FINLAND's INFORMATIVE INVENTORY REPORT 2026

under the UNECE CLRTAP and the EU NECD

Air Pollutant Emissions 1980-2024

Part 3 – Transport

MARCH 2026

FINNISH ENVIRONMENT INSTITUTE
Climate solutions unit, Air pollution group

Finland's IIR

Part 3

Transport

Cover page photo for Part 3 Transport: Riku Lumiaro (2015) Lossi (Ferry boat)

PART 3 TRANSPORT AND OFF-ROAD MOBILE SOURCES (NFR 1A3)

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3.1 Overview of the sector

Changes in chapter	
March 2026	TF

The Transport Sector inventory covers emissions from civil aviation, road transport, railways, navigation and off-road mobile sources, tyre and brake wear, road abrasion and refuelling of cars. Pipeline compressors are also included. The source categories and pollutants included in the transport sector are presented in Table 3.1a.

Table 3.1a Emissions reported under the transport sector.

NFR	Source	Description	Emissions
1A2gvii	Mobile Combustion in manufacturing industries and construction	Mobile machinery in manufacturing industries and construction. For details see Table in Section 4.3.2.3.	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Cd, Cr, Cu, Ni, Se, Zn, PAH-4
1A3a	Aviation	Jet and turboprop powered aircraft (turbine engined fleet) and piston engined aircraft, domestic flights only	NO_X, NMVOC, SO_X, TSP, PM_{10}, $PM_{2.5}$, CO
1A3bi-iv	Road transport: passenger cars, light and heavy duty vehicles, mopeds, motorcycles and motorised quadricycles	Transportation on roads by vehicles with combustion engines: cars, vans, buses, coaches, lorries, articulated vehicles, motorcycles, mopeds and motorised quadricycles	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, PAH-4, HCB, PCB
1A3bv	Road transport: Gasoline evaporation	Gasoline evaporation from automobiles	NMVOC
1A3bvi	Automobile tyre and brake wear	PM and heavy metal emissions from automobile tyre and brake wear	TSP, PM_{10}, $PM_{2.5}$, BC, Pb, Cd, As, Cr, Cu, Ni, Se, Zn, PAH-4
1A3bvii	Automobile road abrasion	PM emissions from road abrasion	TSP, PM_{10}, $PM_{2.5}$, BC
1A3c	Railways	Railway transport operated by diesel locomotives	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Cd, Cr, Cu, Ni, Se, Zn, PAH-4
1A3dii	National Navigation (Shipping)	Sea-going ships (between domestic ports), icebreakers, working boats, cruisers, ferryboats and leisure boats.	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, HCB, PCB
1A4aii	Commercial and institutional (mobile)	Mobile machinery. For details see Table in Section 4.3.2.3.	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Cd, Cr, Cu, Ni, Se, Zn, PAH-4
1A4bii	Residential: Household and gardening (mobile)	Mobile machinery. For details see Table in Section 4.3.2.3.	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Cd, Cr, Cu, Ni, Se, Zn, PAH-4
1A4cii	Agriculture, forestry and fishing: Off-road vehicles and other machinery	Mobile machinery. For details see Table in Section 4.3.2.3.	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Se, Cd, Cr, Cu, Ni, Se, Zn, PAH-4
1A4ciii	Agriculture, forestry and fishing: National fishing	Fishing boats	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, HCB, PCB
1A5a	Other Stationary (including military)	Military mobile sources are included in this category together with some stationary sources	NO_X, NMVOC, SO_X, TSP, PM_{10}, $PM_{2.5}$, BC, CO, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, Se, PCDD/F, PAH-4

Key categories and the tier level of methods used to estimate emissions are presented in Table 3.1b

Table 3.1b Key categories and tier level of methods for the transport sector inventory.

NFR	Fuel	NH_3	Tier	NO_x	Tier	SO_x	Tier	NMVOC	Tier	CO	Tier
1A2gvii	Liquid			L1	3						
1A3bi	Diesel oil			L1, T1	3						
1A3bi	Gasoline	L1, T1	3	L1, T1	3			L1, T1	3	L1, T1	3
1A3bii	Diesel oil			L1, T1	3						
1A3biii	Diesel oil			L1, T1	3			T1	3		
1A3bv								L1, T1	2		
1A3dii	Liquid			L1, T1	3			L1	3	L1, T1	3
1A4aii	Liquid							T1	3	L1	3
1A4bii	Liquid							L1	3	L1, T1	3
1A4cii	Liquid			L1, T1	3						
1A4ciii	Liquid			L1	3						
1B2av								L1	3		
NFR	**Fuel**	**$PM_{2.5}$**	**Tier**	**PM_{10}**	**Tier**	**TSP**	**Tier**	**BC**	**Tier**		
1A2gvii	Liquid	T1	3					L1, T1	1		
1A3bi	Diesel oil	T1	3	T1	3	T1	3	L1, T1	1		
1A3bii	Diesel oil	L1	3					L1	1		
1A3biii	Diesel oil	T1	3	T1	3	T1	3	T1	1		
1A3bvi		L1, T1	2	L1, T1	2	L1, T1	2	L1, T1	2		
1A3bvii		L1, T1	2	L1, T1	2	L1, T1	2				
1A3dii	Liquid	L1	3								
1A4cii	Liquid	T1	3	T1	3	T1	3	T1	3		
NFR	**Fuel**	**Pb**	**Tier**	**Cd**	**Tier**	**Hg**	**Tier**	**As**	**Tier**	**Cr**	**Tier**
1A3bi	Gasoline	T1	3			L1	3				
1A3bvi		L1	2							L1, T1	2
NFR	**Fuel**	**Cu**	**Tier**	**Ni**	**Tier**	**Zn**	**Tier**				
1A3bi	Diesel oil	L1	3								
1A3bi	Gasoline	L1, T1	3								
1A3bvi		L1, T1	2	T1	2	L1, T1	2				
NFR	**Fuel**	**PCDD/F**	**Tier**	**PAHs**	**Tier**	**HCB**	**Tier**	**PCB**	**Tier**		
1A3bi	Diesel oil	L1	3	T1	3						
1A3bi	Gasoline	T1	3								

National characteristics

Emissions from the transport sector in Finland are affected by specific national circumstances such as

(1) winter-time conditions, which require use of studded tyres
(2) long distances and transport-intensive industries
(3) travel to and from free-time residences

NOTE: Fuel based emissions from road transport, navigation, railroads and non-road vehicles and machinery are calculated at Statistics Finland using Guidebook 2023 emission factors. In some cases, also emission factors from earlier versions of the Guidebook are used. The justifications for using EFs from earlier versions are described in the transport sectoral chapters.

3.2 Emission trends

Changes in chapter	
March 2026	AL, TF

The main transport sector emission trends as reported under the UNECE CLRTAP and EU NECD in 1980-2024 by pollutants and the main transport modes are presented in Figure 3.1.

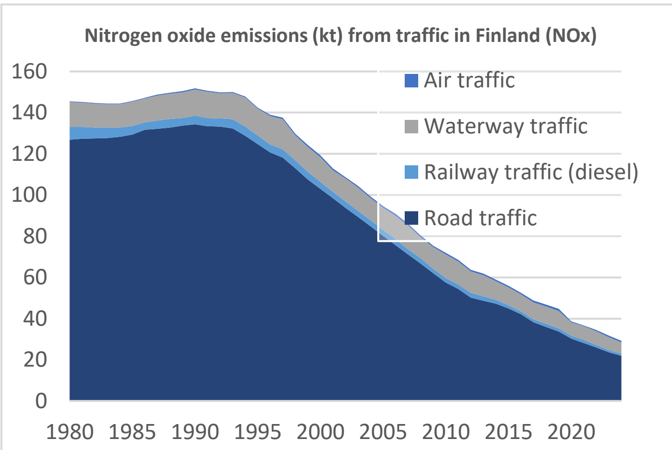
Emissions from the transport sector have been decreasing although fuel consumption is increasing, except for off-road machinery, which is growing for the volume of the machinery. Emissions of sulphur oxides and lead have decreased due to the reduced contents in fuels and implementation of catalysts and filters have removed nitrogen oxide and particle emissions and reduced carbon monoxide.

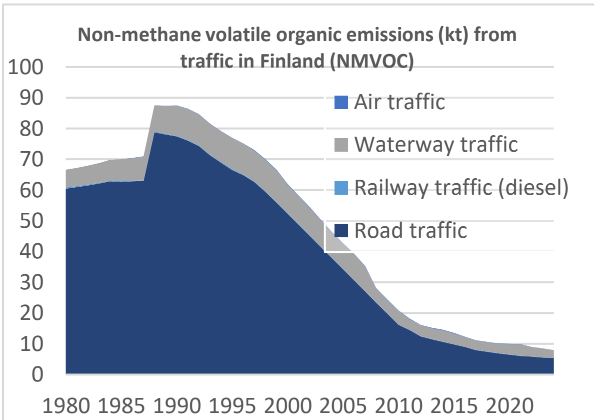
For gasoline passenger cars emission regulations were introduced in Finland in the beginning of 1991 although cars equipped with catalysts were already sold earlier. The Euro 5 standard introduced in September 2009 requires implementation of catalysts. Catalysts and filters in road transport include:

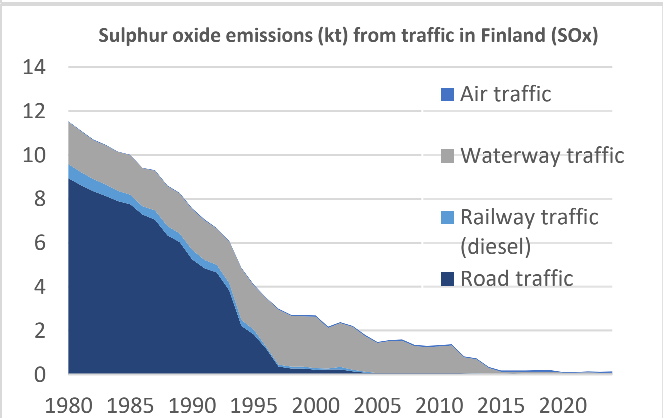
- Diesel Oxidation Catalytic converter *(DOC)* reduces the share of CO and HC in exhaust gases
- Particle filters, especially in diesel cars
- Motor management systems can be adjusted to low particle and NOx levels
- NOx catalyst in diesel cars
- Selective catalytic reduction *(SCR)* for reduced NOx emissions (AdBlue)

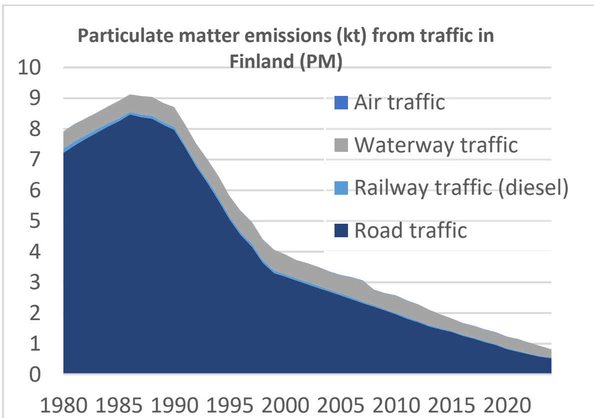
Since the beginning of 2015, based on the EU Sulphur Directive (2016/802), ships in the Baltic Sea and North Sea have used fuels including maximum 0.1% sulphur, or as an alternative, they need to install scrubbers to reduce 90% of sulphur emissions. In the Baltic Sea area, the highest allowed sulphur content before 2015 was 1%.

The significant reduction in most emissions of air and waterway traffic for the year 2020 is due to COVID-19. CO and NMVOC emissions in waterway traffic are increased because leisure boat traffic dominates the emission shares for these emissions and leisure boating did not suffer from COVID restrictions in Finland.









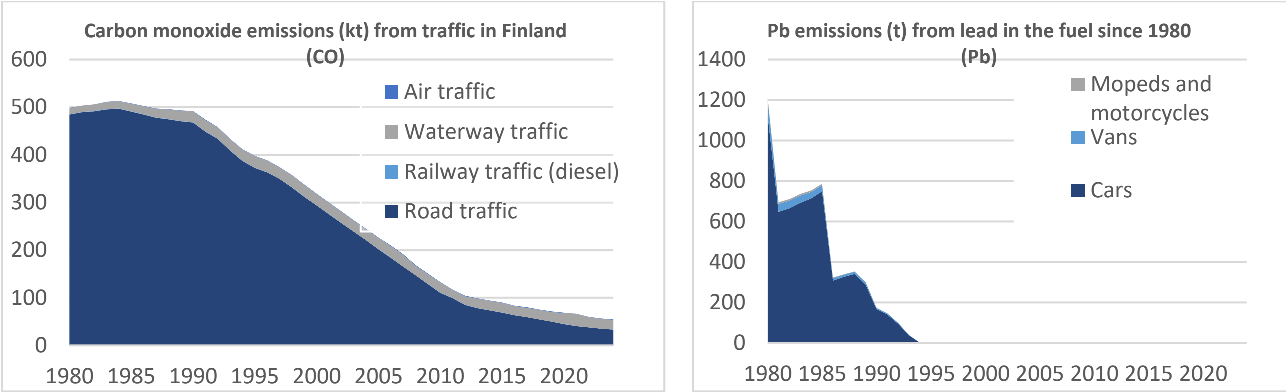


Figure 3.1 (a). Emission trends from fuel combustion in Transport 1980/90-2024.

3.3 Fuel use and Use of lubricants

Changes in chapter	
March 2026	TF

Fuel consumption

In the 1990s the growth of emissions from road transport was slow in Finland compared to many other Annex I countries, mainly due to the impact of the economic recession in the early 1990s on transport. Also, the worldwide economic downturn that began in 2008 decreased the kilometrage of all transport modes.

An overview of transport sector energy consumption 1990-2024 is presented in Table 3.2 (a).

There have been some changes in legislation and fuel tax decisions concerning the use of diesel oil and gasoil over time. A new fuel product, non-road gasoil, was introduced during 2005. Non-road gasoil is technically the same fuel as diesel oil but has lower taxes and includes a Euromarker to allow monitoring of illegal use. From 2011 to 2013 the situation changed again. Almost all gasoil is presently sold under the title “sulphur free gasoil”, which is in practise the same product as non-road-gasoil. In this report, we use the terminology “non-road-gasoil” to describe the use of gasoil in diesel engines in off-road vehicles and other machinery and domestic navigation (wherever it is allowed to use lower taxed gasoil instead of higher taxed diesel oil). In leisure boats, the use of diesel oil (instead of gasoil) was made obligatory from the beginning of 2008.

Bio-shares of transport fuels (Statistics Finland 2026)

Increasing amounts of biogenic additives or biofuels are mixed in road transport and some other fuels. Use of blended bio-gasoline (ethanol) started from 2002 and of blended biodiesel from 2007. Due to the expiration of the periodic deduction of fuel tax, there was no consumption of bioethanol in 2005, but in 2006 bioethanol re-entered the market. Data of other biogenic compounds, like ETBE (ETBE = ethyl tert-butyl ether, a bioethanol-based gasoline component), are not available for 2002 to 2007. Data on blended and pure biofuels from 2008 to 2015 was collected by Finnish Customs. Data from 2016 to 2020 was collected by Tax Administration and data from 2021 by Energy authority. These data include the following biofuels and bio-components[1]:

- Bioethanol, BTL-gasoline, bio-shares of ETBE, TAEE and THxEE
- Biodiesel and synthetic renewable diesel (mostly BTL-diesel, bioshare of FAME)
- Bio-gasoil mixed in the non-road gasoil (mostly BTL-diesel, bioshare of FAME)

[1] TAEE = tertiary amyl ethyl ester, THxEE = tert-hexyl ethyl ether, BTL = biomass to liquid, FAME = fatty acid methyl ester

The time series on biogas data starting from 2002 are available in the Energy statistics. The consumption of biofuels is originally included in the total sales data of gasoline, diesel oil and gasoil which was prior to 2018 received from Petroleum and Biofuels Association both for the LIPASTO system and for the ILMARI system by Statistic Finland. Since the operation of Petroleum and Biofuels Association ended in 2018, Statistics Finland has been responsible for this oil statistics data collection. The shares of biofuels are in the ILMARI system based on data received from Finnish Customs, Tax administration and/or Energy authority. From 2013 until 2020 the bio-share of gasoil decreased to 0.1-0.2%. Because the share was so low, Statistics Finland decided to allocate this bio-share into road transport instead of non-road use. In 2024 bioshares of gasoline and diesel oil were 9.0% and 16.0% respectively (calculated from TJ). The share of biogas (incl. LBG) in transport and non-road machinery gas consumption was 38% in 2024. The bioshare of gasoil was 4.9% in 2024.

