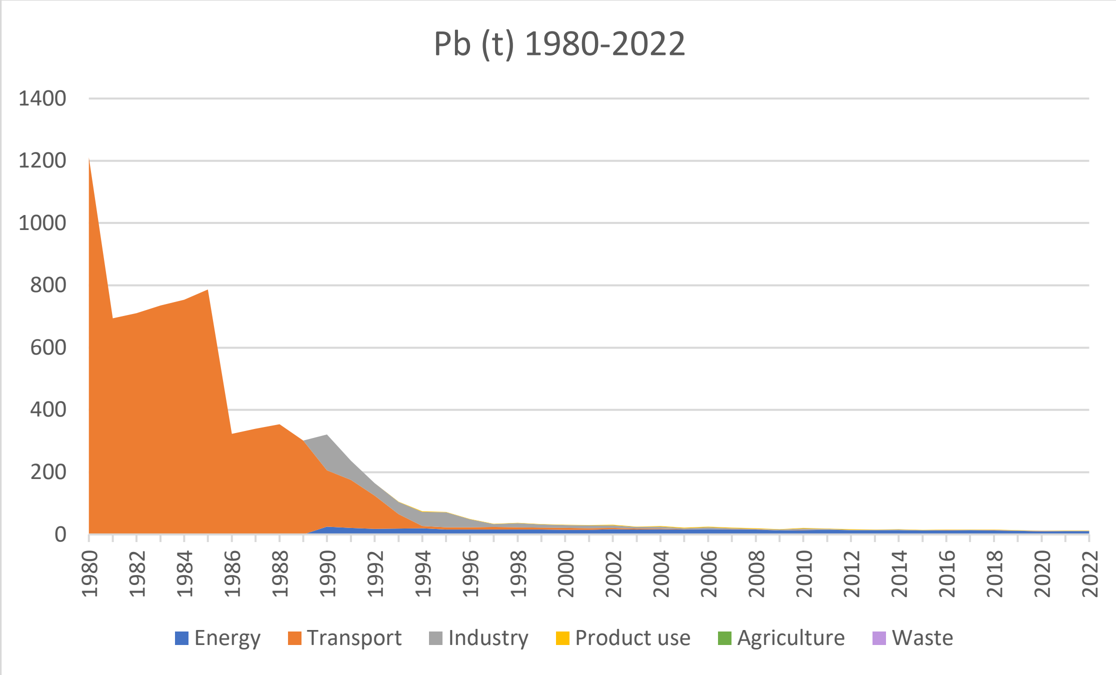
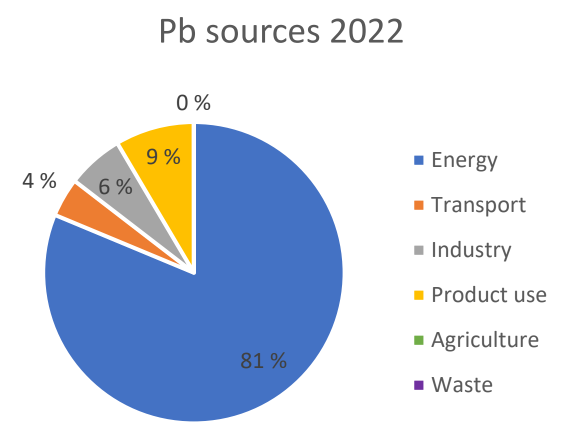


Figure 1.46. Pb emissions (Mg) in 1980-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.47.



Shares of data reported by the plants of total Pb emissions in 2022							
NFR	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**
1A1a	14.4	1.800	13.5	1A4ai	0.7	0.087	0
1A1b	25.0	3.125	0	1A4bi	4.1	0.512	0
1A2a	<0.1	<0.001	0	1A4ci	2.0	0.254	0
1A2b	<0.1	<0.001	0	1A4ciii	<0.1	0.004	0
1A2c	0.2	0.025	0	1A5a	13.2	1.653	0
1A2d	14.7	1.843	6.8	1B1b	0.1	0.013	100
1A2e	0.8	0.101	3.0	2B10a	<0.1	0.001	0
1A2f	5.2	0.646	7.1	2C1	3.4	0.425	100
1A2gviii	0.9	0.111	2.3	2C2	0.2	0.026	100

1A3aii(i)	0.4	0.045	0	2C3	<0.1	<0.001	100
1A3bi	<0.1	0.002	0	2C6	0.1	0.015	100
1A3bii	<0.1	<0.001	0	2C7a	<0.1	0.003	58.0
1A3biii	<0.1	<0.001	0	2C7c	2.3	0.288	100
1A3biv	<0.1	<0.001	0	2G	8.5	1.061	0
1A3bvi	3.7	0.461	0	5C1bv	<0.1	0.001	0
1A3dii	<0.1	0.009	0	5E	<0.1	<0.001	0
				Total	**100**	**12.516**	**9.5**

Figure 1.47 The contribution of different sources to Pb emissions and data reported by the plants.

2.3.8.6 Mercury emissions

Emission trend

Mercury emissions have been reduced from the base year of 1990. The main sources of mercury are energy production and industrial processes (mainly iron and steel production). The emissions are fluctuating annually depending on changes in the annual energy production structure and fluctuations in the industrial production volumes. (Figure 1.48)