Energy consumption in the transport sector is presented in Table 3.2(a) and the amounts of bio-components in transport fuels in Table 3.2(b).

The bio-share data is presented in the NFR tables from 2008. The bio-components have been calculated for road transport in the VTT LIPASTO system until the year 2016. From 2017, the bio-share data have been calculated in the IPTJ system at Syke based on the Copert and Statistics Finland's LIIKE data. For other transport, the bio-components have been calculated at in the IPTJ system at Syke based on bio-share data from Statistics Finland.

Table 3.2 (a) Fuel consumption (PJ) in the transport sector in 1990-2024 (IPTJ, Statistics Finland and VTT Technical Research Centre Finland 2025).

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Civil aviation															
Aviation gasoline	0.11	0.08	0.08	0.04	0.04	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03
Jet kerosene	5.15	3.51	5.11	4.09	3.07	2.42	2.46	2.61	2.92	2.85	1.19	1.07	1.85	1.81	1.98
Road transportation															
Gasoline	80.1	76.1	70.7	74.0	61.4	57.9	56.0	56.1	54.8	55.6	55.2	53.2	52.4	51.2	47.2
Diesel oil	67.1	62.3	76.2	85.8	96.5	83.8	100.7	93.9	96.8	92.4	88.0	81.4	81.8	76.9	77.5
Natural gas	NO	NO	0.00	0.11	0.20	0.15	0.16	0.20	0.29	0.46	0.58	0.68	0.80	0.94	0.90
Liquid biofuels	NO	NO	NO	NO	5.34	20.6	7.29	16.2	15.2	17.7	16.3	27.7	22.4	23.0	19.3
Gaseous biofuels	NO	NO	NO	NO	NO	NO	NO	0.01	0.04	0.07	0.17	0.22	0.36	0.37	0.63
Railways															
Gasoil	2.58	2.61	2.17	1.73	1.30	0.93	0.87	0.91	0.98	0.95	0.87	0.97	0.81	0.76	0.62
Liquid biofuels	NO	NO	NO	NO	0.02	NO	NO	NO	NO	NO	NO	0.03	0.03	0.03	0.03
Navigation and national fishing															
Residual oil	1.56	1.79	2.23	1.74	1.74	0.45	0.41	0.43	0.44	0.47	0.24	0.17	0.17	0.15	0.19
Gasoil	4.89	4.57	4.72	4.67	4.73	4.94	4.64	4.80	4.83	4.98	3.84	3.88	4.10	3.89	3.29
Gasoline	1.80	1.88	1.94	1.92	1.63	1.42	1.37	1.35	1.36	1.36	1.57	1.72	1.40	1.32	1.43
Diesel oil	NO	NO	NO	NO	0.52	0.35	0.39	0.35	0.35	0.34	0.38	0.35	0.30	0.28	0.28
LNG	NO	NO	NO	NO	NO	0.03	0.03	0.06	0.10	0.08	0.16	0.18	0.19	0.13	0.14
Liquid biofuels	NO	NO	NO	NO	0.13	0.14	0.09	0.13	0.13	0.15	0.18	0.34	0.30	0.32	0.28
Off-road working machinery															
Motor gasoline	3.11	3.20	3.60	3.84	3.30	3.37	3.24	3.06	2.96	2.85	2.75	2.63	2.51	2.40	2.36
Gasoil	29.4	28.3	30.4	30.7	31.1	29.5	28.2	29.9	30.0	29.8	29.9	29.0	28.3	27.8	27.7
Liquid gas	0.31	0.26	0.21	0.25	0.19	0.17	0.16	0.16	0.15	0.16	0.16	0.17	0.17	0.17	0.18
Liquid biofuels	NO	NO	NO	NO	0.63	0.16	0.16	0.19	0.20	0.20	0.22	1.25	1.42	1.54	1.67
Other transportation															
Natural gas	0.04	0.45	0.58	0.76	0.50	0.07	0.16	0.05	0.12	0.12	0.02	0.12	0.02	0.00	0.00

Table 3.2 (b) Amount of bio-components of transport fuels (TJ) (IPTJ and Statistics Finland 2026).

Year	Gasoline	Diesel oil	Non-road Gasoil	Natural gas
2008	2 649	475	NO	NO
2009	3 184	2 484	302	NO
2010	2 985	2 591	539	NO
2011	3 797	4 542	626	NO

Year	Gasoline	Diesel oil	Non-road Gasoil	Natural gas
2012	3 974	4 297	245	NO
2013	2 854	6 820	IE	NO
2014	3 030	18 006	IE	NO
2015	2 901	18 037	IE	NO
2016	3 003	4 538	IE	NO
2017	3 586	12 929	IE	14
2018	3 738	11 775	IE	41
2019	3 918	14 178	IE	65
2020	4 144	12 612	IE	171
2021	4 998	23 212	1 103	222
2022	5 222	17 714	1 265	356
2023	6 006	17 617	1 360	373
2024	4 985	14 808	1 553	627

IE = included in diesel oil

The classification of fuels and their properties is presented at Statistics Finland's website http://tilastokeskus.fi/tup/khkinv/khkaasut_polttoaineluokitus.html (see the English language tables).

Use of lubricants

Lubricant consumption in road transport is presented in table 3.3. The data for the years 2017 to 2024 are from the COPERT model that used to estimate the air pollutant emissions for road transport for 2017 onwards.

The estimates for the earlier years have been calculated by other means and have only been used in the inventory as a proxy data to estimate emissions of certain heavy metals as described in more detail in chapter 3.5. For these years, the of amounts of 2-stroke lubricants have been from the gasoline consumption figures available from the LIPASTO system. The amounts have been calculated by assuming maximum 2.5% oil mix in gasoline. The estimates of amounts of 4-stroke lubricants have been calculated by utilizing the mean CO_2 emission factors from combustion of lubricant oil presented in table 3-13 in the road transport chapter of the EMEP/EEA emission inventory guidebook 2019.

Table 3.3. Lubricant consumption (kt) in road transport (IPTJ/Syke Statistics Finland/COPERT 2026).

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Passenger cars	6.296	5.955	5.743	6.323	6.480	6.266	6.250	5.802	5.814	5.818	5.590	5.507	5.404	5.337	5.261
Light duty vehicles	1.203	1.242	1.421	1.440	1.218	1.097	1.037	0.818	0.827	0.829	0.821	0.833	0.805	0.804	0.801
Heavy duty vehicles	1.351	1.352	1.653	1.756	1.868	1.722	1.713	0.728	0.738	0.738	0.720	0.714	0.713	0.687	0.678
L-category vehicles	0.374	0.271	0.214	0.198	0.205	0.256	0.254	0.203	0.205	0.201	0.197	0.199	0.198	0.194	0.188

3.4 Aviation

Changes in chapter	
February 2026	AL, TF, KG

1 A 3 a i (i) International aviation (LTO)
1 A 3 a ii (i) Civil aviation (Domestic, LTO)

Source category description

The contribution of the category to total emissions is presented in Tables 3.4 (a) and (b).

Table 3.4 (a) Contribution of NFR 1A3ai(i) in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	0.729	Gg	0.8
NMVOC	0.069	Gg	<0.1
SOx (as SO_2)	0.045	Gg	0.3
$PM_{2.5}$	0.007	Gg	<0.1
PM_{10}	0.007	Gg	<0.1
TSP	0.007	Gg	<0.1
BC	0.003	Gg	0.1
CO	0.723	Gg	0.2

Table 3.4 (b) Contribution of NFR 1A3aii(i) in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	0.129	Gg	0.1
NMVOC	0.018	Gg	<0.1
SOx (as SO_2)	0.009	Gg	<0.1
$PM_{2.5}$	0.001	Gg	<0.1
PM_{10}	0.001	Gg	<0.1
TSP	0.001	Gg	<0.1
BC	<0.001	Gg	<0.1
CO	0.262	Gg	<0.1
Pb	0.055	Mg	0.5

Emission trend

Variations in fuel consumption and emissions are caused by variations in the number of flights, flight hours as well as changes in the fleet of aircraft. The economic recession in the early 1990s decreased the number of flights. In the late 1990s, the demand on domestic air transport and the number of commercial flights increased. During the 2000s, the overall emission trends have been decreasing, partly due to renewed fleet and the years after 2008 due to the recession that started in 2008. The significant reduction in all emissions for the year 2020 is due to COVID-19.

After the flight numbers have started to increase, there is clear increase in NO_x emissions although the domestic carrier has several low-NO_x –engine equipped aircrafts.

The emission trends of NO_x, NMVOC, SO_x, particles, BC, CO and Pb from aviation are presented in Figure 3.2.

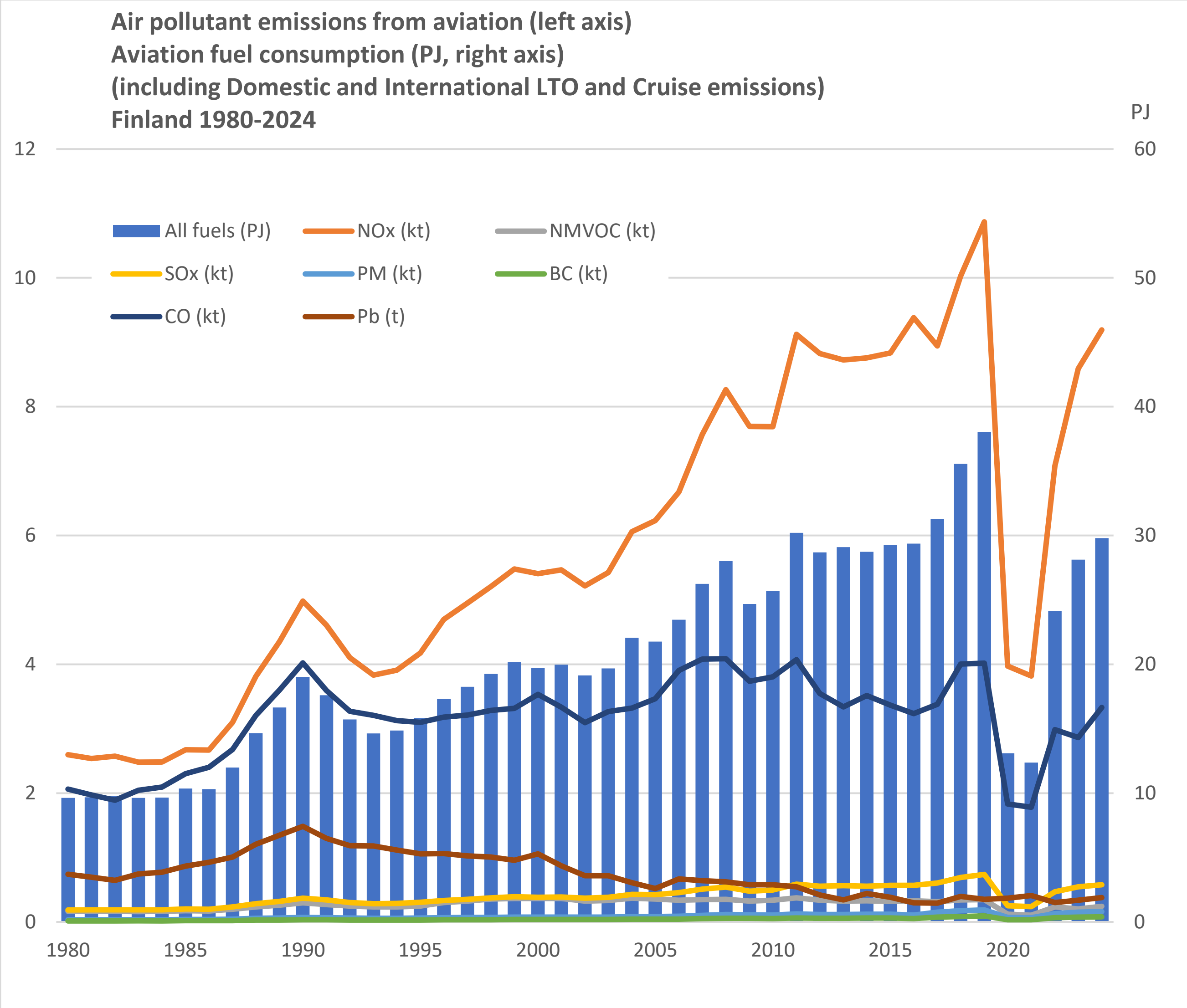


Figure 3.2. An overview of aviation emissions and fuel use 1980-2024.

Domestic aviation

Emissions from civil aviation include all domestic civil aviation: jet and turboprop powered aircraft (turbine-engined fleet in air transport) and piston engined aircraft (mostly general aviation). Helicopters are not included in the calculations of civil aviation as a separate category due to the small number of flights and lack of emission factors. However, the fuel consumption of helicopters is included under NFR 1.A.5 (part of jet fuel consumption). These emissions were neither covered by the earlier estimates of FINAVIA.

International aviation

International LTO and Cruise emissions include all aircrafts in international aviation.

International aviation volumes to and from Finland have been in constant increase since the late 1980s, while there have been some periods of decrease in the early 1990s and in the beginning of the 2000s.

The emission trends of NO_x, NMVOC, SO_x, CO, NH_3, Pb and particles are presented by NFR category in Figures 3.3 a-d.

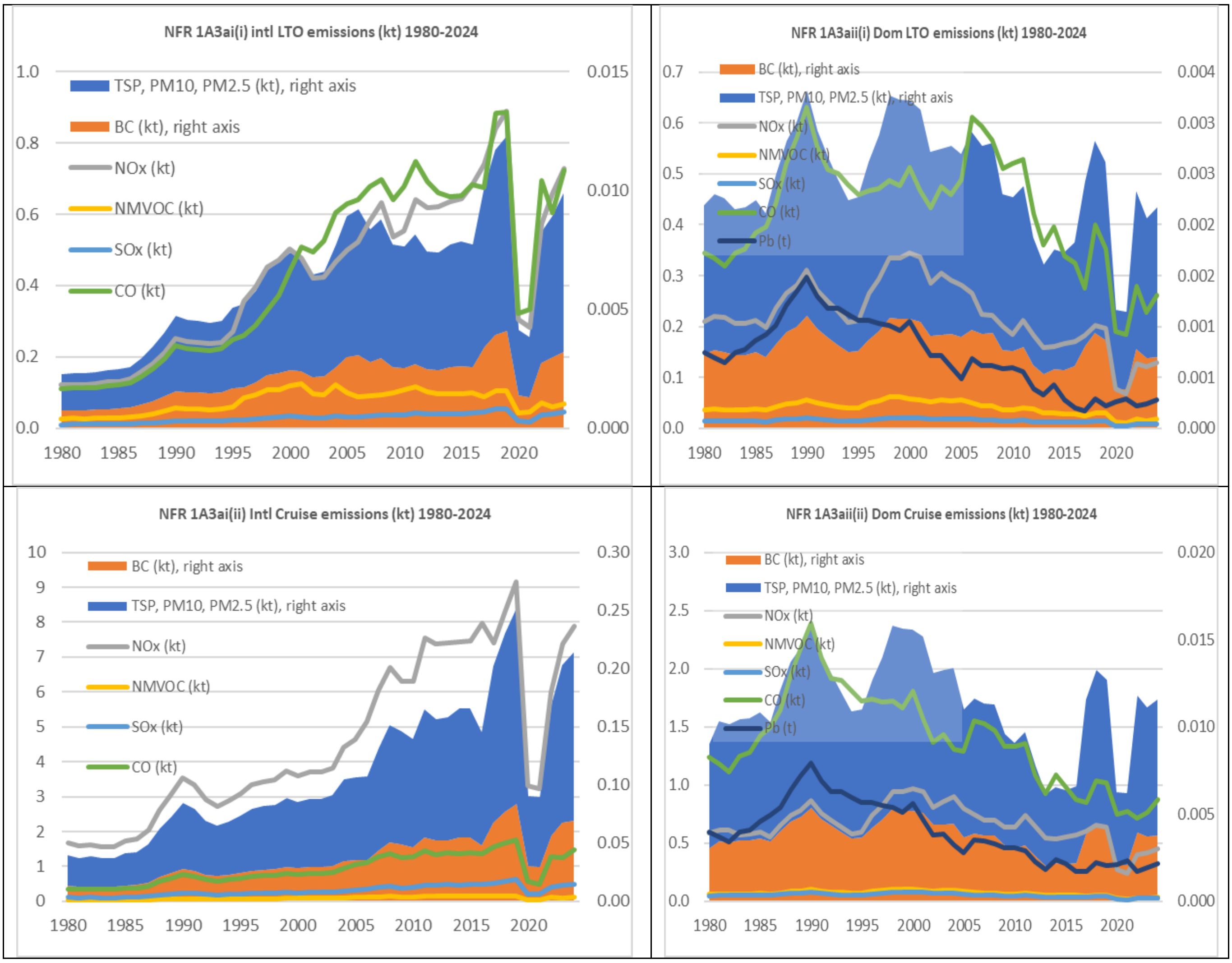


Figure 3.3 a-d: NFR category specific emission trends in aviation 1980-2024.

Methodological issues

Previous method

Calculation of aviation emissions until the year 2009 was carried out by the Finnish Civil Aviation Administration (Finavia). Activity data used in the calculation was from Finavia as well as the split between the national and international aviation emissions, which was based on the share of departure and arrival information of the total fight data (coefficients between 0.3 - 0.4). The calculations were based on traffic statistics, aircraft performance data and aircraft engine emission factors of each flight segment from the ICAO (International Civil Aviation Organisation) database. The description of the methodology was provided under the LIPASTO sub-model for aviation (ILMI).

In accordance with the Guidelines, international aviation fuel emissions were not included in national totals. In this system international aviation (LTO and Cruise) values included only the flight segments inside the Finnish Flight Information Region (almost similar to the Economic Region of Finland), not the whole flight or the overflights within Finland. LTO emissions included taxi in, take-off, approach and taxi out (approximately < 1000 m altitude). Cruise emissions included climb-out, cruise and descent (approximately > 1000 m altitude).

Finavia did not prepare the inventory for years after 2010 for 2008 but started discussion with EUROCONTROL on possibilities to move the calculation of aviation emissions to be carried out through a data system maintained by EUROCONTROL. As the project by EUROCONTOL did not fully reach an accuracy level that could be used in reporting of national aviation emissions, a modified calculation was continued for the period 2009-2014 at Syke. This was based on shares of LTO and

Cruise emissions in domestic and international aviation from the CRF tables in the Finnish greenhouse gas inventory under the UNFCCC.

The revised method since the 2017 submission

Aviation emissions since the 2017 submission have been calculated with a national Aviation emissions calculation model on the basis of EUROCONTROL data and national statistics on fuel use. The model is maintained by Statistics Finland and shared with Finnish Environment Institute to include air pollutant emissions. Finavia experts supported the adoption of the new model.

The calculation uses national fuel statistics for 1980-2024 and EUROCONTROL fuel and emissions data by EU Member State for the period 2005-2024. The estimates by EUROCONTROL do not cover the following sources: non-scheduled flights, such as training, rescue and hobby flights. Table 3.5 presents the current fuel use data used in the calculation for aviation.

The EUROCONTROL data is calculated with a Tier 3 methodology applying the Advanced Emissions Model AEM (https://www.eurocontrol.int/model/advanced-emission-model). The EUROCONTROL emission calculation system description is available at (https://www.eurocontrol.int/publication/eurocontrol-method-estimating-aviation-fuel-burnt-and-emissions).

Emissions from domestic aviation 1980-2004 and partly until 2008 have been calculated in the calculation model maintained for those years by Finavia. The new national Aviation emissions calculation model is based on fuel shares for different aircraft types from the EUROCONTROL data since 2005. Slight differences (3-10%) between the Eurocontrol jet fuel data and fuel data received from FINAVIA for 2005-2010 have been identified and considered reasonable as the latest changes in the fleet had not been fully updated in the earlier Finavia system.

For piston-engined aircraft using aviation gasoline fuel data is based on the earlier model and corrected with changes in flight hours because EUROCONTROL data cannot be used as its coverage is very low for these aircraft.

Statistics Finland has made minor corrections to the international aviation fuel consumption data, based on fuel sales statistics.

Description of the calculation model maintained by Finavia for 1980-2008 and the current calculation method is presented in the Finnish NID (chapter 3.2.5.3).

Emission factors

Emissions are mostly taken from EUROCONTROL calculation system, thus emission factors and sources are included in the documentation of EUROCONTROL system.

Statistics Finland has estimated some corrections to results of NOx, CO and HC/NMVOC emission data taken from the EUROCONTROL model to reflect the very rare types of low-NOx engines used in the national fleet. Correction factors have been defined comparing the results from previous ILMI model and EUROCONTROL calculations (overlapping years 2005-2008).

The PM emission fractions in EUROCONTROL system are $PM_{2.5}$=PM_{10}=TSP. BC fraction is calculated according to the Annex III of the aviation chapter of the EMEP/EEA Guidebook 2023.

Lead emissions

For the calculation of lead emissions from avgas volumes presented in Table 3.5, the domestic emission factor of 0.013443936 t/TJ was used. The EF is based on the known mix of avgas qualities, including low leaded, used in the country.

Table 3.5 Fuel use in Aviation 1980-2024.

Year	Domestic fuels								International Fuels			
	Jet fuel		Jet fuel		Avgas		Avgas		Jet fuel		Jet fuel	
	LTO		Cruise		LTO		Cruise		LTO		Cruise	
	TJ (43.3)	kt	TJ (43.3)	kt	TJ (43.7)	kt	TJ (43.7)	kt	TJ (43.3)	kt	TJ (43.3)	kt
1980	730	16.9	2 312	53.4	11.0	0.25	44.1	1.0	527	12.2	6 011	138.8
1985	739	17.1	2 779	64.2	12.9	0.29	51.5	1.2	571	13.2	6 211	143.4
1990	1 082	25.0	4 072	94.0	22.1	0.51	88.3	2.0	1 093	25.2	12 674	292.7
1995	737	17.0	2 772	64.0	15.7	0.36	63.0	1.4	1 181	27.3	11 073	255.7
2000	1 073	24.8	4 036	93.2	15.7	0.36	62.8	1.4	1 713	39.6	12 813	295.9
2005	951	22.0	3 144	72.6	7.3	0.17	31.2	0.7	1 656	38.2	15 970	368.8
2006	934	21.6	2 882	66.6	10.2	0.23	39.5	0.9	1 676	38.7	17 922	413.9
2007	875	20.2	2 705	62.5	9.2	0.21	38.6	0.9	1 822	42.1	20 795	480.3
2008	868	20.1	2 614	60.4	9.2	0.21	37.1	0.8	1 872	43.2	22 610	522.2
2009	780	18.0	2 404	55.5	8.7	0.20	34.2	0.8	1 849	42.7	19 600	452.7
2010	758	17.5	2 309	53.3	8.9	0.20	34.0	0.8	1 919	44.3	20 670	477.4
2011	838	19.3	2 589	59.8	8.2	0.19	32.4	0.7	2 182	50.4	24 548	566.9
2012	689	15.9	2 163	49.9	5.9	0.13	25.3	0.6	2 061	47.6	23 739	548.2
2013	602	13.9	1 834	42.4	4.9	0.11	20.4	0.5	2 025	46.8	24 604	568.2
2014	604	14.0	1 847	42.7	6.4	0.15	26.4	0.6	2 047	47.3	24 193	558.7
2015	605	14.0	1 812	41.8	4.2	0.10	24.3	0.6	2 054	47.4	24 764	571.9
2016	616	14.2	1 846	42.6	3.0	0.07	19.1	0.4	2 136	49.3	24 744	571.4
2017	639	14.7	1 971	45.5	2.5	0.06	19.2	0.4	2 314	53.4	26 339	608.3
2018	739	17.1	2 184	50.4	4.3	0.10	25.1	0.6	2 732	63.1	29 895	690.4
2019	708	16.4	2 138	49.4	3.4	0.08	22.7	0.5	2 820	65.1	32 346	747.0
2020	281	6.5	908	21.0	3.9	0.09	23.5	0.5	983	22.7	10 890	251.5
2021	262	6.0	812	18.8	4.3	0.10	26.2	0.6	945	21.8	10 313	238.2
2022	482	11.1	1 369	31.6	3.3	0.08	19.0	0.4	1 952	45.1	20 309	469.0
2023	430	9.9	1 384	32.0	3.6	0.08	21.6	0.5	2 045	47.2	24 229	559.6
2024	466	10.8	1 509	34.9	4.1	0.09	24.0	0.5	2 298	53.1	25 488	588.6

Uncertainties

Uncertainties are presented in Annex 6 of the IIR.

QA/QC and verification

Normal statistical quality checking related to assessment of magnitude and trends has been carried out. At present, no verification has been carried out for the specific source-sector emissions.

Recalculations and source-specific improvements

2018
- Ammonia and lead emissions as well as all particle sizes and BC were included for the whole time series.

2021
- All emissions for the whole time series were recalculated due to update of fuel data in the EUROCONTROL data

2023

- All emissions for 2017 to 2020 were recalculated due to updates in the EUROCONTROL calculation system. These updates resulted also in the recalculation of NMVOC emissions in domestic aviation for the years until 2004.
- Particle emissions in international aviation were recalculated for 2005 following the recommendation in 2022 NECD inventory review. As a result of the corrections made to the 2005 calculation, the emissions for the earlier years were also corrected and recalculated.

2025

- All emissions for the years 2018 to 2022 were recalculated due to updates in the EUROCONTROL data

Source-specific planned improvements

The possibility to add additional heavy metal and POP emissions will be studied for future years.

3.5 Road transport

Changes in chapter	
March 2026 2025	AL, TF, KG, JMP

1A3bi	**Road transport: Passenger cars**
1A3bii	**Road transport: Light duty vehicles**
1A3biii	**Road transport: Heavy duty vehicles**
1A3biv	**Road transport: Mopeds & motorcycles**
1 A 3 b v	**Road transport: Gasoline evaporation**

Calculation models used for road transport emission estimation

All road transport emission estimations for 2017 to 2024 are made with COPERT version 5.8.1 (COmputer Programme to calculate Emissions from Road Transport). It has not been possible use COPERT for the years prior to 2017 since the vehicle fleet data in the required COPERT classifications is only available from 2017 onwards.

Until the 2025 submission, all road transport emission estimations were made with the national model for transport sector emissions – LIPASTO/LIISA. It was developed and maintained by the VTT Technical Research Centre of Finland Ltd. However, VTT decided to discontinue the model, and it wasn't available for the emission estimation anymore in the 2026 submission. In 2025, a new transport energy and emission calculation system (LIIKE) was established by Statistics Finland. The new LIIKE calculation system is operated and maintained by Statistics Finland and it is used to produce both the greenhouse gas and air pollutant emissions for road transport in Finland.

Implementation of the COPERT model to the 2026 submission resulted in major recalculations of air pollutant emissions for road transport. Since it is not possible to estimate air pollutant emissions for the whole time series with COPERT, different pollutant specific methodologies have been used to estimate the emissions for the years until 2016. These are described in more detail in section *Methodologies used to estimate the time series from 1980 to 2016* below. LIPASTO/LIISA emissions data is used in the time series for all pollutants except for certain heavy metals (Cd, Cr, Cu, Ni, Se, Zn) and HCB.

The methodological description of the LIPASTO/LIISA model is also included in the IIR and is provided below in the section Methodological issues.

Source category description

The contribution of the category to total emissions is presented in Tables 3.6 (a)-(d).

Table 3.6 (a) Contribution of NFR 1A3bi in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	9.315	Gg	10.1
NMVOC	1.547	Gg	2.1
SOx (as SO_2)	0.021	Gg	0.1
NH_3	0.781	Gg	2.6
$PM_{2.5}$	0.190	Gg	1.5
PM_{10}	0.190	Gg	0.8
TSP	0.190	Gg	0.5
BC	0.118	Gg	3.9
CO	25.917	Gg	8.8
Pb	0.002	Mg	<0.1
Cd	0.024	Mg	3.3
Hg	0.013	Mg	3.4
As	<0.001	Mg	<0.1
Cr	0.114	Mg	0.9
Cu	4.102	Mg	9.6
Ni	0.171	Mg	1.7
Se	0.024	Mg	6.9
Zn	2.418	Mg	2.1
PCDD/ PCDF	0.417	g I-Teq	4.8
PAH-4	0.116	Mg	0.6
HCB	<0.001	kg	<0.1
PCB	<0.001	kg	<0.1

Table 3.6 (b) Contribution of NFR 1A3bii in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	5.559	Gg	6.0
NMVOC	0.316	Gg	0.4
SOx (as SO_2)	0.004	Gg	<0.1
NH_3	0.023	Gg	<0.1
$PM_{2.5}$	0.205	Gg	1.6
PM_{10}	0.205	Gg	0.8
TSP	0.205	Gg	0.6
BC	0.129	Gg	4.2
CO	1.785	Gg	0.6
Pb	<0.001	Mg	<0.1
Cd	0.004	Mg	0.5
Hg	0.002	Mg	0.5
As	<0.001	Mg	<0.1
Cr	0.018	Mg	0.1
Cu	0.626	Mg	1.5
Ni	0.026	Mg	0.3
Se	0.004	Mg	1.1
Zn	0.367	Mg	0.3
PCDD/ PCDF	0.118	g I-Teq	1.4
PAH-4	0.037	Mg	0.2
HCB	<0.001	kg	<0.1
PCB	<0.001	kg	<0.1

Table 3.6 (c) Contribution of NFR 1A3biii in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	6.896	Gg	7.5
NMVOC	0.342	Gg	0.5
SOx (as SO_2)	0.011	Gg	<0.1
NH_3	0.028	Gg	<0.1
$PM_{2.5}$	0.118	Gg	0.9
PM_{10}	0.118	Gg	0.5
TSP	0.118	Gg	0.3
BC	0.073	Gg	2.4
CO	2.169	Gg	0.7
Pb	<0.001	Mg	<0.1
Cd	0.003	Mg	0.4
Hg	0.006	Mg	1.5
As	<0.001	Mg	<0.1
Cr	0.022	Mg	0.2
Cu	0.533	Mg	1.3
Ni	0.022	Mg	0.2
Se	0.003	Mg	0.9
Zn	0.325	Mg	0.3
PCDD/ PCDF	0.067	g I-Teq	0.8
PAH-4	0.047	Mg	0.3
HCB	<0.001	kg	<0.1
PCB	<0.001	kg	<0.1

Table 3.6 (d) Contribution of NFR 1A3biv in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	0.146	Gg	0.2
NMVOC	0.523	Gg	0.7
SOx (as SO_2)	<0.001	Gg	<0.1
NH_3	0.002	Gg	<0.1
$PM_{2.5}$	0.009	Gg	<0.1
PM_{10}	0.009	Gg	<0.1
TSP	0.009	Gg	<0.1
BC	0.002	Gg	<0.1
CO	3.473	Gg	1.2
Pb	<0.001	Mg	<0.1
Cd	<0.001	Mg	0.1
Hg	<0.001	Mg	<0.1
As	<0.001	Mg	<0.1
Cr	0.004	Mg	<0.1
Cu	0.146	Mg	0.3
Ni	0.006	Mg	<0.1
Se	<0.001	Mg	0.2
Zn	0.086	Mg	<0.1
PCDD/ PCDF	0.013	g I-Teq	0.2
PAH-4	0.001	Mg	<0.1
HCB	<0.001	kg	<0.1
PCB	<0.001	kg	<0.1

Emission trend

The consumption of diesel and gasoline increased by about 1 PJ per year during the 1970s and 1980s. Then the consumption fell rapidly from 1990 onwards due to recession. Diesel consumption returned to the pre-recession growth rate, but gasoline consumption has decreased, on average, by 1 PJ per year since the 1991 record-high level. Had the consumption of both fuels followed the pre-recession growth rate, without the decrease of the early 1990s, then the current level of consumption would give comparable percentage growth rates to those observed for other countries. The economic recession of the early 1990s explains why road traffic kilometrage (mileage) did not increase as rapidly in Finland as in other countries. Since 1990 traffic volumes have increased although slower than in many other industrialised countries due to recession in the early 1990s. The market share of public transport in proportion to the total volume of passenger transport decreased steadily since 1990 until 1997. The significant reduction in all emissions for the year 2020 is due to COVID-19. Strong fluctuations in fuel prices in 2022 have decreased kilometrage and thus emissions as well. In 2023, the total kilometrage of road transport remained stable, but the increasing proportion of BEVs and PHEVs in the vehicle fleet in service is gradually having more significant impact on overall emissions.