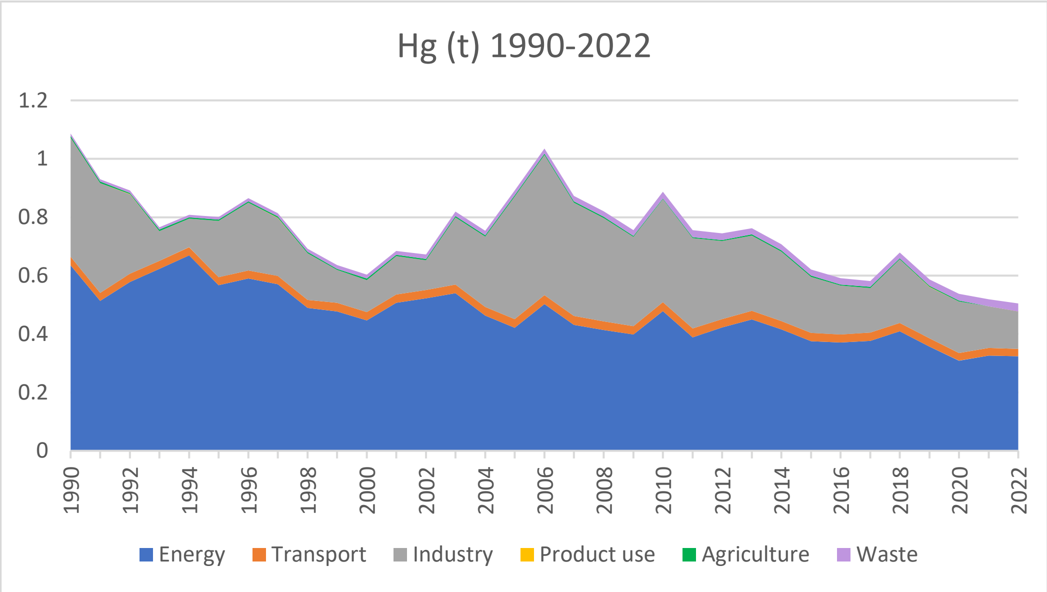
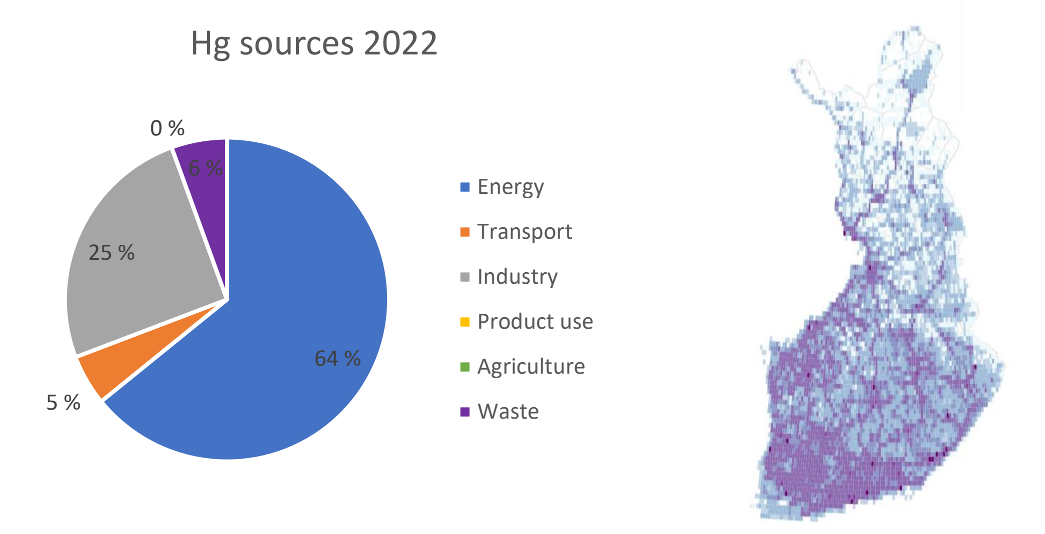


Figure 1.48. The emissions of mercury (t) in 1990-2022.

The uncertainties of emission data are presented in Annex67 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.49.



Shares of data reported by the plants of total Hg emissions in 2022							
NFR	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**
1A1a	27.8	0.140	70.0	1A4bi	4.9	0.025	0
1A1b	2.9	0.015	0	1A4ci	1.2	0.006	0
1A2a	<0.1	<0.001	0	1A4ciii	0.2	<0.001	0
1A2b	<0.1	<0.001	0	1A5a	3.6	0.018	0
1A2c	<0.1	<0.001	0	1B1b	<0.1	<0.001	0
1A2d	15.7	0.079	42.3	2B10a	6.9	0.035	0.3
1A2e	0.4	0.002	12.5	2C1	16.7	0.085	100
1A2f	4.5	0.023	87.7	2C2	0.3	0.002	100
1A2gviii	2.7	0.013	74.7	2C6	0.6	0.003	100
1A3bi	2.6	0.013	0	2C7a	<0.1	<0.001	0
1A3bii	0.3	0.002	0	2C7c	0.7	0.004	100
1A3biii	1.5	0.008	0	2G	<0.1	<0.001	0
1A3biv	<0.1	<0.001	0	5C1bv	5.4	0.027	0
1A3dii	0.4	0.002	0	5E	0.2	<0.001	0
1A4ai	0.4	0.002	0	**Total**	**100**	**0.505**	**50.5**

Figure 1.49 The contribution of different sources to Hg emissions and data reported by the plants.

2.3.8.7 Nickel emissions

Emission trend

Nickel emissions have been reduced from from the base year of 1990. The emission trend is decreasing (Figure 1.50) and the emissions are fluctuating annually depending on the consumption of fossil fuels and production rates in the manufacturing industries (mainly non-ferrous metals).

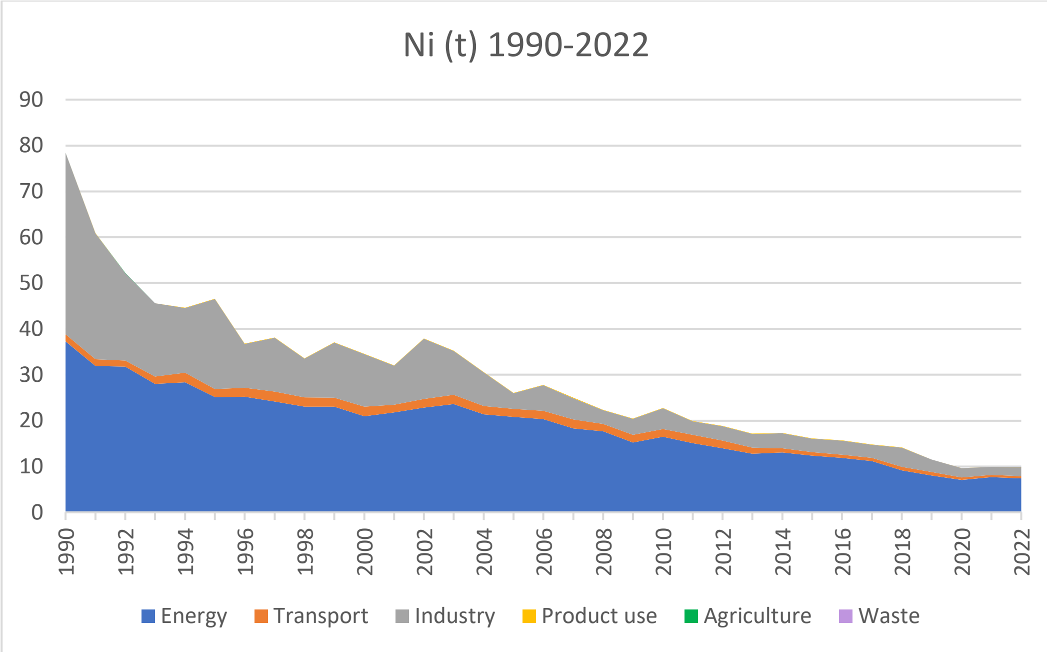
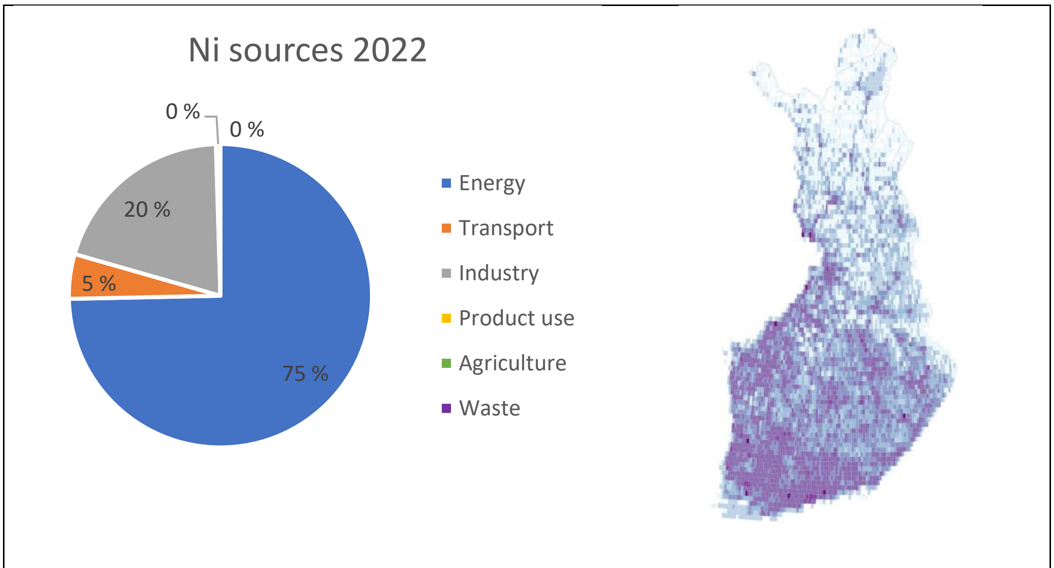


Figure 1.50. Nickel emissions (t) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.51.