From 2008 onwards, the emissions have decreased due to many simultaneous different factors, both societal and legislative.
- A new prolonged economic depression decreased kilometrage.
- The fuel consumption of cars has decreased due to EU CO_2 limits set to the car manufacturers
- A national car tax reform based on CO_2 emissions caused a dramatic transition from gasoline to diesel cars and decreased CO_2 emissions in 2009.
- Biofuels have lowered the CO_2 emissions but there are strong yearly fluctuations in the bio-shares of diesel oil. While gasoline has a technical limit for the maximum ethanol blend, diesel has no technical limit for HVO fuels. This fact is used for the bio-share obligations i.e. to increase the bio-share in diesel oil when needed. The fuel suppliers are allowed high yearly fluctuations in the bio component mix as long as the long-term trend fulfils the legislative targets.

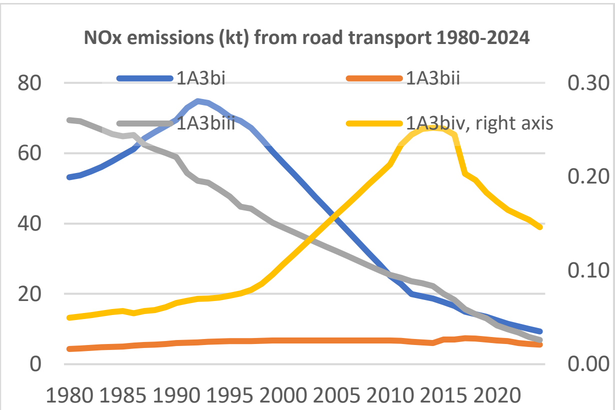
Passenger car fuel consumption per vehicle has lowered steadily since 2008. For heavy vehicles, fuel consumption has stayed rather stable.

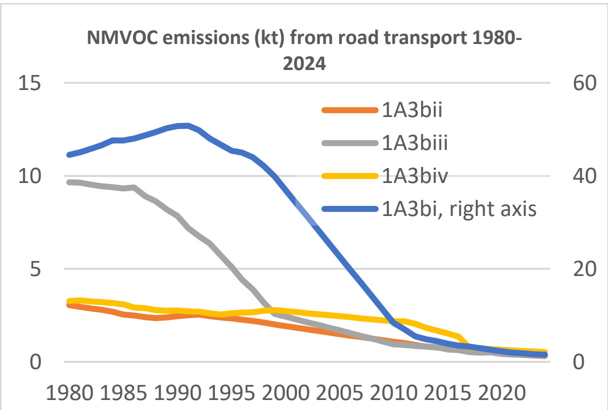
Emission trends for NO_x, SO_x, NMVOC and NH_3 are presented in Figure 3.4. All emissions except ammonia are currently decreasing. The trends in emissions have continued downwards because of the prolonged economic downturn and due to the still tightening emission standards (e.g. use of SCR technology in diesel vehicles significantly reduces NO_x emissions).

In the case of ammonia, vast majority of the emissions originate from gasoline passenger cars equipped with catalytic converters. Ammonia was formed extensively in Euro 1 and Euro 2 cars, which led to a sharp increase in ammonia emissions from passenger cars in the 1990s. Successive Euro classes have seen significant reductions in emissions resulting in lower passenger car emissions. The rapid increase in ammonia emissions from heavy duty vehicles from 2010 onwards is due to the urea additive used in SCR diesel technology, which has become the main technology since Euro 5. The increase in ammonia emissions from light duty vehicles (almost all diesel vehicles) from 2010 is due to the same deployment of SCR technology as in heavy duty vehicles.

The economic recession in the early 1990s slowed down the increase of fuel use, which, however, grew per 2 PJ per year during 1970-1980s. In the latest years there has been a growing share of biofuels in road transport. The intended purpose for the introduction of biofuels is to limit greenhouse gas emission as the annually driven kilometrage is growing. Passenger car use has been growing steadily. The energy efficiency of new registered cars began to improve in the 1990s. Since 1995 the consumption of diesel has grown while the consumption of gasoline has decrease by 1 PJ per year since the 1990s.

Fuel consumption and energy use data are presented in Figures 3.5 and 3.6 and the road kilometrage in Tables 3.7. and 3.10.





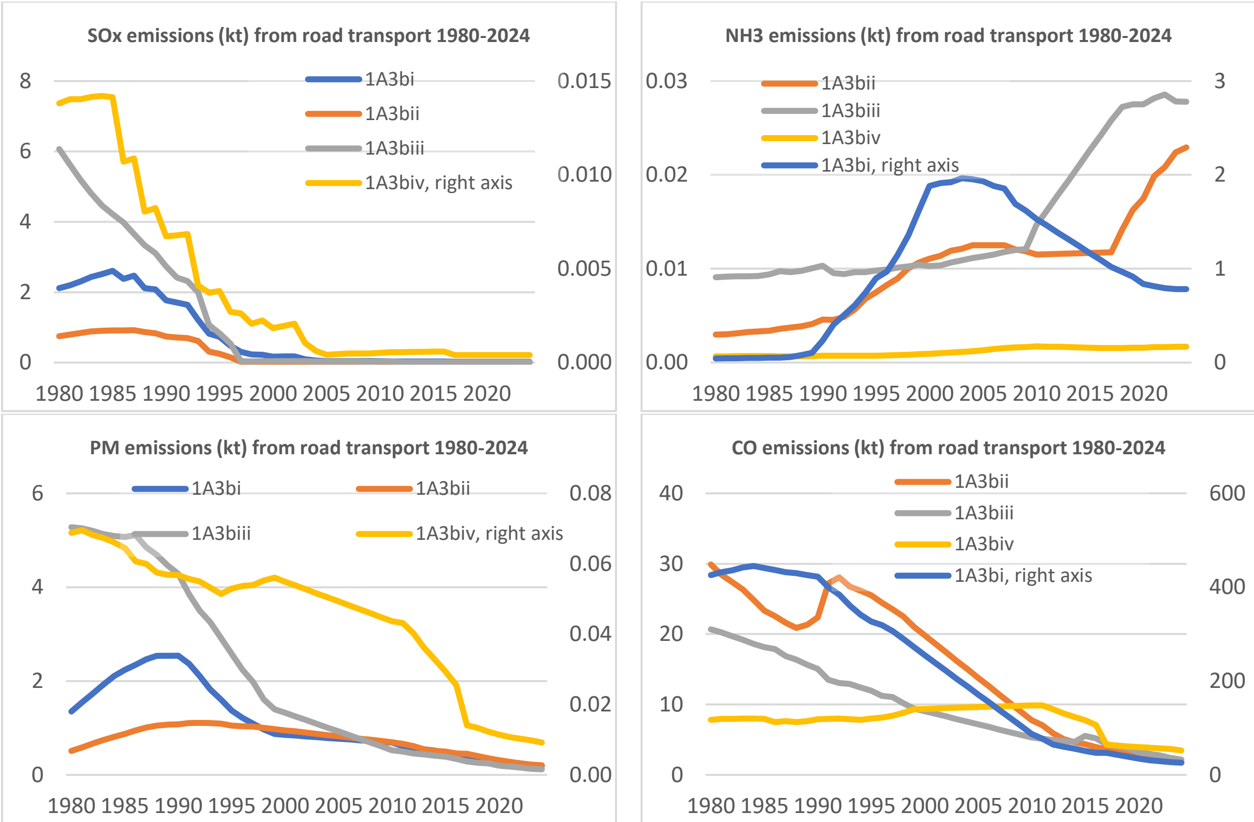


Figure 3.4. NO_x, NMVOC, SO_x, NH_3, PM and CO emissions from road transport 1980-2024.

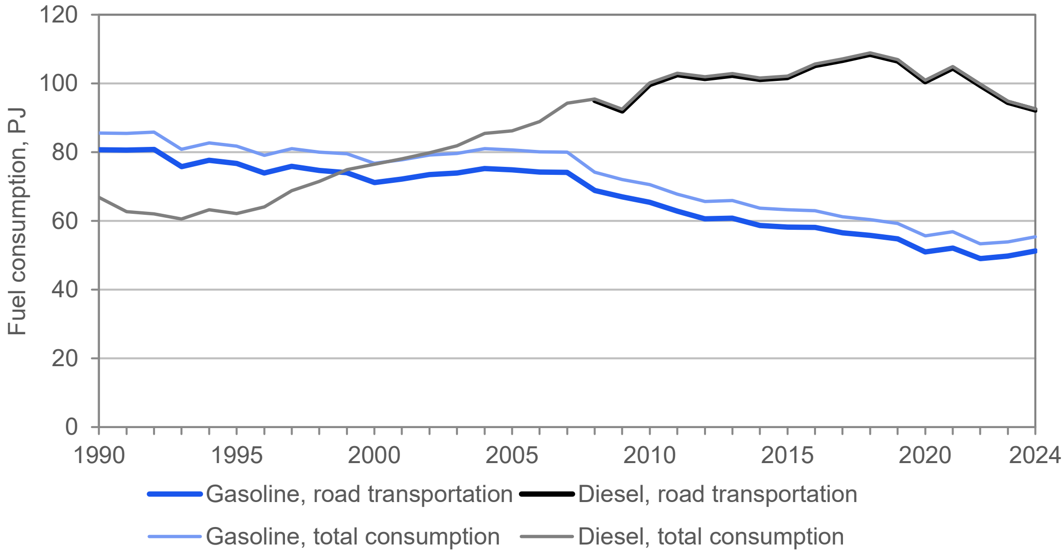


Figure 3.5. Consumption of diesel oil and gasoline (including bioshares) in road transportation in 1990 to 2024 (Energy Statistics, Statistics Finland, NID 2026).

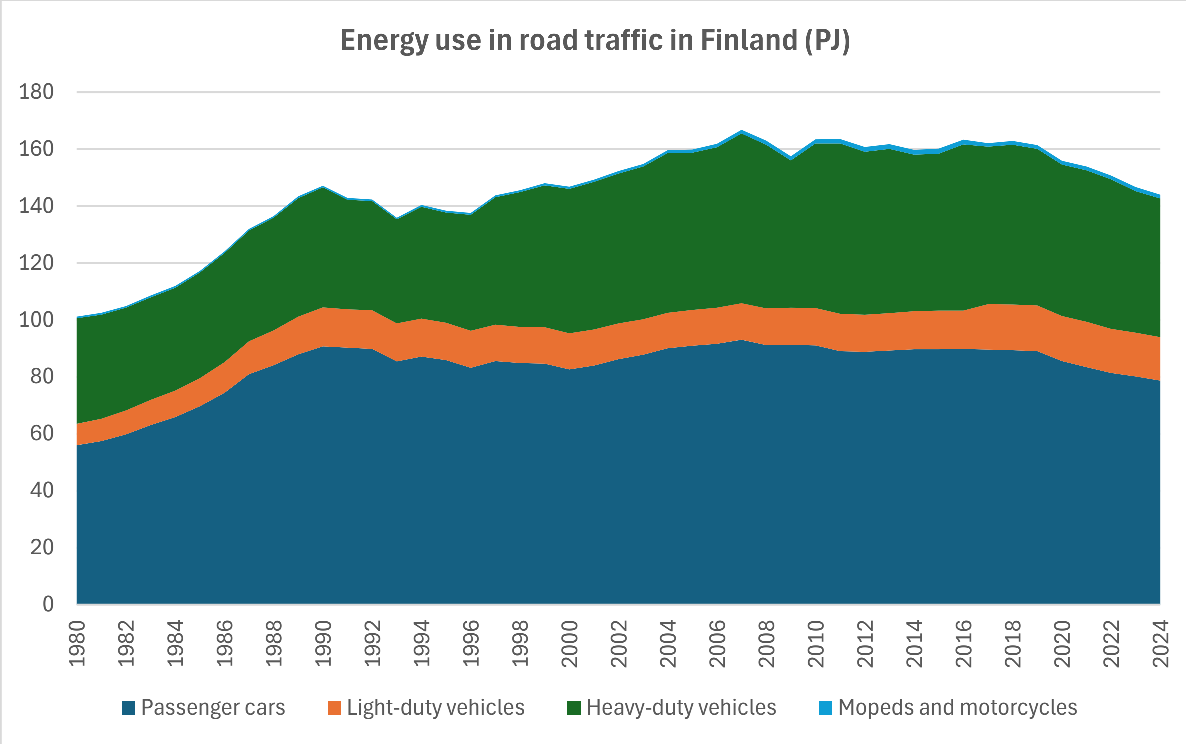


Figure 3.6. Energy use by vehicle category (LIPASTO/VTT and Statistics Finland 2025).

Methodological issues

Changes in chapter	
March 2026	AL, TF, KM, KG

COPERT calculation system

Detailed methodological description of the COPERT model is available on Emisia website (https://copert.emisia.com/copert/methodology/). The methodological details are not reproduced in the IIR. The Tier 3 level detailed methodology of the COPERT model is used for NOx, NMVOC, NH_3, PM and CO. SO_2 and heavy metal emissions are estimated in COPERT based on fuel consumption. For POP emissions, the default methodology of the COPERT is used.

Activity data

For COPERT activity data sources are largely the same as in LIPASTO/LIISA (described below) but there are differences in the division into vehicle categories. Kilometrage data (street and urban) broken down into Euro class, vehicle type, segment and vehicle propulsion type is received from transport statistics (LIIVI) at Statistics Finland. This data is based on vehicle inspection data, which is maintained by Finnish Transport and Communications Agency, Traficom and automatic traffic measurement station data from the Finnish Transport Infrastructure Agency. The motorcycle, moped and microcars kilometrage is estimated based on unpublished literature study. Road traffic kilometrage in Finland used in the COPERT model is presented in table 3.7. The vehicle fleet data used in COPERT is available from the Finnish Transport and Communications Agency, Traficom.

Table 3.7. Road traffic kilometrage in Finland [Million km/a] used in the COPERT model.

Year	Cars	Light-duty vehicles	Heavy-duty vehicles	MC + Mopeds + Micro cars	Total
2017	40 604	5 605	3 998	905	51 112
2018	40 711	5 684	4 024	915	51 334
2019	40 717	5 713	3 942	909	51 281
2020	39 094	5 651	3 781	911	49 438

Year	Cars	Light-duty vehicles	Heavy-duty vehicles	MC + Mopeds + Micro cars	Total
2021	38 782	5 757	3 751	925	49 215
2022	38 403	5 580	3 710	932	48 625
2023	38 614	5 589	3 548	939	48 691
2024	38 642	5 571	3 498	931	48 642

Total fuel sales are from statistics compiled by the Finnish Petroleum and Biofuels Association until 2018 and Statistics Finland from 2018 on. These data are compared to and supplemented with the data received from the Tax administration. Unlike in many parts of Europe, where through traffic is heavy, in Finland, national fuel sales correspond well with the fuel used in Finland. The main fuels for Road transport in Finland are reformulated gasoline and diesel oil.

LIISA submodel of the LIPASTO calculation system

The following road transport emissions have been calculated with the LIISA sub-model of LIPASTO in the 2026 submission:

- SO_2, Pb, Hg and As for 1980-2016.
- NH3, PCDD/F and PCB for 1980-2010.
- NO_x, NMVOC, TSP, $PM_{2.5}$, PM_{10}, BC, CO and PAHs for 1980-1999.

In the latest version of the LIISA calculation model the emission factors are from EMEP/EEA Guidebook 2023. The exceptions are cold-start emissions methodology, which is based on the Guidebook 2019 (update 2021) and emission degradation due to vehicle age which is based on the Guidebook 2016 method.

For emission degradation due to vehicle age, the method in the Guidebook 2019 and 2023 has been updated and simplified from the Guidebook 2016 method which is in use in the LIISA-model. New method seems to lead to significantly higher emissions compared to the one in the Guidebook 2016, but differences seemed illogical between Euro classes. For example, the CO emission factor (g/km) for passenger cars and vans increased by 120% for Euro 3 but decreased 4 % for Euro 2 class. Deeper examination of the discrepancies and determining if the new method is more reliable for Finland has not been possible with the available resources, and therefore the 2016 Guidebook method is used.