Shares of data reported by the plants of total Ni emissions in 2022							
NFR	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**
1A1a	18.4	1.823	23.6	1A4ai	5.7	0.564	0
1A1b	0.1	0.011	62.1	1A4aii	<0.1	0.007	0
1A2a	<0.1	<0.001	0	1A4bi	15.0	1.487	0
1A2b	0.3	0.035	0	1A4bii	<0.1	0.004	0
1A2c	3.0	0.298	0	1A4ci	3.7	0.363	0
1A2d	3.8	0.379	46.2	1A4cii	0.2	0.016	0
1A2e	1.4	0.134	20.8	1A4ciii	0.3	0.032	0
1A2f	6.6	0.656	1.1	1A5a	15.4	1.527	0
1A2gvii	0.3	0.026	0	1B1b	0.1	0.012	100
1A2gviii	1.2	0.116	5.1	2B10a	0.1	0.013	100
1A3bi	<0.1	0.003	0	2C1	6.4	0.637	100

1A3bii	<0.1	<0.001	0	2C2	0.4	0.037	100
1A3biii	<0.1	<0.001	0	2C7a	<0.1	<0.001	0
1A3biv	<0.1	<0.001	0	2C7b	11.0	1.088	100
1A3bvi	1.9	0.184	0	2C7c	2.2	0.218	100
1A3c	<0.1	0.001	0	2G	0.5	0.046	0
1A3dii	2.0	0.198	0	5C1bv	<0.1	<0.001	0
				Total	**100**	**9.917**	**26.8**

Figure 1.51 The contribution of different sources to Ni emissions and data reported by the plants.

2.3.8.8 Zinc emissions

Emission trend

Zinc emissions have been reduced from the base year of 1990. The main source category until the end of 1990s was industrial processes (metal industry), where significant reductions occurred during the decade. Emissions from energy production have been fluctuating due to changes in the annual energy supply structure. (Figure 1.52)

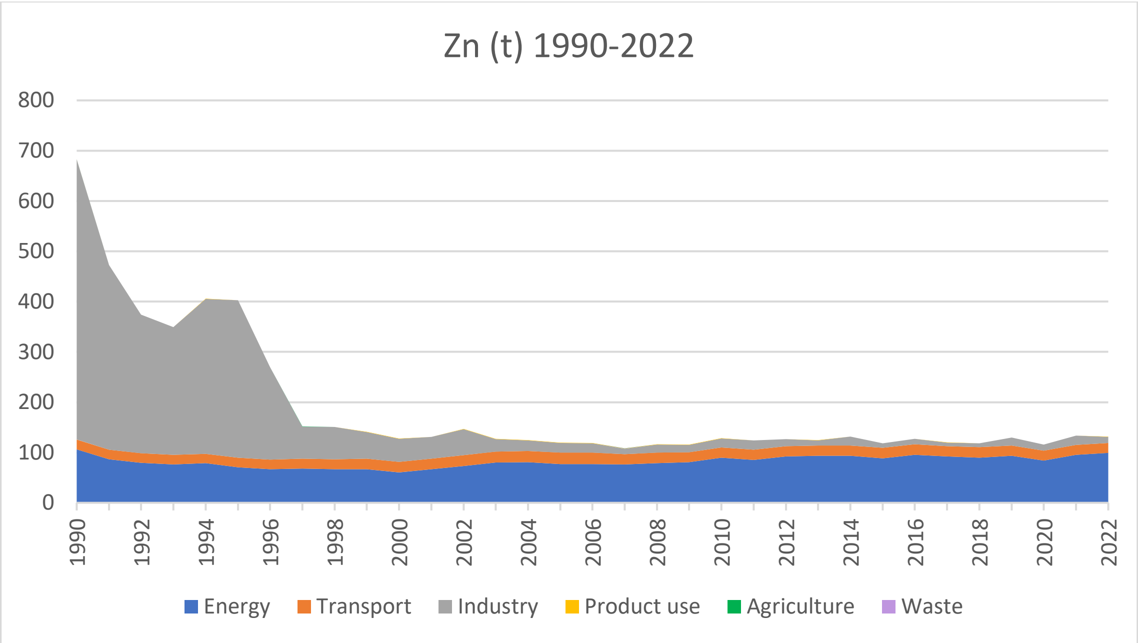
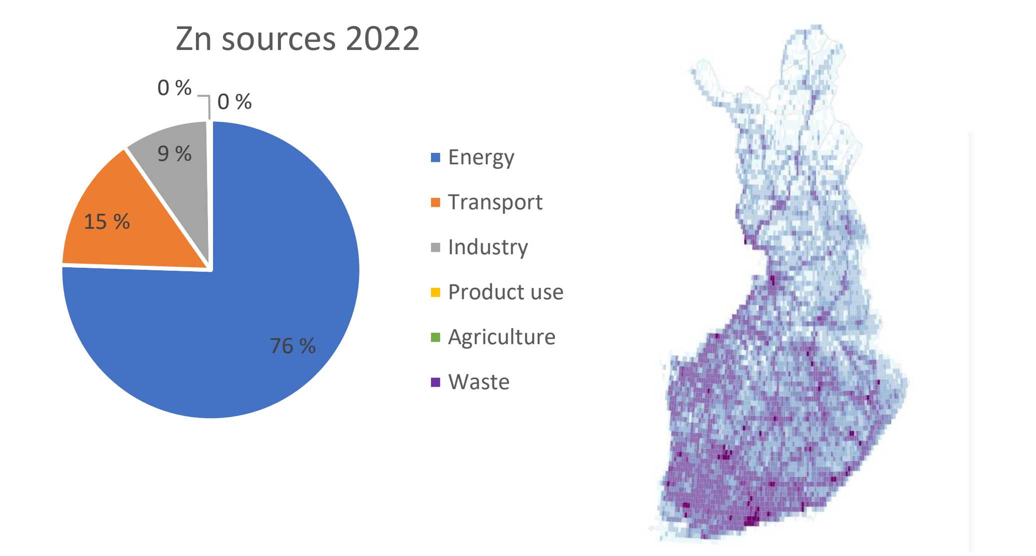


Figure 1.52. Emissions of zinc (t) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.53.



Shares of data reported by the plants of total Zn emissions in 2022							
NFR	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [Mg]**	**Percentage reported by the plants**
1A1a	14.2	18.688	10.1	1A4aii	<0.1	0.095	0
1A1b	4.5	5.936	0	1A4bi	26.0	34.22	0
1A2a	<0.1	0.008	0	1A4bii	<0.1	0.056	0
1A2b	<0.1	<0.001	0	1A4ci	3.5	4.659	0
1A2c	<0.1	0.016	0	1A4cii	0.2	0.233	0
1A2d	0.9	1.194	35.3	1A4ciii	<0.1	0.038	0
1A2e	0.2	0.267	6.2	1A5a	19.1	25.152	0
1A2f	3.2	4.159	0	1B1b	<0.1	0.041	100
1A2gvii	0.3	0.369	0	2B10a	0.2	0.250	0
1A2gviii	2.0	2.687	0	2C1	1.9	2.522	100
1A3bi	<0.1	0.048	0	2C2	1.0	1.334	100
1A3bii	<0.1	0.005	0	2C3	<0.1	0.004	100
1A3biii	<0.1	0.026	0	2C6	5.9	7.787	100
1A3biv	<0.1	0.001	0	2C7a	<0.1	0.003	100
1A3bvi	14.0	18.403	0	2C7c	0.4	0.550	100
1A3c	<0.1	0.019	0	2G	0.3	0.357	0
1A3dii	<0.1	0.083	0	5C1bv	<0.1	0.006	0
1A4ai	1.8	2.312	0	**Total**	**100**	**131.533**	**11.1**

Figure 1.53. The contribution of different sources to Zn emissions and data reported by the plants.

2.3.9 Persistent organic pollutants

The time series of PCDD/F, PAH-4, HCB and PCBs are presented in Figure 1.54.

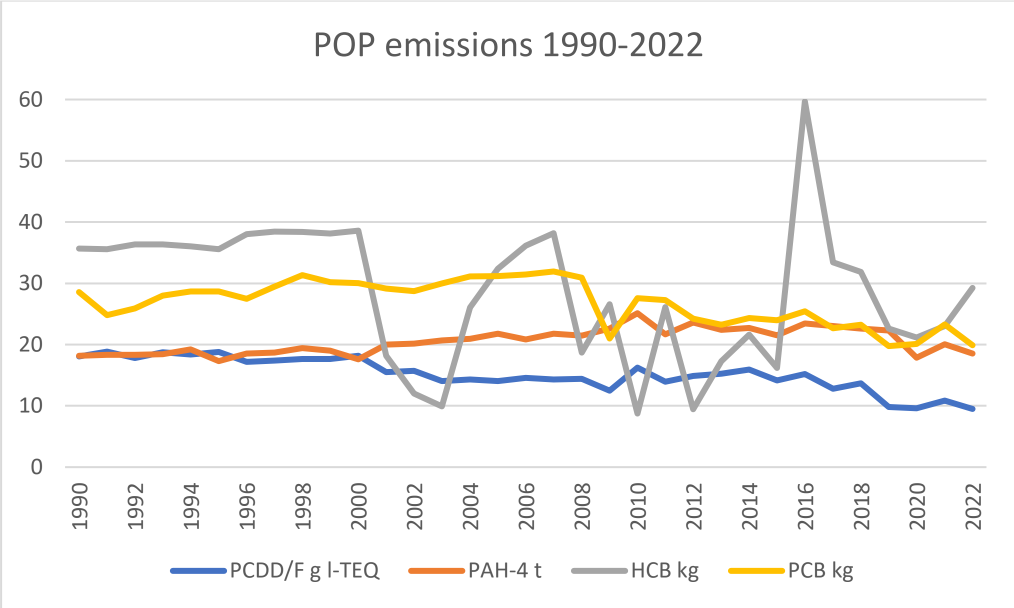


Figure 1.54. POP emissions PCDD/F (gI-Teq), PAH-4 (t), HCB (kg) and PCB (kg)) emissions 1990–2020.

2.3.9.1 Polychlorinated dioxins and furanes, PCDD/F

Emission trend

PCDD/F emissions have been reduced from the base year of 1990 (Figure 1.55). The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.56.

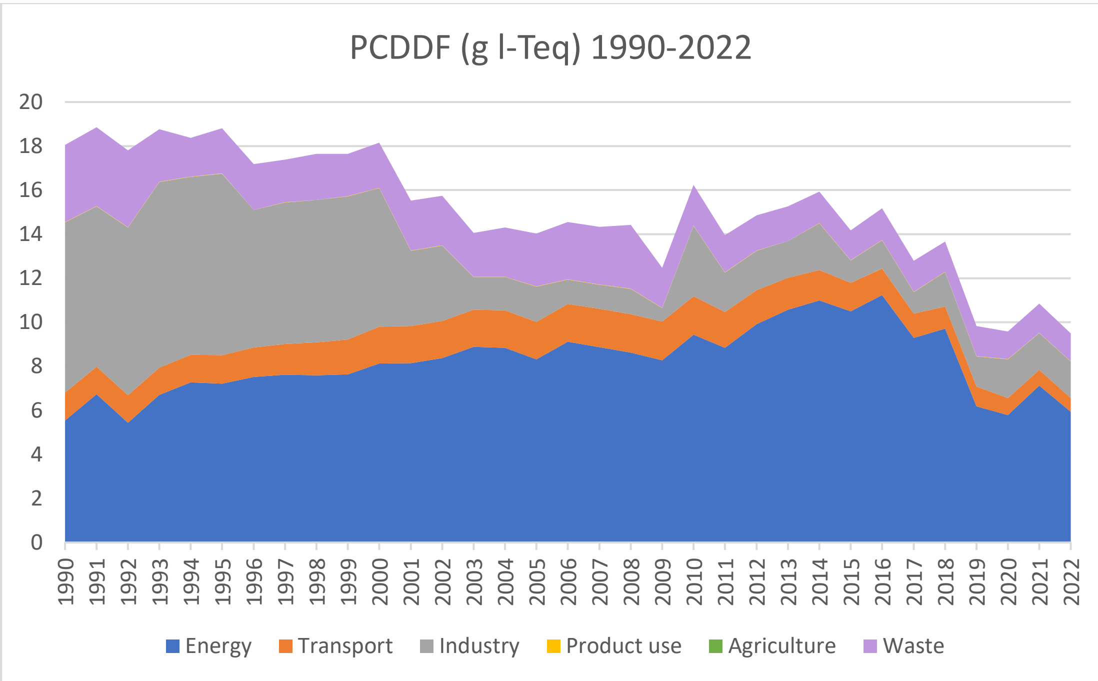


Figure 1.55. Emissions of PCDD/F (g I-Teq) in 1990-2022.