The LIISA model also includes new vehicle technologies (FFV, gas, electric vehicles etc. as described in paragraph Methodological Issues) and for example urea additive AdBlue.

Basis of calculation

The emission calculation is based on annual kilometrage (km/a) per vehicle type (NO_x, SO_2, NMVOC, CO, TSP, $PM_{2.5}$, PM_{10}, BC, PCDD/ PCDF and PCB). The emission factors are classified according to the emission standards (Euro0-Euro6 classes) and include degradation of vehicles. Also cold start of vehicles is taken into account. The calculation follows the EMEP/EEA Emission Inventory Guidebook 2023.

SO_2 as well as PAHs and HCB emissions are calculated from fuel consumption of road vehicles and emission factors. The definition of consumption of fuel on the country level is based on fuel sales.

Fuels

Road traffic in Finland uses basically two different fuels, reformulated gasoline and diesel oil. Besides road traffic use, the gasoline sold in Finland is also used in working machines and leisure boats. Diesel fuel sold in Finland is used almost exclusively by road traffic. Starting from year 2008 diesel has been used also as fuel in leisure boats. The amounts of fuels (gasoline and diesel) used for other purposes than road transport is deducted from the total sales of fuels before the emission calculation. Fuels used for other purposes than road traffic are calculated by separate models. The amount of fuel imported in fuel tanks of vehicles from other countries is estimated to be small. The emission factors are a sum of hot driving, idle and cold start-ups.

Kilometrage (mileage)

The kilometrage [km/a] data for automobiles consist of two main categories: kilometrage on public roads (roads governed by the Finnish Transport Infrastructure Agency) and kilometrage on streets (governed by municipalities).

Automobile kilometrage on public roads consists of aggregated kilometres driven by five vehicle types (cars, vans, buses and coaches, lorries and articulated vehicles) on four road types (main roads in built-up areas, classified roads in built-up areas, main roads in rural areas and classified roads in rural areas) in six speed limit classes (50, 60, 70, 80, 100 and 120 km/h). These data allow detailed calculations to be performed on a smaller area than a country because the detailed data in the model are on the municipality level. For nation-wide calculations the kilometrage is summed up. An essential part of defining the total annual kilometrage is the annual analysis of the odometer readings available from the Periodic Technical Inspection Centres and done by Statistics Finland.

Street kilometrage is based on a total kilometrage (km/a) estimation made by the Finnish Transport Infrastructure Agency and crosschecked by the studies made at inspection stations. The estimated street kilometrage data are further divided into street types (main street, collector street, residential street, local plan road) based on information from traffic calculations in some cities.

Both public road and street mileage are divided according to the vehicle technology for every vehicle type: vehicles without catalytic converters, with catalytic converters, FFV, diesel, gas (CNG), PHEV(BE), PHEV(DI), BEV and Hydrogen. Road traffic kilometrage in Finland in the LISA model is presented in Table 3.10.

Vehicle fleet model ALIISA and the kilometrage

The source of the number, types and age of vehicles is the Finnish vehicle register (data obtained from Statistics Finland, the register is maintained by the Finnish Transport and Communications Agency, Traficom).

The division of kilometrage by vehicle types and technologies is done by an ALIISA model, which is a vehicle fleet model and sub-model to LIISA. The ALIISA model has 45 different vehicle types including gasoline, diesel, FFV (Flexible-fuel vehicle), ED95 (ethanol-diesel vehicle), gas, PHEV (plug-in hybrid electric vehicle), BEV (battery electric vehicle) and FCEV (fuel cell electric vehicle, hydrogen). Besides kilometrage, the ALIISA model comprises data on vehicle sales, fleet, fuel consumption, biofuels, energy and CO_2 emissions. All this forecasted to 2050. The ALIISA model ensures that all foreseeable technologies can be included in the emission calculations. Furthermore, kilometrage is divided according to vehicle age (model year).

Motorcycle and moped kilometrage is specified in a separate model using the number of motorcycles and mopeds and estimation of yearly kilometrage of each two-wheel types on two road types (roads and streets). Mopeds have only one engine type but kilometrage is further divided according to different emission standards (Euro 0 to Euro 5). Motorcycles have two main types of engines, two-stroke and four-stroke. Kilometrage is divided into these main types and further to three engine volumes (under 250 ccm, 251-750 ccm and over 750 ccm) and according to emission standards (Euro 0 to Euro 5). Also, L6e class (diesel, moped car, quadricycle) is included in this category.

Fuels sold

Total fuel sales are from statistics compiled by the Finnish Petroleum and Biofuels Association until summer 2020 and Statistics Finland from autumn 2020 on. These data are compared to and supplemented with the data received from Tax administration. Fuel sales statistics are very accurate in Finland because national fuel sales correspond well with the fuel used in Finland.

The amount of gasoline used in other purposes than for road transportation is deducted from the total sales of gasoline. Gasoline used in working machines is calculated with the TYKO model. Gasoline and diesel used in leisure boats are calculated with the MEERI model.

The activity data for natural gas used in road transport are from the Energy Statistics.

For modelling purposes, the data are broken down into different vehicle types and road types as explained above.

Information on fuel properties can be found on Statistics Finland's website http://tilastokeskus.fi/tup/khkinv/khkaasut_polttoaineluokitus.html.

Degradation of vehicles

The national road transport calculation method LIISA takes into account the degradation of vehicles. Degradation has impact on CO, HC and NO_x emissions of cars and light duty vehicles as stated in the Guidebook.

In the Guidebook degradation factors are based on vehicle kilometrage. As in the LIISA model the calculation of emission is based on the total kilometrage of each vehicle type and the vehicle age, the degradation factors published in the Guidebook cannot be used as such in the LIISA model. Instead, the kilometrage based factors in the Guidebook have been used to define age-based factors for the LIISA model. In each calculation year the factors are defined for the different Euro-classes. The correlation between the vehicle age and the kilometrage in the Finnish fleet has been calculated using the ALIISA vehicle model. The newest Euro class (Euro 6 2020+) has not yet been included into the degradation calculation (correction factor is 1.00). The correction factors for the Euro-classes for the year 2023 are expressed in Table 3.8.

Table 3.8. Correction factors for degradation in the LIISA model. (LIPASTO)

Compound and vehicle type	**Emission factors for degradation in LIISA model, gasoline vehicles**								
	Euro 0	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 6 pre 2017	Euro 6 2017–2019	Euro 6 2020+
CO cars	1.84	1.84	1.84	1.15	1.15	1.15	1.11	1.07	1.00
CO vans	1.84	1.84	1.84	1.15	1.15	1.15	1.11	1.07	1.00
HC cars	1.88	1.88	1.88	1.00	1.00	1.00	1.00	1.00	1.00
HC vans	1.88	1.88	1.88	1.00	1.00	1.00	1.00	1.00	1.00
NOx cars	2.02	2.02	2.02	1.22	1.22	1.22	1.18	1.11	1.00
NOx vans	2.02	2.02	2.02	1.22	1.22	1.22	1.18	1.11	1.00

Emission factors and other parameters

The methods for calculating emissions from road transportation correspond to the EMEP/EEA Guidebook Tier 3.

Emission factors are determined for all the activity categories mentioned above.

For each automobile type, the cold start emission and fuel consumption surplus is calculated according to the EMEP/EEA emission inventory guidebook 2019 (update 2021).

The formula below has been used in calculation of emissions from automobiles in LIISA model:

$$E^c = \sum_{r=1}^{6}\sum_{v=1}^{6}\sum_{l=1}^{5}\sum_{x=1}^{6}\sum_{f=1}^{6}\sum_{y=1}^{7}\left(M_{r,v,l,x,f,y}\left(e_{r,v,l,x,f,y}^{c,h}+e_{r,v,l,x,f,y}^{c,s}\right)\right)$$

where

E^c	total emissions of compound c
c	compound
r	road type (6 types)
v	speed limit class (6 classes)
l	type of vehicle (5 types)
x	type of driving power (6 types)
f	fuel type (6 types)
y	emission standard level (Euro) (7 classes)
M	kilometrage (given by road type, speed limit class and main type of vehicle, and divided to vehicle subclasses using a car fleet model called ALIISA)
$e^{c,h}$	emission factor for hot driving
$e^{c,s}$	emission factor for cold start-ups

Particle emissions

Particle emissions cover TSP, PM_{10} and $PM_{2.5}$. According to the EMEP/EEA Emission Inventory Guidebook 2023 the fraction factors, i.e. the rations between all particle fractions is 1:1. Black carbon emissions from road transport are calculated with the Tier 1 emission factors of the EMEP/EEA Guidebook 2023.

Black carbon emissions from road transport are calculated with the Tier 1 emission factors of the EMEP/EEA Guidebook 2023.

NH_3 emissions

Ammonia emissions from road transport were included in the inventory for the first time in the 2015 submission. The emissions are calculated by EURO classes as described in the EMEP/EEA Guidebook 2023. In cases no emission factor is provided in Guidebook 2023, an expert estimate has been used. Emission factors are presented in Table 3.9 and activity data (driven kilometres) in Table 3.10.

Table 3.9. NH_3 emissions factors for road transport (EMEP/EEA Guidebook 2023. Estimates made by VTT LIPASTO experts are marked as "ex").

Vehicle type	EFs from EMEP EEA Guidebook 2023, unit mg/km								
	EURO 0	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	Euro 6 pre 2017	Euro 6 2017–2019	Euro 6 2020+
Passenger cars, diesel	1	1	1	1	1	2	7	7	7
Passenger cars, without catalytic (gasoline)	2								
Passenger cars, with catalytic (gasoline)		88	107	32	31	14	14	13	13
Heavy duty with trailer, diesel*	3	3	3	3	3	11	9	9	9
Heavy duty without trailer, diesel	3	3	3	3	3	11	9	9	9
Heavy duty with and without trailer, gas	2ex	89ex	109ex	32ex	31ex	13ex	13ex	13ex	13ex
Busses, diesel	3	3	3	3	3	11	9	9	9
Busses, gas	2ex	89ex	109ex	32ex	31ex	13ex	13ex	13ex	13ex
Motocycles	2	2	2	2	2	2			
Mopeds	1	1	1	1	1	1			
Vans, diesel	1	1	1	1	1	2	7	7	7
Vans without catalytic	2								
Vans with catalytic		89	109	32	32	15	14	13	13
Vans (gas)	2ex	89ex	109ex	32ex	31ex	13ex	13ex	13ex	13ex

Passenger cars (gas)	2ex	89ex	109ex	32ex	31	13	13	13	13
Motorised quadricycles	0.3	0.3	0.3	0.3	0.3	0.3			
Passenger cars (FFV)*					33.9	33.9	33.9	33.9	33.9

*No values in Guidebook 2023; Guidebook 2019 values used

POP emissions

The calculation of road transport POP emissions is based on emission factors and driven kilometres or consumed fuel (Table 3.10). of fuels as tonnes is converted into litres by dividing it with the density of petrol (0.746 kg/l for the year 2023) or diesel (0.807 kg/l for the year 2023, depending on the bioshare).

PAH-4

The road transport emission factors for the four indicator substances, i.e. benzo(a)pyrene, benzo(b)fluoranthene, benzo(k) fluoranthene and indeno(1,2,3-cd)pyrene are from EMEP/EEA Guidebook 2023. The sum of PAH-4 is calculated from the four indicator substances.

PCDD/F

The PCDD/F emissions from road transport are calculated with the emission factors provided in the Tables 3.75 and 3.76 of the EMEP/EEA Guidebook 2023. Emission factors are given separately for PCDD and PCDF.

PCB

PCB emissions from road transport are calculated with the emission factors provided in the Tables 3.75 and 3.76 of the EMEP/EEA Guidebook 2023.

Lead emissions from lead added to the fuel

Lead emissions of lead added to the fuel are included in the LIISA model and have thus been reported in all earlier submissions. These emissions occurred for 1980 to 1994.

Table 3.10 Activity data for 1980-2023 in the LIISA sub-model.

Year	Driven kilometers (10^6 km/year)					Fuel consumption (t/year)				
	Passenger cars	Light duty trucks	Buses	Heavy duty trucks	MC+Mopeds	Passenger cars	Light duty trucks	Buses	Heavy duty trucks	MC+Mopeds
1980	22 620	2 024	640	2 390	480	1 309 687	175 937	167 979	701 332	14 043
1985	27 748	2 709	670	2 460	480	1 629 157	233 514	170 380	698 507	14 436
1990	35 757	3 593	660	2 780	448	2 121 152	320 819	173 647	816 880	14 020
1995	34 740	3 743	633	2 639	447	2 008 346	307 250	184 893	724 734	14 303
2000	38 699	4 266	598	2 814	556	1 932 179	298 538	189 261	1 001 041	18 373
2005	41 195	4 676	596	3 136	781	1 964 373	297 317	190 956	1 026 173	19 442
2006	41 262	4 779	596	3 195	848	2 015 906	295 912	194 116	1 041 516	20 650
2007	41 771	4 895	593	3 290	924	2 053 074	293 140	185 230	1 072 408	21 995
2008	41 102	4 945	605	3 336	964	2 105 923	292 376	191 014	1 125 112	23 584
2009	41 236	5 048	609	3 088	989	2 127 510	294 466	189 635	1 107 045	25 575
2010	40 991	5 136	612	3 223	1 045	2 142 867	298 166	188 101	1 134 923	27 596
2011	40 682	5 145	611	3 295	1 131	2 181 718	302 511	184 974	1 213 675	29 965
2012	40 030	5 133	609	3 301	1 171	2 156 534	302 580	186 381	1 163 569	32 378
2013	40 455	5 189	615	3 339	1 194	2 176 379	307 187	186 127	1 026 120	32 936
2014	41 064	5 306	620	3 354	1 205	2 169 931	310 781	185 021	1 168 364	34 598
2015	40 603	5 488	622	3 404	1 220	2 137 427	309 818	183 024	1 218 343	37 557
2016	40 682	5 511	636	3 493	1 226	2 131 035	305 957	180 617	1 162 413	38 801
2017	40 528	5 608	630	3 369	1 225	2 130 849	307 914	180 396	1 170 726	39 050
2018	40 537	5 686	613	3 409	1 194	2 139 090	314 712	182 338	1 101 121	39 558
2019	40 446	5 720	598	3 338	1 154	2 106 966	314 951	175 269	1 102 725	40 033
2020	38 602	5 655	517	3 254	1 125	2 106 307	313 512	181 827	1 172 566	40 194

Year	Driven kilometers (10^6 km/year)					Fuel consumption (t/year)				
	Passenger cars	Light duty trucks	Buses	Heavy duty trucks	MC+Mopeds	Passenger cars	Light duty trucks	Buses	Heavy duty trucks	MC+Mopeds
2021	37 841	5 758	447	3 285	1 115	2 094 989	321 008	184 195	1 200 216	40 566
2022	36 797	5 560	487	3 172	1 092	2 089 356	322 228	181 924	1 252 187	39 604
2023	35 999	5 541	501	2 983	1 072	2 058 054	316 710	177 484	1 223 883	38 390

NOTE: The figures presented in the table do not include electric or hydrogen vehicles.

Methodological differences between COPERT and LIPASTO/LIISA

Both LIPASTO/LIISA and COPERT are based on the Tier 3 level methodologies from the EMEP/EEA emission inventory guidebook. However, some differences occur in the methodologies used in these models that cause differences in emission estimates produced for certain pollutants. The key differences are:

- In LIISA, the cold-start emissions methodology is based on the Guidebook 2019 (update 2021) and emission degradation due to vehicle age is based on the Guidebook 2016 method. In COPERT, the methodologies used for cold-start emissions and emission degradation due to vehicle age are based on Guidebook 2023.
    - These methodological differences cause significant differences in emissions for NOx, NMVOC, particulate matter and CO between COPERT and LIISA.
- In LIISA, heavy metal emissions from lubricant consumption were not calculated separately. Guidebook 2023 contains heavy metal emission factors for lubricant consumption in table 3-83 (chapter 1.A.3.b.i-iv Road Transport). COPERT uses these default emission factors to calculate heavy metal emissions from lubricant consumption. The absence of these emissions was an error in the LIISA model.
    - This causes significant differences in emissions for Cd, Cr, Cu, Ni, Se and Zn between COPERT and LIISA.

Methodologies used to estimate the time series from 1980 to 2016

Since it is not possible to estimate road transport air pollutant emissions for the whole time series with COPERT, different pollutant specific methodologies have been used to estimate the emissions for the years prior to 2017. In the case of SO2, Pb, Hg and As the emission estimates calculated with both models, COPERT and LIPASTO/LIISA, for 2017 to 2023 are well in line. For these pollutants, the time series 1980-2016 is produced with the LIPASTO/LIISA model and from 2017 onwards, results from the COPERT model are used.

NOx, NMVOC, particles and PAHs

For NOx, NMVOC, particles and CO, emission estimates for 1980-1999 are produced with LIPASTO/LIISA. NOx, NMVOC, particle and CO emissions turned into decrease already at the late-1980s or early-1990s. The emission estimates produced with LIPASTO/LIISA are based on the same Tier 3 level methodological approach of the EMEP/EEA Guidebook as is used in COPERT.

The current emission estimates for 1980s and 1990s are considered reliable. For 2017 to 2023 (the common years of LIPASTO/LIISA and COPERT), there are significant differences in the emission levels of the models as described above. However, the emission trends for categories 1A3bi-iii are consistent in both models for these years. Therefore, for these categories the overlap method presented in EMEP/EEA Guidebook 2023 (Chapter A.4 Time series consistency) has been used to calculate emissions for 2010 to 2016. The emissions associated with the new method for 2010 to 2016 are estimated by adjusting the previous estimate (LIPASTO/LIISA) by the constant amount equal to the average difference in the years of overlap (2017-2023). Currently, the average lifetime of passenger cars, light-duty and heavy-duty vehicles is around 15 years in Finland. On this basis, the year 2010 was selected as the last year to apply the overlap method (15 years backwards from the latest inventory year 2024). The emission estimates for the years for 2000 to 2009 are based on linear interpolation.

For category 1A3biv, the emission trends are not as consistent as for categories 1A3bi-iii. For this reason, the overlap method was applied for 1A3biv. The emission estimates for the years for 2000 to 2016 are based on linear interpolation for category 1A3iv.

In the case of PAHs, the peak level of emissions in the LIPASTO/LIISA model occurred at the end of 2010s. After that the emissions turned into decrease. The same decreasing trend is also observed in COPERT. For PAHs, the emission estimates for 1980-1999 are produced with LIPASTO/LIISA. For the years 2010 to 2016 the above-described overlap method is applied for all categories 1A3bi-iv. The emission estimates for the years for 2000 to 2009 are based on linear interpolation.

NH_3, PCDD/F and PCB

In the case of ammonia, PCDD/F and PCB the peak level of emissions in the LIPASTO/LIISA model occurred in the mid-2000s (ammonia) or at the turn of 2010s (PCDD/F and PCB). For these pollutants, emission estimates for 1980-2010 are produced with LIPASTO/LIISA. Applying the same approach as for NOx, NMVOC, particles and PAHs for the years 2000 to 2016 was not deemed the best practise. For ammonia, that approach would unrealistically cut the peak level of the emissions in the time series in the mid-2000s. Therefore, ammonia, PCDD/F and PCB emission estimates between 2010 and 2017 are linearly interpolated.

Cd, Cr, Cu, Ni, Se, Zn and HCB

The most significant differences between the emission estimates produced with LIPASTO/LIISA and COPERT occur for Cd, Cr, Cu, Ni, Se, Zn and HCB. The reason for the difference for these heavy metals is the absence of emission estimation from the use of lubricants in the LIPASTO/LIISA model. As described above, these emissions are included in the COPERT model.

For HCB, the EMEP/EEA Guidebook 2023 does not provide default emission factors. In the LIPASTO/LIISA model, HCB emissions were estimated based on old study by BiPRO (BiPRO, 2006). The emission factors were fuel based. In COPERT, HCB emissions are estimated with kilometrage based emission factors.

As the difference between the emission estimates of LIPASTO/LIISA and COPERT are so enormous, the best methodology to estimate the emissions for the years prior to 2017 was deemed to be the surrogate data method presented in EMEP/EEA Guidebook 2023 (Chapter A.4 Time series consistency). In COPERT, the vast majority of Cd, Cr, Cu, Ni, Se and Zn emissions originate from the use of lubricants. Therefore, the use of lubricants was selected as the surrogate data (see chapter 3.3 above for lubricant consumption). In the case of HCB, COPERT uses kilometrage based emission factors and for that reason, kilometrage was selected as the surrogate data.

Uncertainties

Uncertainties are presented in Annex 6 of the IIR. The results of the uncertainty analysis are used to improve the accuracy of the inventory.

QA/QC and verification

Normal statistical quality checking related to assessment of magnitude and trends has been carried out. At present, no verification has been carried out for the specific source-sector emissions.

Total diesel oil and gasoline consumption taken as a sum from the transport submodels is annually compared at Statistics Finland with total fuel sales data taken from the Energy Statistics.

Source specific recalculations

2014-2015

- During the revision of the LIPASTO model in 2014 – 2015, year 2012 emissions were calculated both with the old and new models to see the effect of the renovation of the model.

SO_x, NO_x, NMVOC and CO were compared to the data reported under the UNFCCC calculated at Statistics Finland.

2015-2016

- Revision of the calculation model LIPASTO, major changes into the estimation of kilometrages driven

2015

- Aviation emissions previously calculated by Finavia, were estimated at SYKE based on approximations from different data sources
- Ammonia emissions from transport were included in the inventory

2016

- PAH emission factors were revised according to the GB

2017

- The emissions were updated according to the results of the revised LIPASTO models.
- Aviation emissions calculated according to the Eurocontrol data in cooperation with Statistics Finland (ghg and ap inventories)
- Heavy metal emissions were included for the first time.

2018

- Calculation of PM_{10} and $PM_{2,5}$ size fractions of TSP emissions from the results in the LIISA model was revised according to the method of the 2016 EMEP/EEA Emission Inventory Guidebook, i.e. the rations between all particle fractions is 1:1. The impact of the revision was below the threshold of the 2% for a technical correction in the NECD review.
- The time series 1980-1989 was updated according to the new version of the LIISA model
- PCDD/F and PCB emission factors were revised according to the 2016 EMEP/EEA Emission Inventory Guidebook.

2019

- Details of the recalculations carried out in 2018 and 2019 to the 2017 submission are presented in Annex 9 to be submitted by 1 May 2019.
- NFR 1A3bv - Method to calculate NMVOC emissions from gasoline evaporation according to
- the Tier 2 methodology of the EMEP/EEA Emission Inventory Guidebook 2016 was carried out.

2020

- Impact of speed was included in the calculation of TSP emissions which resulted in higher emissions, i.e. an increase of about 13% to all particle species (see Tables 3.11 c,d,e,f) and to heavy metal emissions as these are fractions of TSP.
- Abrasion emissions include some small changes to all years due to adoption of latest kilometrage values in the LIISA model, the impact being 0-16%.
- Selene from tyre wear was included in the calculation for the first time.
- A summary of recalculations under NFR 1A3b to the 2020 submission (Table 3.11):

Table 3.11. A summary of recalculations under NFR 1A3b to the 2020 submission.

NFR	Pollutant	Year	Effect on emissions	Justification
1A3bi	All reported pollutants	1987-1989	Only a minor increasing or decreasing effect on emissions	Update of kilometrage data on passenger cars with catalytic converter
1A3bi	SOx and heavy metals	1986-1989	Only a minor increasing or decreasing effect on emissions	Update of sulphur content of the fuel
1A3biii	All reported pollutants	2015-2017	Only a minor increasing on emissions	Update of kilometrage data on EURO3-6 busses and some trucks
1A3biv	All reported pollutants	1980-1989		Correction of incorrect emissions in the NFR tables and update of fuel use data in the emission calculation
1A3biv	SOx and heavy metals	1990-2017	Only a minor increasing or decreasing effect on emissions	Update of sulphur content of the fuel
1A3biv	NMVOC	1999-2017	Only a minor increasing effect on emissions	Correction of CH4 emissions in the calculation for motorcycles
1A3biv	Particles	2003-2017	Slight increase of emissions	Correction of errors in the calculation of emissions for motorcycles
1A3biv	PAH	1990-2017	Only a minor decreasing effect on emissions in the 1990's and slight increase of emissions after that	Correction of errors in the calculation

2021

- Recalculation of 1A3biv. The definition of emission factors for vehicle category L6e-B, light quadri-mobile (moped cars) has long been a problem for the lack of proper data. Now the Guidebook 2019 includes emission factors for micro-cars, intended for this vehicle category. The entire time series has been recalculated using these coefficients.
- Checking and revision of fuel properties (density, NCV, bio share) has slightly changed results for the years 2013-2018.

2022

- As a reference to the 2021 NECD inventory review question FI-1A3biv-2021-0001, the recalculation of heavy metal, small particle and POP emissions from 2003 onwards for category 1A3biv was finalized and the revised estimates were included in the 2022 submission.

2025

- The speed-dependent emission (CO, HC, NOx, PM, CH4, N2O) and energy consumption factors were updated into the LIISA-models according to EMEP/EEA Guidebook 2023 and it’s appendix (1.A.3.bi-iv Road Transport Appendix 4 Emission Factors 2024) and years 2015–2022 were recalculated. The emission factors were also updated in the submodel MP-LIISA and L-category was recalculated for 1990–2022, but changes to L-category’s emissions started to appear from the early 2000s.
- Errors found in gas consumption figures for gas powered articulated trucks were corrected. According to newer estimates, minor adjustments were made to the amount of FFV vehicles and to the relative share of driving on electricity for plug-in hybrid vehicles. The average fuel consumption of vehicles with various power sources was recalibrated so that the calculated total consumption better matches the statistics on different fuels sold for road transport.
- The air pollutant emission factors based on fuel consumption or kilometrage (NH_3, PCDD/PCDF, PCB, heavy metals, PAHs and HCB) were updated based on EMEP/EEA Guidebook 2023 and the entire time series was recalculated.

2026

- As a result of the implementation of the COPERT model to estimate road transport emissions for the air pollutant emission inventory, major recalculations of emissions were performed.
    - The emissions of all pollutants were recalculated for 2017 to 2023.
    - For 1980 to 2016, emissions of all pollutants except for SO_2, Pb, Hg and As were recalculated.

Source specific planned improvements

For the 2027 submission, the following improvement issues have been identified:

- The need to check the heavy metal contents assumed for fuels and lubricant oils in the COPERT model. Currently, the default values in COPERT are used and they may overestimate some of the emissions.
- Other issues may also arise as the updated 5.9 versions of COPERT will be investigated during 2026.

3.6 Gasoline evaporation

1 A 3 b v Road transport: Gasoline evaporation

Changes in chapter	
March 2026	AL, TF

Source category description

The contribution of the category to total emissions is presented below.

Table 3.12. Contribution of NFR 1A3bv in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NMVOC	2.719	Gg	3.7

Emission trend

NMVOC emissions from gasoline evaporation in 1990-2024 are presented in Figure 3.7 and Table 3.13. The emissions have decreased strongly due to capture of gasoline fumes in petrol distribution network and during refuelling of cars, due to less evaporative emissions from cars and better storage of chemicals at the refineries.

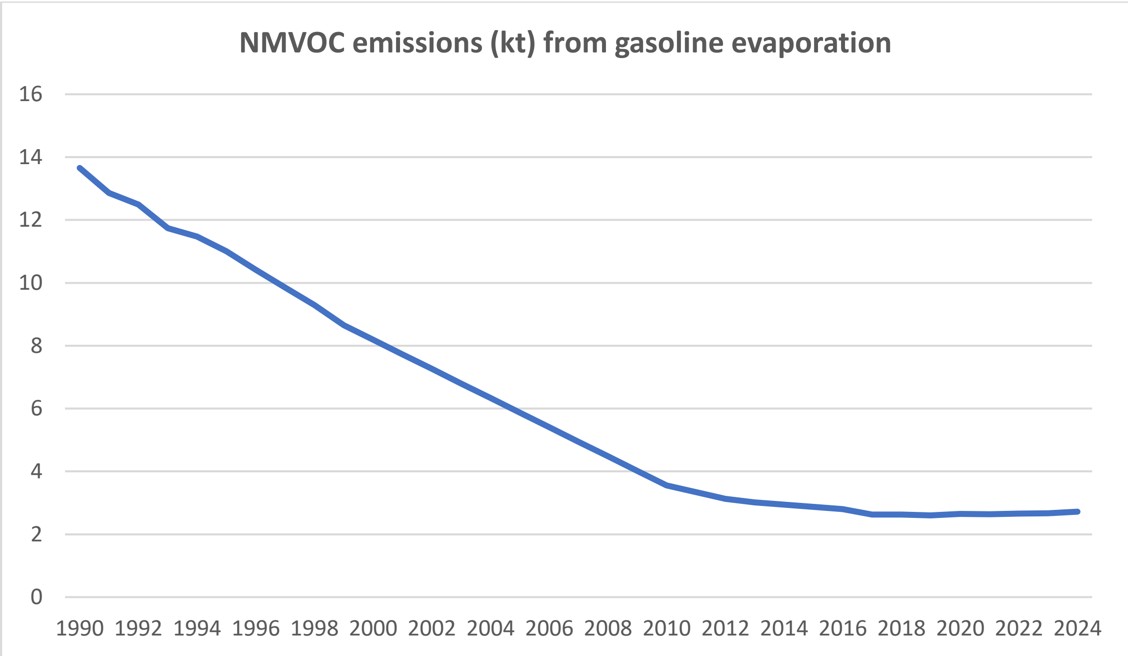


Figure 3.7. NMVOC emissions from gasoline evaporation 1990-2024.

Table 3.13 NMVOC evaporative emissions 1990-2024 from vehicles.

Year	Gasoline evaporation (t/a)	Year	Gasoline evaporation (t/a)
1990	13 655	2008	4 480
1991	12 863	2009	4 017
1992	12 490	2010	3 553
1993	11 743	2011	3 335
1994	11 470	2012	3 126
1995	11 006	2013	3 018
1996	10 415	2014	2 946
1997	9 850	2015	2 875
1998	9 291	2016	2 803
1999	8 651	2017	2 630
2000	8 188	2018	2 627

Year	Gasoline evaporation (t/a)	Year	Gasoline evaporation (t/a)
2001	7 725	2019	2 601
2002	7 261	2020	2 650
2003	6 798	2021	2 637
2004	6 334	2022	2 660
2005	5 871	2023	2 667
2006	5 407	2024	2 719
2007	4 944		

Methodological issues

COPERT model for the years from 2017 to 2024

NMVOC emissions of gasoline evaporation from petrol fuelled vehicles for 2017 to 2024 are estimated with COPERT version 5.8.1 (COmputer Programme to calculate Emissions from Road Transport). It has not been possible use COPERT for the years prior to 2017 since the vehicle fleet data in the required COPERT classifications is only available from 2017 onwards. In 2025, a new transport energy and emission calculation system (LIIKE) was established by Statistics Finland. The new LIIKE calculation system is operated and maintained by Statistics Finland and it is used to produce both the greenhouse gas and air pollutant emissions for road transport in Finland, including the NMVOC emissions from gasoline evaporation.

Detailed methodological description of the COPERT model is available on Emisia website (https://copert.emisia.com/copert/methodology/). The methodological details are not reproduced in the IIR. The Tier 3 level methodology of the COPERT model is used for estimating the emissions for 2017 to 2024. As the different fuel, vehicle and activity parameters specific for the fuel evaporation of the Tier 3 method, mostly the default values provided in COPERT are used.

Methodology for emission estimates for the years until 1999

NMVOC emissions of gasoline evaporation from petrol fuelled vehicles until the year 1999 are estimated with the Tier 2 methodology of the 2023 EMEP/EEA Guidebook. This methodology was used for the whole time series until the 2025 submission.

According to the methodology, three different mechanisms related to evaporative emissions are considered:

- diurnal losses
- running losses
- hot-soak losses

Diurnal losses occur due to daily temperature variations. The increase of ambient temperature causes the thermal expansion of the fuel and vapour in the fuel tank. As a result, some of the increased volume of fuel vapour is vented to the atmosphere. Running losses result from the vapour generation in the fuel tank when the vehicle is in motion. Hot-soak emissions are evaporative emissions from the fuel delivery system when a hot engine is turned off and the vehicle is no longer in motion.