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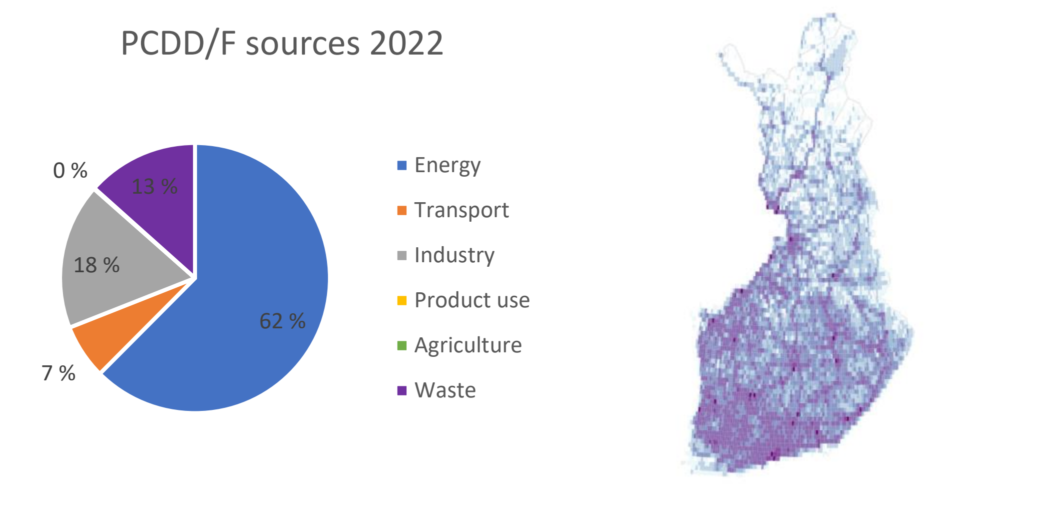


Shares of data reported by the plants of total PCDD/F emissions in 2022							
NFR	**Percentage of national total**	**Total release [g I-Teq]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [g I-Teq]**	**Percentage reported by the plants**
1A1a	31.4	2.981	13.7	1A4ci	1.6	0.151	0
1A1b	0.4	0.040	0	1A4ciii	<0.1	0.004	0
1A2a	<0.1	0.006	0	1A5a	8.0	0.764	0
1A2b	<0.1	<0.001	0	1B1b	0.2	0.023	100
1A2c	<0.1	0.007	0	2A1	0.1	0.010	100
1A2d	7.0	0.664	37.1	2A2	0.3	0.026	0
1A2e	0.2	0.024	0	2A3	<0.1	<0.001	0
1A2f	0.2	0.019	53.2	2B10a	8.3	0.790	100
1A2gviii	1.6	0.148	9.4	2C1	5.4	0.509	100
1A3bi	4.3	0.409	0	2C3	0.5	0.045	0
1A3bii	1.4	0.134	0	2C6	0.7	0.064	0
1A3biii	0.5	0.051	0	2C7a	2.1	0.201	0.3
1A3biv	0.2	0.015	0	2D3b	0.1	0.010	0
1A3dii	0.1	0.010	0	2G	<0.1	<0.001	0
1A3ei	<0.1	<0.001	0	2L	0.2	0.015	0
1A4ai	0.8	0.075	0	5C1bv	<0.1	0.001	0
1A4bi	10.9	1.031	0	5E	13.4	1.271	0
				Total	**100**	**9.497**	**21.2**

Figure 1.56. The contribution of different sources to PCDD/F emissions and data reported by the plants.

The uncertainties of emission data are presented in Annex 6 of the IIR.

2.3.9.2 Polyaromatic hydrocarbons, PAH

Polyaromatic hydrocarbons under the CLRTAP convention are reported as the sum of four indicator substances (PAH-4), i.e. benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3_cd)pyrene as well as separately for the individual indicator substances.

Emission trend

The emissions have not been reduced as expected from the base year of 1994 (Figure 1.57). The main source is small scale wood combustion, which has been increasing in the last years. However, the emissions are expected to decrease to be in line with the reduction commitments in the next years, due to the expected development in the wood combustion appliance fleet, see Ch. 2.x.

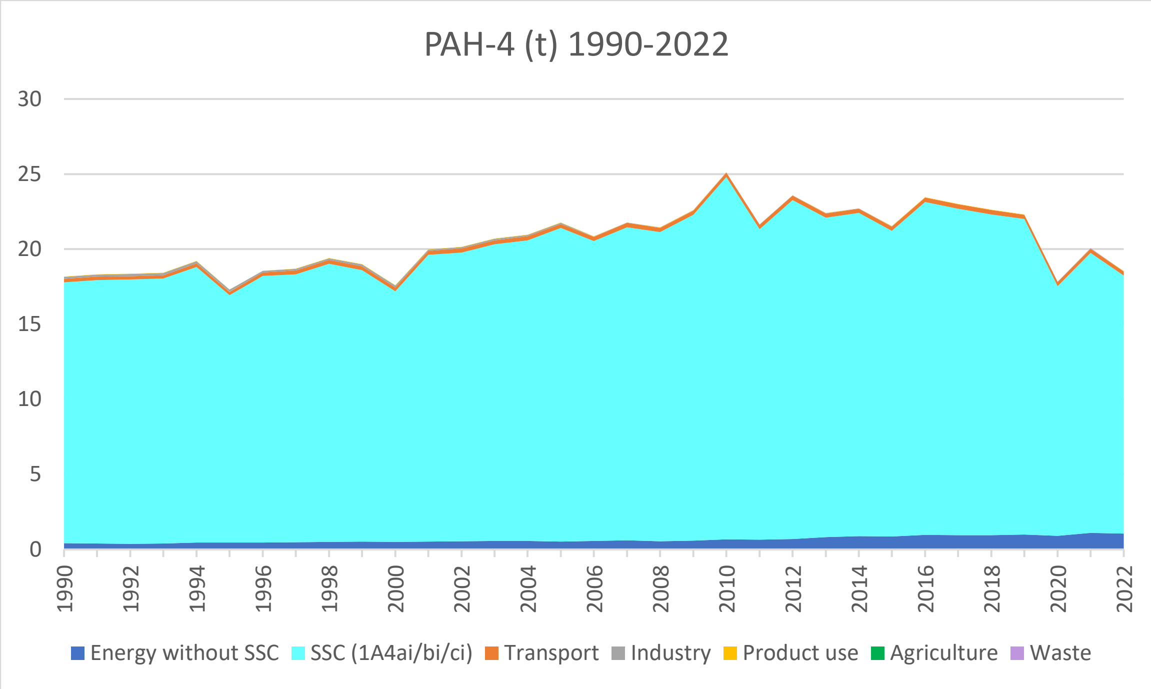
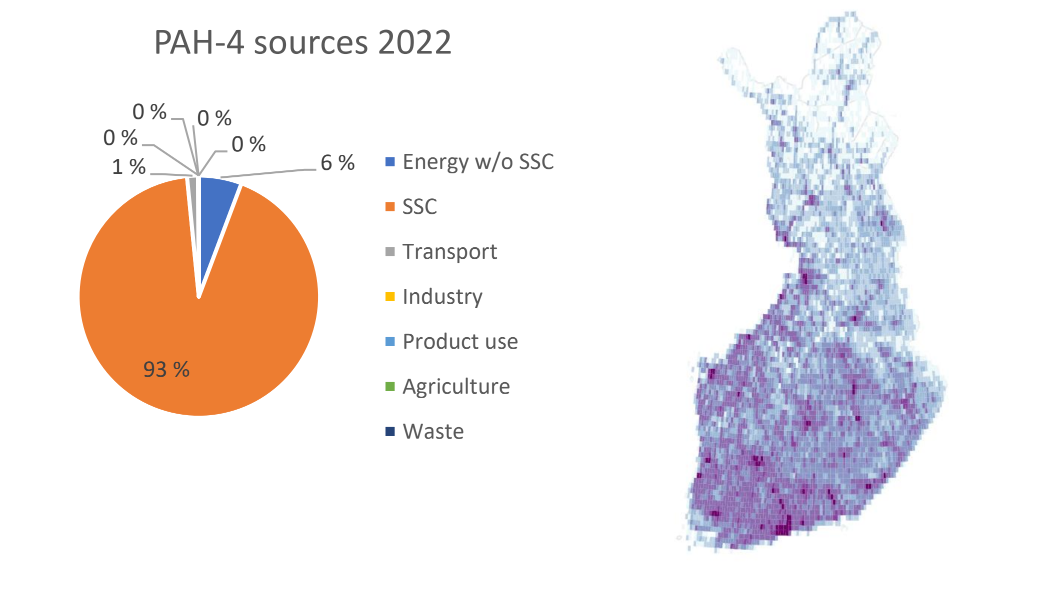