NMVOC emissions from gasoline evaporation are calculated with equations (2)-(4) of the Guidebook (chapter 3.3.1, p. 10 of section 1.A.3.b.v Gasoline evaporation). The annual gasoline vehicle fleet (number of passenger cars, vans, motorcycles and mopeds) was available for the calculation from 2007 onwards. In the case of passenger cars and vans, the data was available according to the Euro classification but not according to the size class. Due to this, a conservative assumption to use emission factors of size class 1.4-2.0 l for the whole fleet was made. The number motorcycles and mopeds were available according to the Euro classification and size class. In addition, motorcycles were further divided into 2-stroke and 4-stroke engines. Emission factors needed in the calculation were taken from Tables 3-5 (passenger cars and vans) and 3-6 (motorcycles and mopeds) of the Guidebook. The emission factors are given for typical temperature ranges in winter and summer, and for typical fuels which are produced with seasonally different vapour pressures. Based on this, and taking into account the Finnish climate conditions, the following assumptions were made when choosing the emission factors:

- emission factors from the temperature range summer 10 to 25 °C were applied for June, July, August and September (altogether 122 days of the year),
- emission factors from the temperature range winter 0 to 15 °C were applied for April, May, October and November (altogether 122 days of the year),
- emission factors from the temperature range winter -5 to -10 °C were applied for January, February, March and December (altogether 121 days of the year)

The assumptions from the fuel tank sizes and carbon canisters size were based on information in Table 3-13 of the Guidebook. It was assumed that all conventional passenger cars and vans are uncontrolled, Euro 1 and 2 vehicles have small canisters and Euro 3 to 6 vehicles have medium canisters. No information on the carbon canisters on motorcycles or mopeds were given in the Guidebook. In the absence of any national information either, it was assumed that no motorcycles or mopeds are equipped with carbon canisters in Finland.

The average number of trips per day in different vehicle categories was calculated by means of equation (5) of the Guidebook and the average trip length. The average trip length of passenger cars was available from the latest national passenger traffic survey conducted by Finnish Transport Infrastructure Agency in 2018. The average trip length of 18 km from the survey was used in the calculation. In the case of vans, motorcycles and mopeds, no national estimate for average trip length was available. Therefore, the average European trip length of 12,4 km available in the road transport exhaust emission chapter of the Guidebook (chapter 3.4.1, p. 48) was applied for them. No specific national information on the fraction of gasoline powered vehicles equipped with carburettor and/or fuel return systems was available. Therefore, the default assumption from the Guidebook was used. According to the Guidebook, in Europe, the fraction of passenger cars and vans equipped with a carburettor is approximately 99 % for pre-Euro 1 vehicles (i.e. only 1 % equipped with fuel injection) and 0 % for post-Euro 1 vehicles. For motorcycles, the fraction is 100 % for conventional and Euro 1 vehicles, 20 % for Euro 2 and 0 % for Euro 3. In the absence of specific national data, the fraction of trips finished with hot engine also needed in the calculation, was assumed to be 100%.

Since the number of annual vehicle fleet is available for the calculation from 2007 onwards, the emissions for earlier years need to be estimated by other means. The trend in the emissions calculated with the Tier 2 approach of the Guidebook and the old approach used prior to 2019 submission is identical for the years 2007 to 2016. Therefore, the emissions for 1990 to 2006 are estimated by assuming the same emission trend prior to 2007 as in the old approach.

Methodology for the years from 2000 to 2016

The emission estimates produced with the COPERT model are significantly higher compared to previous calculation model described above. As with the road transport exhaustive emissions, it is not possible to calculate the emissions for the years prior to 2017 with COPERT. However, the emission trends for the category 1A3bv are consistent in both models for 2017 to 2023. Therefore, the overlap method presented in EMEP/EEA Guidebook 2023 (Chapter A.4 Time series consistency) has been used to calculate emissions for 2010 to 2016. The emissions associated with the new method for 2010 to 2016 are estimated by adjusting the previous estimate by the constant amount equal to the average difference in the years of overlap (2017-2023). Currently, the average lifetime of passenger cars is around 15 years in Finland. On this basis, the year 2010 was selected as the last year to apply the overlap method (15 years backwards from the latest inventory year 2024). The emission estimates for the years for 2000 to 2009 are based on linear interpolation.

Uncertainties

Uncertainties are presented in Annex 6.

QA/QC and verification

Normal statistical QA/QC procedures are carried out.

Source specific recalculations

2019

- The whole time series of NMVOC emissions from gasoline evaporation for 1990 to 2016 was recalculated due to implementation of a Tier 2 method of the EMEP/EEA Guidebook following the recommendation of the TERT in the 2017 NECD review.

2020

- NMVOC emissions in 2002, 2007-2017 were recalculated. All EURO 1 vehicles corrected to be equipped with fuel injection system in the calculation (previously only 1% was assumed to be equipped with fuel injection). Only a minor decreasing impact on emissions.

2026

- As a result of implementation of the COPERT model in the emission inventory, the NMVOC emissions were recalculated for 2000 to 2023.

Source specific planned improvements

For the 2027 submission, all the calculation parameters in the COPERT model will be carefully reviewed and the differences of the emission estimates between COPERT and the previous method will be further analysed. Based on this analysis, calculation parameters will be updated in COPERT where deemed necessary.

3.7 Tyre and brake wear

1A3bvi Road transport: Automobile tyre and brake wear

Changes in chapter	
March 2026	AL, TF

Source category description

The contribution of the category to total emissions is presented below.

Table 3.14. Contribution of NFR 1A3bvi in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
$PM_{2.5}$	0.599	Gg	4.7
PM_{10}	1.087	Gg	4.4
TSP	1.464	Gg	3.9
BC	0.154	Gg	5.1
Pb	0.456	Mg	4
Cd	0.002	Mg	0.2
As	0.04	Mg	2.4
Cr	1.269	Mg	9.9
Cu	28.572	Mg	67
Ni	0.182	Mg	1.9
Se	0.029	Mg	8.4
Zn	18.119	Mg	15.9

Emission trend

In the inventory, TSP, PM_{10}, $PM_{2.5}$ and BC emissions are included since the year 1980 and heavy metals since 1990.

Because in both tyre and brake wear particulate and BC emissions are determined as fixed factors by the kilometres driven, their trend is consistent with the trend of kilometres driven described above. The trend is upwards, with the exception of the recession of the 1990s and 2008 onwards.

Heavy metals are defined relative to TSP. Therefore, their trend also depends on the kilometres driven. An exception to this is Cu, Pb and Zn in brake wear, for which the method has time series for emission factors. This can also be seen in the figure and tables as decreasing emissions.

Particle and heavy metal emission trends are presented in Figure 3.8. and in Tables 3.15 (a-f) and kilometres driven in Tables 3.7. and 3.10.

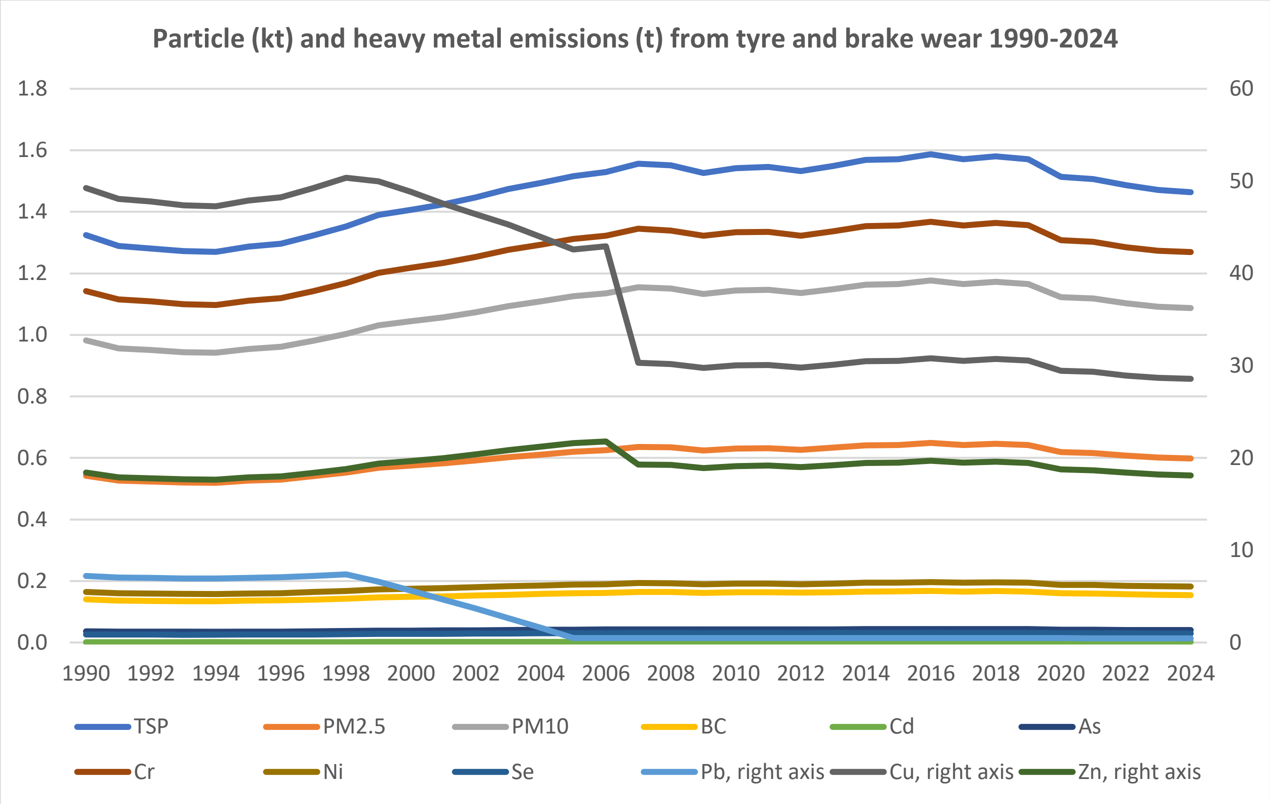


Figure 3.8. Particle and heavy metal emissions from tyre and brake wear 1990-2024.

Table 3.15 (a). Heavy metal emissions (kg) 1990–2024 from road transport tyre wear.

Year	Pb [kg]	Cd [kg]	As [kg]	Cr [kg]	Cu [kg]	Ni [kg]	Zn [kg]	Se [kg]
1990	7.8	0.84	3.2	1.3	6.8	2.6	8 586	16.6
1991	7.6	0.82	3.1	1.3	6.6	2.5	8 301	16.1
1992	7.6	0.82	3.0	1.3	6.6	2.5	8 242	16.0
1993	7.5	0.81	3.0	1.2	6.5	2.5	8 217	15.9
1994	7.5	0.81	3.0	1.2	6.5	2.5	8 205	15.9
1995	7.6	0.82	3.1	1.3	6.6	2.5	8 318	16.1
1996	7.7	0.82	3.1	1.3	6.6	2.5	8 381	16.2
1997	7.8	0.84	3.2	1.3	6.8	2.6	8 555	16.6
1998	8.0	0.86	3.2	1.3	6.9	2.6	8 732	16.9
1999	8.2	0.89	3.3	1.4	7.1	2.7	8 964	17.4
2000	8.3	0.90	3.3	1.4	7.2	2.7	9 044	17.6
2001	8.4	0.91	3.4	1.4	7.3	2.8	9 150	17.8
2002	8.5	0.92	3.4	1.4	7.4	2.8	9 305	18.1
2003	8.7	0.94	3.5	1.4	7.6	2.9	9 480	18.4
2004	8.8	0.95	3.6	1.5	7.7	2.9	9 621	18.7
2005	9.0	0.97	3.6	1.5	7.8	2.9	9 765	19.0
2006	9.0	0.97	3.6	1.5	7.8	3.0	9 857	19.2
2007	9.2	0.99	3.7	1.5	8.0	3.0	10 039	19.5
2008	9.2	0.99	3.7	1.5	8.0	3.0	10 031	19.4
2009	9.0	0.97	3.6	1.5	7.8	3.0	9 813	19.1
2010	9.1	0.98	3.7	1.5	7.9	3.0	9 946	19.3
2011	9.1	0.98	3.7	1.5	7.9	3.0	9 989	19.4
2012	9.1	0.98	3.7	1.5	7.9	3.0	9 914	19.2
2013	9.2	0.99	3.7	1.5	7.9	3.0	10 023	19.4
2014	9.3	1.00	3.7	1.5	8.0	3.0	10 139	19.7
2015	9.3	1.00	3.7	1.5	8.1	3.0	10 173	19.7
2016	9.4	1.01	3.8	1.5	8.1	3.1	10 294	19.9
2017	9.3	1.00	3.7	1.5	8.1	3.0	10 159	19.7
2018	9.3	1.01	3.8	1.5	8.1	3.1	10 223	19.8
2019	9.3	1.00	3.7	1.5	8.1	3.0	10 143	19.7
2020	8.9	0.96	3.6	1.5	7.8	2.9	9 769	19.0
2021	8.9	0.96	3.6	1.5	7.7	2.9	9 723	18.9
2022	8.8	0.95	3.5	1.5	7.6	2.9	9 594	18.6
2023	8.7	0.94	3.5	1.4	7.5	2.9	9 453	18.4

Year	Pb [kg]	Cd [kg]	As [kg]	Cr [kg]	Cu [kg]	Ni [kg]	Zn [kg]	Se [kg]
2024	8.6	0.93	3.5	1.4	7.5	2.8	9 400	18.3

Table 3.15 (b). Heavy metal emissions (kg) 1990–2024 from road transport brake wear.

Year	Pb [kg]	Cd [kg]	As [kg]	Cr [kg]	Cu [kg]	Ni [kg]	Zn [kg]	Se [kg]
1990	7 212	0.69	33.3	1 141	49 231	161	9 833	9.9
1991	7 040	0.67	32.5	1 114	48 055	158	9 598	9.6
1992	6 998	0.67	32.3	1 107	47 766	157	9 541	9.6
1993	6 939	0.66	32.1	1 098	47 366	155	9 461	9.5
1994	6 925	0.66	32.0	1 096	47 268	155	9 441	9.5
1995	7 014	0.67	32.4	1 110	47 878	157	9 563	9.6
1996	7 064	0.67	32.6	1 118	48 217	158	9 631	9.7
1997	7 211	0.69	33.3	1 141	49 224	161	9 832	9.9
1998	7 376	0.70	34.1	1 167	50 348	165	10 056	10.1
1999	6 567	0.72	35.1	1 201	49 965	170	10 415	10.4
2000	5 624	0.73	35.6	1 217	48 813	172	10 633	10.5
2001	4 647	0.74	36.0	1 233	47 554	174	10 839	10.7
2002	3 656	0.75	36.6	1 252	46 394	177	11 082	10.8
2003	2 639	0.77	37.2	1 275	45 294	180	11 358	11.0
2004	1 576	0.78	37.7	1 292	43 935	183	11 586	11.2
2005	485	0.79	38.3	1 311	42 588	185	11 833	11.3
2006	489	0.79	38.6	1 321	42 925	187	11 926	11.4
2007	474	0.81	39.2	1 344	30 285	190	9 244	11.6
2008	472	0.80	39.1	1 338	30 154	189	9 205	11.6
2009	466	0.79	38.6	1 320	29 762	187	9 085	11.4
2010	470	0.80	38.9	1 332	30 017	188	9 163	11.5
2011	470	0.80	38.9	1 333	30 050	189	9 173	11.5
2012	466	0.79	38.6	1 321	29 766	187	9 086	11.4
2013	471	0.80	39.0	1 335	30 091	189	9 185	11.6
2014	477	0.81	39.5	1 352	30 484	191	9 305	11.7
2015	478	0.81	39.5	1 354	30 519	192	9 316	11.7
2016	482	0.82	39.9	1 366	30 792	193	9 399	11.8
2017	477	0.81	39.5	1 354	30 512	192	9 314	11.7
2018	480	0.82	39.8	1 362	30 706	193	9 373	11.8
2019	478	0.82	39.6	1 355	30 550	192	9 325	11.7
2020	461	0.79	38.2	1 306	29 444	185	8 988	11.3
2021	459	0.78	38.0	1 301	29 319	184	8 949	11.3
2022	453	0.77	37.5	1 283	28 925	182	8 829	11.1
2023	449	0.77	37.2	1 272	28 676	180	8 753	11.0
2024	447	0.76	37.0	1 267	28 565	179	8 719	11.0

Table 3.15 (c). Tyre and brake wear particle emissions from Passenger cars 1980–2024.