Figure 1.57. The emissions of PAH-4 (Mg) in 1990-2022 SSC stands for small scale combustion.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.58.



Shares of data reported by the plants of total PAH-4 emissions in 2022							
NFR	Percentage of national total	Total release [Mg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [Mg]	Percentage reported by the plants
1A1a	2.6	0.476	36.3	1A4ai	0.2	0.031	0
1A1b	<0.1	0.008	0	1A4aii	<0.1	0.008	0
1A2a	<0.1	<0.001	0	1A4bi	92.5	17.134	0
1A2b	<0.1	0.002	0	1A4bii	<0.1	0.005	0
1A2c	<0.1	0.004	0.5	1A4ci	<0.1	0.015	0
1A2d	1.5	0.281	73.5	1A4cii	0.1	0.019	0

1A2e	<0.1	0.004	0	1A4ciii	<0.1	<0.001	0
1A2f	<0.1	0.009	0	1A5a	0.6	0.117	0
1A2gvii	0.2	0.030	0	1B1b	<0.1	<0.001	0
1A2gviii	0.9	0.161	7.7	2A1	<0.1	<0.001	0
1A3bi	0.4	0.076	0	2C1	<0.1	0.008	0
1A3bii	<0.1	0.016	0	2C2	<0.1	<0.001	0
1A3biii	0.6	0.112	0	2D3i	<0.1	0.009	0
1A3biv	<0.1	0.001	0	2G	<0.1	<0.001	0
1A3c	<0.1	0.002	0	5C1bv	<0.1	0.001	0
1A3dii	<0.1	0.002	0	**Total**	**100**	**18.531**	**2.1**

Figure 1.58 The contribution of different sources to PAH-4 emissions and data reported by the plants.

2.3.9.3 Hexachlorobenzene, HCB

Emission trend

HCB emissions have been reduced from the base year 1994. The emission trend is dominated by the fluctuations in the industrial processes sector and may be overestimated for the other sources due to the highly uncertain methods. (Figure 1.59)

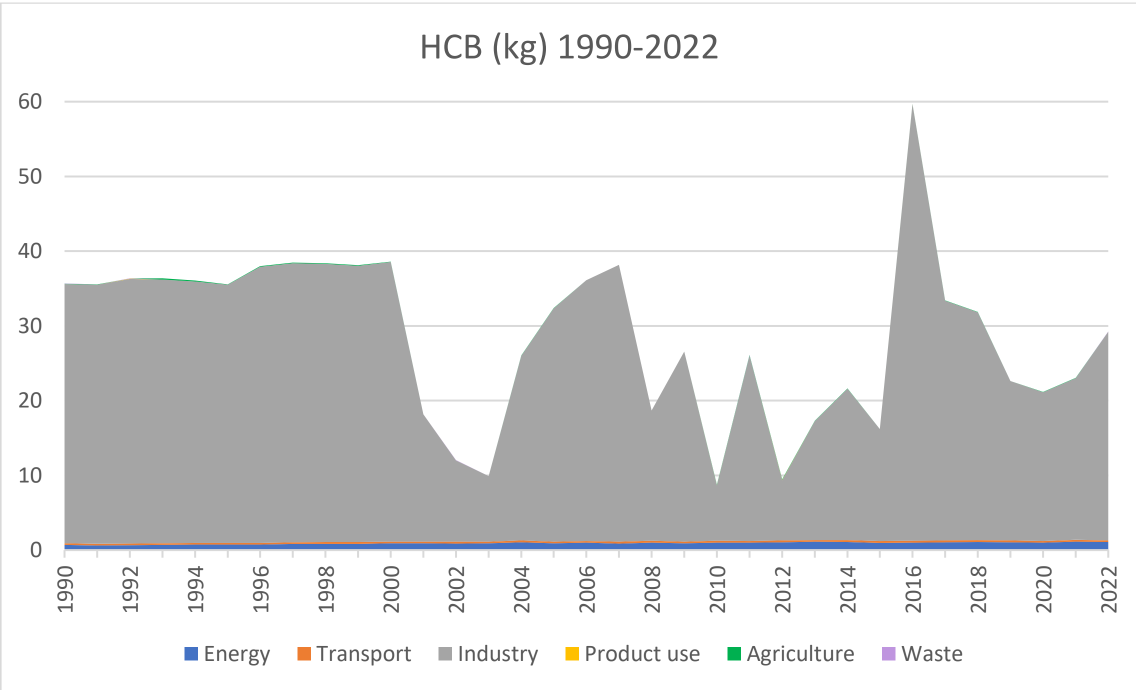
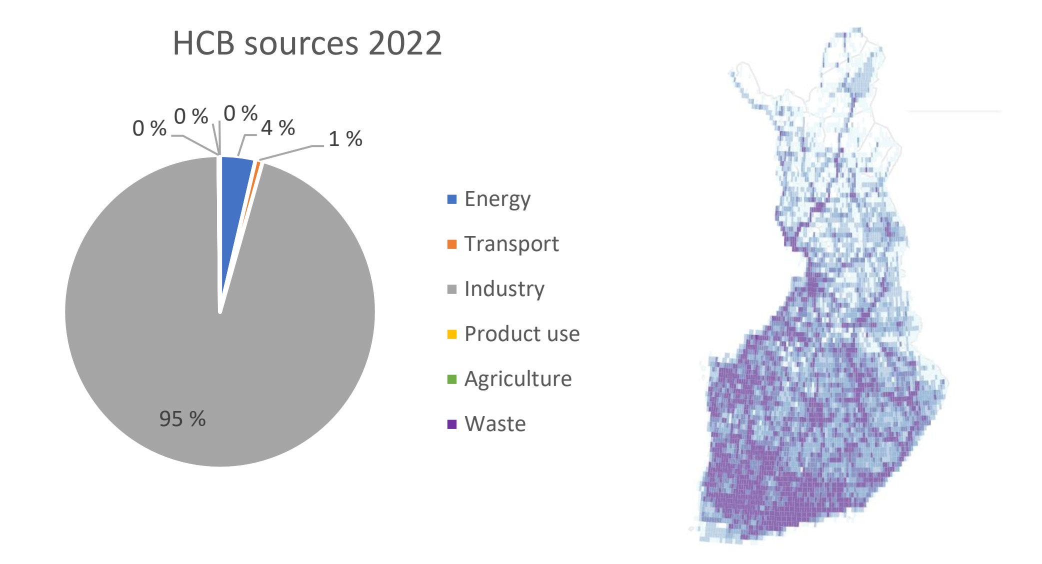


Figure 1.59. Emissions of HCB (kg) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.60.



Shares of data reported by the plants of total HCB emissions in 2022							
NFR	**Percentage of national total**	**Total release [kg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [kg]**	**Percentage reported by the plants**
1A1a	1.6	0.455	0	1A4ai	<0.1	0.016	0
1A2a	<0.1	<0.001	0	1A4bi	0.8	0.244	0
1A2b	<0.1	<0.001	0	1A4ci	0.1	0.032	0
1A2c	<0.1	<0.001	0	1A4ciii	<0.1	0.003	0
1A2d	0.4	0.120	0	1A5a	0.1	0.037	0
1A2e	<0.1	0.002	0	2B10a	74.9	21.900	100
1A2f	<0.1	0.002	0	2C1	<0.1	0.014	0
1A2gviii	0.6	0.162	0	2C3	0.1	0.036	0
1A3bi	0.4	0.105	0	2C7a	20.4	5.962	0
1A3bii	<0.1	0.017	0	2D3i	<0.1	0.002	0
1A3biii	0.3	0.087	0	3Df	0.1	0.035	0
1A3biv	<0.1	0.002	0	5C1bv	<0.1	0.006	0
1A3dii	<0.1	0.006	0	**Total**	**100**	**29.245**	**74.9**

Figure 1.60 The contribution of different sources to HCB emissions and data reported by the plants.

2.3.9.4 Polychlorinated biphenyls, PCBs

Emission trend

Emissions of PCBs have been reduced from the base year of 1994. The PCB emission trend (Figure 1.61) is fluctuating mainly due to changes in emission levels in the IPPU sector.

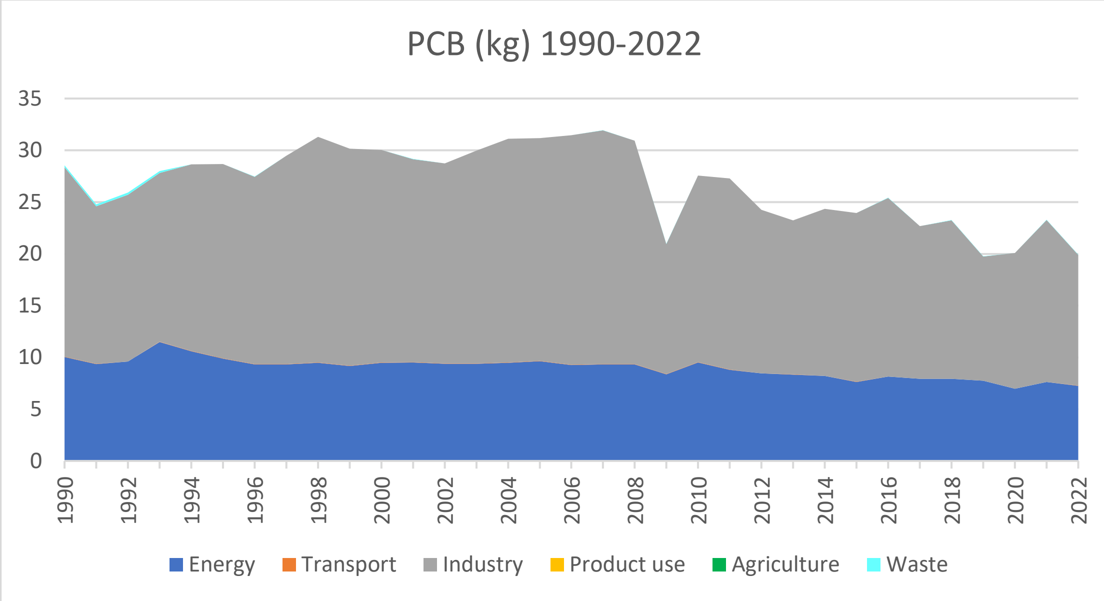
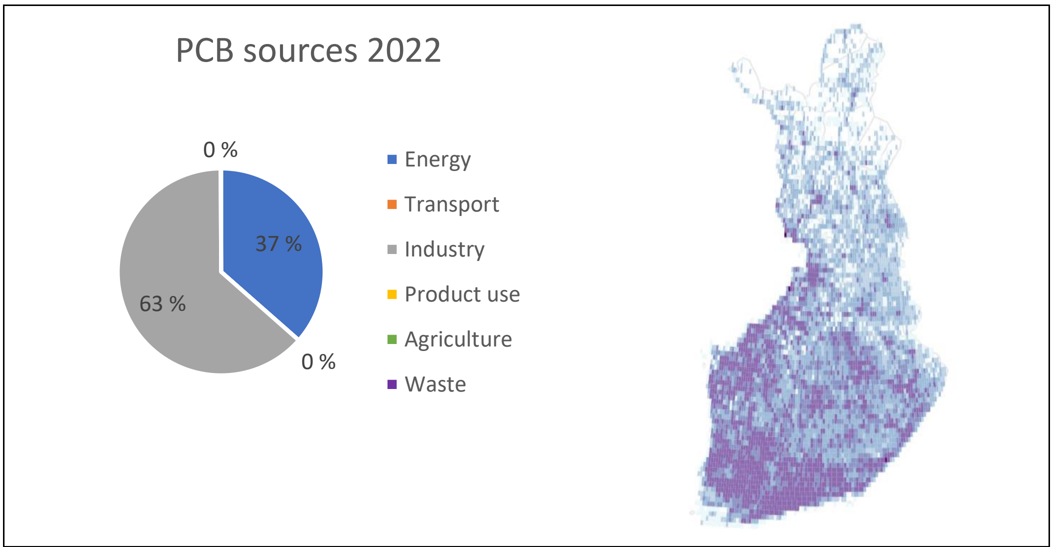


Figure 1.61. Emissions of PCB (kg) in 1990-2022.

The uncertainties of emission data are presented in Annex 6 of the IIR.

The contribution of different sources to emissions, the spatial distribution of emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Figure 1.67.



Shares of data reported by the plants of total PCB emissions in 2022							
NFR	**Percentage of national total**	**Total release [kg]**	**Percentage reported by the plants**	**NFR**	**Percentage of national total**	**Total release [kg]**	**Percentage reported by the plants**
1A1a	1.6	0.318	0	1A4ai	1.0	0.195	0
1A2a	0.5	0.093	0	1A4bi	14.7	2.930	0
1A2b	0.1	0.021	0	1A4ci	1.8	0.365	0
1A2c	<0.1	<0.001	0	1A4ciii	<0.1	0.001	0
1A2d	0.1	0.026	0	1B1b	14.6	2.909	0
1A2e	0.2	0.033	0	2A1	15.4	3.061	0
1A2f	1.8	0.350	0	2A2	<0.1	<0.001	0
1A2gviii	0.1	0.028	0	2C1	47.5	9.460	46.7
1A3bi	<0.1	<0.001	0	2C3	0.5	0.096	0
1A3bii	<0.1	<0.001	0	2C7a	<0.1	<0.001	0
1A3biii	<0.1	<0.001	0	2C7c	<0.1	0.015	0
1A3biv	<0.1	<0.001	0	5C1bv	<0.1	0.016	0
1A3dii	<0.1	0.005	0	**Total**	**100**	**19.922**	**22.2**

Figure 1.62 The contribution of different sources to emissions of PCBs and data reported by the plants.

2.3.9.5 Polychlorinated biphenols PCP

Emission trend

PCP emissions were earlier, but not currently requested to be reported under the CLRTAP. Emissions of PCP originate mainly in the waste sector (Figure 1.63).

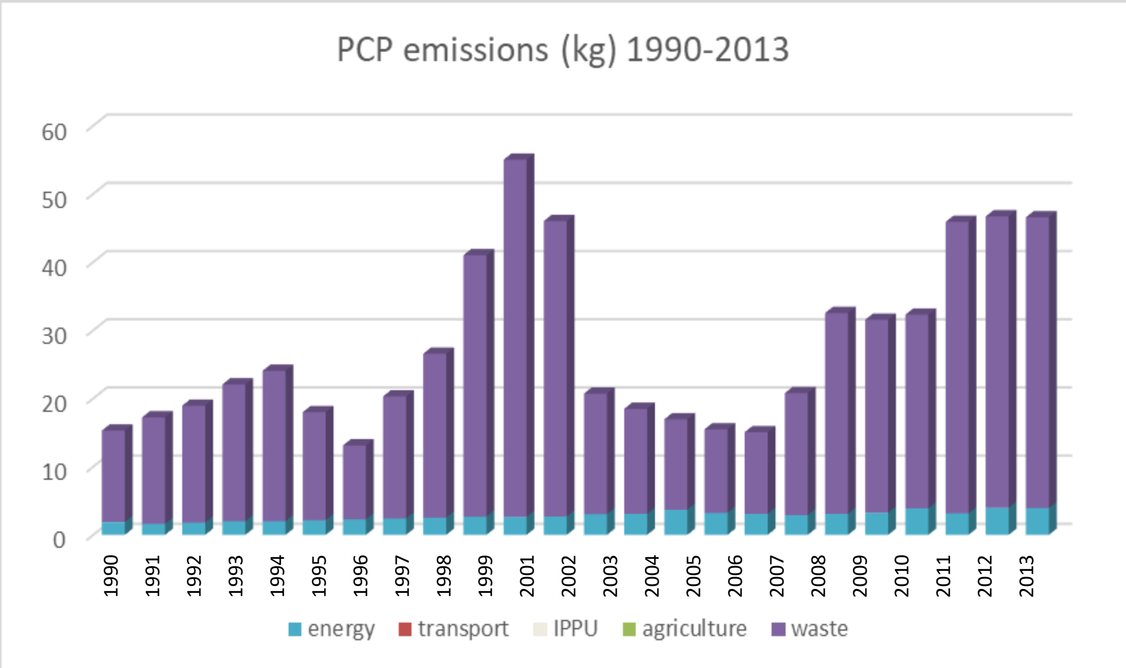


Figure 1.63. Emissions of PCP (kg) in 1990-2007.

Emissions in 2007

The contribution of different sources to emissions and the shares of data reported by operators of industrial plants of total emissions are presented in Table 1.19

Table 1.19. PCP emissions, the share of emissions reported by the plants of the total emissions by NFR categories in 2007.

NFR	Percentage of national total	Total release [kg]	Percentage reported by the plants	NFR	Percentage of national total	Total release [kg]	Percentage reported by the plants
1A1a	4.3	2.025	0	1A4ci	0.4	0.170	0
1A2gviii	1.3	0.590	0	2C7c	<0.1	0.003	0
1A4ai	<0.1	0.004	0	5C1a	91.5	42.595	0
1A4bi	2.4	1.140	0	5C1bi	<0.1	0.040	0
				Total	**100**	**152.046**	**2.6**

2.3.9.6 Short chain chlorinated paraffins, SCCP

According to studies carried out at the Finnish Environment Institute in 2007-200
8 showed that no SCCP emissions occurred from industrial processes after 1995 and that they totalled around 0.02 kilogrammes in 1990-1995. SCCP emissions from the use of products were not included in the inventory because no methodology existed that time. Further work to develop estimation methods and quantify emissions will be carried out when resources allow.

2.4 Description and interpretation of emissions by source

The sources of the air pollutant emissions are reported in the NFR (Nomenclature for Reporting) classification: energy (NFR 1), industrial processes and solvent and other product use (NFR 2), agriculture (NFR 3), waste (NFR 5) and other (NFR 6).

More detailed information of the contribution of different sources to the emissions of the specific air pollutants is provided in Chapter 2.3 Description and interpretation of emission trends by pollutants.

NFR 1 Sulphur dioxide (SO_2) emissions are mainly due to fuel combustion in the energy industries. Nitrogen oxides (NO_2) and carbon monoxide (CO) are generated both in the energy industries and in the traffic sector. NMVOC and POP emissions are released mainly from small combustion processes in the energy sector.

The emissions in the energy sector have varied considerably throughout the 1990s with an overall slightly increasing trend being visible.

NFR 2 Industrial processes release mainly heavy metals and POP compounds from production of iron, steel and non-ferrous metals as well as SO_2 from wood processing industries and NMVOC from the chemical industry.

The trends are in general decreasing but variations due to fluctuations in production occur annually.

Solvent and other product use emit mainly NMVOC compounds. Paint application and printing are the most significant NMVOC sources, since 2020 also use of hand desinfectants due to the pandemic. Small amounts of particles are generated in spray painting, barbeques, meat frying, tobacco smoking, fires and fire works. The trends of both NMVOC and particulate matter emissions are decreasing.

NFR 3 Agriculture is the main source of ammonia emissions in Finland. The main sources of NH_3 are manure management and application of fertilizers. The annual emissions have been reduced compered to emissions level in 1990 due to strong decreases in the number of livestock, and in nitrogen fertilisation. The decreasing emission trend will be safeguarded in the EU common agricultural policy by adopting support measures encouraging production that minimises the burden on the greenhouse gas balance.

NFR 5 The emissions from the waste sector include NMVOC and particle emissions from solid waste disposal on land, from wastewater treatment and composting. NH3 emissions are reported from composting, anaerobic digestion and wastewater treatment. Waste incineration in Finland includes energy recovery and the emissions are therefore reported in energy sector NFR 1. Particle, heavy metal and POP emissions are reported from cremation and house and car fires.

NFR 6 The source category Other includes ammonia emissions from animals that cannot be attributed to the agricultural or natural sectors. Because in the Finnish emission inventory all horses - including agricultural, recreational and racing horses - are included in the agriculture sector, the category other considers only pets, i.e., cats and dogs.

Detailed information of the emissions under the NFR categories is presented in Sections 4-10 as well as information of the source sector specific emissions and the calculation methodologies.