Year	Tyre wear (t)				Brake wear (t)			
	TSP	PM_{10}	$PM_{2.5}$	BC	TSP	PM_{10}	$PM_{2.5}$	BC
1980	289	174	122	44	192	188	75	5.0
1985	355	213	149	54	235	230	92	6.1
1990	457	274	192	70	303	297	118	7.9
1995	444	267	187	68	294	289	115	7.7
2000	495	297	208	76	328	321	128	8.6
2001	502	301	211	77	332	326	130	8.7
2002	507	304	213	78	336	329	131	8.8
2003	516	309	217	79	342	335	133	8.9
2004	520	312	218	80	345	338	134	9.0
2005	527	316	221	81	349	342	136	9.1
2006	528	317	222	81	350	343	136	9.1
2007	534	321	224	82	354	347	138	9.2
2008	526	315	221	80	348	341	136	9.1
2009	528	317	222	81	349	342	136	9.1
2010	524	315	220	80	347	340	135	9.1
2011	520	312	219	80	345	338	134	9.0
2012	512	307	215	78	339	332	132	8.9
2013	518	311	217	79	343	336	134	8.9
2014	525	315	221	80	348	341	136	9.1
2015	519	312	218	79	344	337	134	9.0
2016	520	312	219	80	345	338	134	9.0
2017	518	311	218	79	343	337	134	9.0

Year	Tyre wear (t)				Brake wear (t)			
	TSP	PM_{10}	$PM_{2.5}$	BC	TSP	PM_{10}	$PM_{2.5}$	BC
2018	521	313	219	80	345	338	135	9.0
2019	521	313	219	80	345	338	135	9.0
2020	500	300	210	77	331	325	129	8.6
2021	496	298	208	76	329	322	128	8.6
2022	491	295	206	75	325	319	127	8.5
2023	494	296	207	76	327	321	128	8.5
2024	494	297	208	76	328	321	128	8.6

Table 3.15 (d). Tyre and brake wear particle emission from Light duty vehicles 1980–2024.

Year	Tyre wear (t)				Brake wear (t)			
	TSP	PM_{10}	$PM_{2.5}$	BC	TSP	PM_{10}	$PM_{2.5}$	BC
1980	41	25	17	6	27	26	10	0.7
1985	55	33	23	8	36	35	14	0.9
1990	73	44	30	11	48	47	19	1.2
1995	76	45	32	12	49	48	19	1.3
2000	86	52	36	13	56	55	22	1.5
2001	88	53	37	13	58	57	22	1.5
2002	90	54	38	14	59	58	23	1.5
2003	91	55	38	14	60	58	23	1.6
2004	93	56	39	14	61	59	24	1.6
2005	94	57	40	14	62	61	24	1.6
2006	97	58	41	15	63	62	25	1.6
2007	99	59	42	15	65	63	25	1.7
2008	100	60	42	15	65	64	25	1.7
2009	102	61	43	16	67	65	26	1.7
2010	104	62	44	16	68	67	26	1.8
2011	104	62	44	16	68	67	27	1.8
2012	104	62	44	16	68	67	26	1.8
2013	105	63	44	16	69	67	27	1.8
2014	107	64	45	16	70	69	27	1.8
2015	111	67	47	17	73	71	28	1.9
2016	111	67	47	17	73	71	28	1.9
2017	113	68	48	17	74	73	29	1.9
2018	115	69	48	18	75	74	29	2.0
2019	116	69	49	18	76	74	30	2.0
2020	114	69	48	18	75	73	29	2.0
2021	117	70	49	18	76	75	30	2.0
2022	113	68	48	17	74	73	29	2.0
2023	113	68	48	17	74	73	29	2.0
2024	113	68	47	17	74	72	29	2.0

Table 3.15 (e). Tyre and brake wear particle emission from Heavy duty vehicles 1980–2024.

Year	Tyre wear (t)				Brake wear (t)			
	TSP	PM_{10}	$PM_{2.5}$	BC	TSP	PM_{10}	$PM_{2.5}$	BC
1980	263	158	111	40	125	123	49	3.3
1985	272	163	114	42	130	127	51	3.4
1990	299	179	125	46	142	139	56	3.7
1995	284	171	119	43	135	133	53	3.5
2000	296	178	124	45	141	138	55	3.7
2001	298	179	125	46	142	139	55	3.7
2002	305	183	128	47	145	143	57	3.8
2003	312	187	131	48	149	146	58	3.9
2004	319	191	134	49	152	149	59	4.0
2005	324	194	136	50	154	151	60	4.0
2006	329	198	138	50	157	154	61	4.1
2007	337	202	142	52	161	157	63	4.2
2008	342	205	144	52	163	160	64	4.3
2009	321	193	135	49	153	150	60	4.0
2010	333	200	140	51	159	156	62	4.1
2011	339	204	142	52	162	158	63	4.2
2012	340	204	143	52	162	159	63	4.2
2013	343	206	144	53	164	160	64	4.3
2014	345	207	145	53	164	161	64	4.3
2015	350	210	147	53	167	163	65	4.3
2016	359	215	151	55	171	167	67	4.5
2017	347	208	146	53	165	162	65	4.3
2018	350	210	147	53	167	163	65	4.3
2019	342	205	144	52	163	160	64	4.3
2020	329	197	138	50	157	153	61	4.1
2021	326	196	137	50	155	152	61	4.1
2022	322	193	135	49	154	151	60	4.0
2023	308	185	130	47	147	144	57	3.8
2024	304	183	128	47	145	142	57	3.8

Table 3.15 (f). Tyre and brake wear particle emission from Mopeds and Motorcycles 1980–2024.

Year	Tyre wear (t)				Brake wear (t)			
	TSP	PM_{10}	$PM_{2.5}$	BC	TSP	PM_{10}	$PM_{2.5}$	BC
1980	2.1	1.3	0.9	0.33	1.0	1.0	0.4	0.027
1985	2.1	1.3	0.9	0.33	1.0	1.0	0.4	0.026
1990	2.1	1.2	0.9	0.32	1.0	1.0	0.4	0.026
1995	2.1	1.2	0.9	0.32	1.0	1.0	0.4	0.025
2000	2.6	1.5	1.1	0.39	1.2	1.2	0.5	0.032
2001	2.7	1.6	1.1	0.41	1.3	1.3	0.5	0.033
2002	2.8	1.7	1.2	0.44	1.4	1.3	0.5	0.035
2003	3.1	1.8	1.3	0.47	1.4	1.4	0.6	0.038
2004	3.3	2.0	1.4	0.50	1.6	1.5	0.6	0.041
2005	3.6	2.2	1.5	0.55	1.7	1.7	0.7	0.045
2006	3.9	2.3	1.6	0.60	1.9	1.8	0.7	0.048
2007	4.3	2.6	1.8	0.65	2.0	2.0	0.8	0.053
2008	4.4	2.7	1.9	0.68	2.1	2.1	0.8	0.055
2009	4.6	2.7	1.9	0.70	2.2	2.1	0.8	0.056
2010	4.8	2.9	2.0	0.74	2.3	2.2	0.9	0.060
2011	5.2	3.1	2.2	0.80	2.5	2.4	1.0	0.064
2012	5.4	3.2	2.3	0.82	2.6	2.5	1.0	0.067
2013	5.5	3.3	2.3	0.84	2.6	2.6	1.0	0.068
2014	5.5	3.3	2.3	0.85	2.6	2.6	1.0	0.069
2015	5.6	3.4	2.4	0.86	2.7	2.6	1.0	0.070
2016	5.6	3.4	2.4	0.86	2.7	2.6	1.0	0.070
2017	5.6	3.4	2.4	0.86	2.7	2.6	1.0	0.070
2018	5.5	3.3	2.3	0.84	2.6	2.6	1.0	0.068
2019	5.3	3.2	2.2	0.81	2.5	2.5	1.0	0.066
2020	5.2	3.1	2.2	0.79	2.5	2.4	1.0	0.064
2021	5.1	3.1	2.2	0.79	2.4	2.4	0.9	0.064
2022	5.0	3.0	2.1	0.77	2.4	2.3	0.9	0.062
2023	4.9	3.0	2.1	0.76	2.3	2.3	0.9	0.061
2024	4.3	2.6	1.8	0.66	2.0	2.0	0.8	0.053

Methodological issues

Particle emissions

<u>Tyre wear</u>

TSP emissions from tyre wear are estimated according to the Tier 2 method of Guidebook 2023 (Table 3-4). In the case of passenger cars, the EF 'ICE – Medium' is applied, and in the case of light-duty vehicles, the EF 'N1 – II, III' is applied. In order to calculate the emission factor for heavy-duty vehicles (equation 3 and 4 in the Guidebook), it is assumed that on average, heavy-duty vehicles in Finland have five axes and that the average load factor for heavy-duty vehicles is 0.5. These assumptions are based on expert judgements.

For determination of the speed correction factor (Equation 5 of Guidebook 2023), it is assumed that the average speed of the different vehicle types is as listed in Table 3.16.

Particle emission factors for tyre and brake wear are presented in Table 3.17 and activity data as driven kilometres in Tables 3.7. and 3.10.

Table 3.16. Average speed per vehicle type and corresponding speed correction factor, tyre wear.

Vehicle type	Average speed (km/h)	Speed correction factor
Two-wheelers	80	1.0
Passenger cars	60	1.2
Light-duty vehicles	60	1.2
Heavy-duty vehicles	50	1.3

PM_{10} and $PM_{2.5}$ emission factors are calculated according to Table 3-5 in Guidebook 2023, and BC emissions are calculated as 0.153 * TSP emissions, also according to the Guidebook.

Table 3.17. PM emission factors for tyre wear (mg/vkm).

	Passenger cars	Light duty vehicles	Heavy duty vehicles	Mopeds and Motorcycles
TSP	13	20	87	4.6
PM_{10}	7.7	12	52	2.8
$PM_{2.5}$	5.4	8.5	36	1.9

Brake wear

TSP emissions from passenger car brake wear are estimated using emission factors according to Table 3-6 of Guidebook 2019 (2021 update). For others, EFs from Table 3-6 of Guidebook 2023 are used (for LDVs, the EF 'N1 – I' is applied). In order to calculate the emissions from heavy-duty vehicles with equations 6 and 7 in the Guidebook a load factor of 0.5 is assumed.

For determination of the speed correction factor (Equation 8 in Guidebook 2023), it is assumed that the average speed of the different vehicle types is as listed in Table 3.18.

Particle and black carbon emission factors for tyre and brake wear are presented in Table 3.19 and activity data as driven kilometres in Tables 3.7. and 3.10.

Table 3.18. Average speed per vehicle type and corresponding speed correction factor, brake wear.

Vehicle type	Average speed (km/h)	Speed correction factor
Two-wheelers	80	0.59
Passenger cars	60	1.13
Light-duty vehicles	60	1.13
Heavy-duty vehicles	50	1.40

PM_{10} and $PM_{2.5}$ emission factors are calculated according to Tables 3-7 in the Guidebook 2023. Black carbon emissions are calculated as 0.0261 * TSP emissions, also according to the Guidebook values. The emission factors are presented in Table 3.19.

Table 3.19. Particle emission factors for brake wear (mg/vkm) Including speed correction factors.

Pollutant	Passenger cars	Light duty vehicles	Heavy duty vehicles	Mopeds and Motorcycles
TSP	8.5	13	41	2.2
PM_{10}	8.3	13	41	2.1
$PM_{2.5}$	3.3	5.2	16	0.9
Share of TSP				
Pollutant	Passenger cars	Light duty vehicles	Heavy duty vehicles	Mopeds and Motorcycles
BC	0.153	0.153	0.153	0.153

Tyre wear

Heavy metal emissions

Heavy metals (Cd, Cr, Cu, Ni, Pb, Zn, Se) are calculated as a fraction of TSP according to the metal content of tyres from a Swedish study from 2006 (Hjortenkrans et al. 2006). Several other studies on metal content from tyres are available, however the Hjortenkrans study is assumed to be most relevant for the Nordic conditions. In this study, the metal contents of tyres are measured for retreaded tyres and non-retreaded tyres. For the purposes of the emission inventory, retreaded tyres are assumed to be used for heavy-duty vehicles and buses and non-retreaded tyres are assumed to be used for all other vehicle types.

Emission estimates of arsenic are based on the metal fractions given in Guidebook 2023 since arsenic is not included in the Hjortenkrans study.

The EFs are presented in Table 3.19 and the activity data as driven kilometres in Tables 3.7. and 3.10.

Brake wear

Heavy metal emissions

Heavy metals (Cd, Cu, Pb and Zn) are calculated as a fraction of TSP emissions according to the metal content of brakes available from the Swedish study Hjortenkrans et al. 2006. Hjortenkrans distinguishes between front and rear brakes as well as branded brakes and brakes from independent suppliers. In order to make an average emission factor it is assumed that 58 % of brake lining wear comes from rear brakes and 42% from front brakes, which is in line with the assumptions made in Westerlund (2001)[2]. In addition, it is assumed that 40 % of vehicle kilometers (vkm) are travelled by new cars (assumed to be newer than four years) that use branded brake lining and 60% by older cars using brake lining from independent brands, based on by the same study (Westerlund 2001)[3]

Where metal fractions are missing in Hjortenkrans 2006, values from Guidebook 2023 are used. This is the case for arsenic, chromium, nickel and selenium.

Corresponding information on the content of lead, copper and zinc in brakes from a 1998 study (Westerlund 1998) is provided in Hjortenkrans 2006. These values are applied in the inventory from 1990 to 1998 in the same way as the Hjortenkrans values in Table 6. For the years 1999-2004, the metal contents are interpolated, and from 2005 onwards, the values from Hjortenkrans 2006 are applied (Table 3.20).

Table 3.20. Cu, Pb and Zn as fractions of TSP for the time series 1990 onwards.

Year	Cu	Pb	Zn
1990-1998	99686	14604	19911
1999	96173	12640	20047
2000	92661	10676	20184
2001	89148	8712	20320

[2] Assumptions in Westerlund (2001) are based on personal communication with Roland Hedlund, BBA Friction Sweden AB, in 1998.

[3] Assumptions in Westerlund (2001) are based on personal communication with Lars Burman, Slb Analys, The Stockholm Environment and Health Protection Administration, in 1998.

Year	Cu	Pb	Zn
2002	85635	6748	20456
2003	82123	4784	20593
2004	78610	2820	20729
2005	75097	856	20865
2006	75097	856	20865
2007-	52089	815	15900

Uncertainties

Uncertainties are presented in Annex 6.

QA/QC and verification

Normal statistical QA/QC procedures have been carried out.

Source specific recalculations

2004
- Heavy metal emissions from road transport tyre and brake wear have been included in the inventory since the submission in 2004.

2009
- To the submission in 2009 the calculation method for particles was changed as a result from the Nordic co-operation in developing methodologies that better correspond to the regional circumstances. The method is based on Hjortenkrans 2006 and 2008 publications and information in the Swedish IIR.

2014
- Black carbon emissions were included in the inventory for first time in the 2014 submission.

2018
- Mercury emissions were corrected for the whole time series due to the incorrect unit used in the earlier calculations.
- The shares of old/new cars were updated for the whole time series for Cu, Pb and Zn emissions.

2019
- The calculation methods changed to follow the Guidebook 2016 methodology
- Emission factors from Guidebook 2016 have been adopted to the LIPASTO calculation sub-models

2020
- Particles and heavy metals 1980-2017 were recalculated with an increase of max 16% to emissions. Speed effect added to the brake wear formula (error in NAEGG co-operation report), recalculation done for the whole timeseries of heavy metals and particles.
- Tyre wear added to the selenium calculation, recalculation done for the whole timeseries.

2025
- Certain vehicle categories (e.g. electric vans) that did not have any kilometrage earlier but have gradually increased their share (total of 0,4% in 2018) were incorrectly ignored in previous calculations. This is now corrected, and wear emissions were recalculated for years 2018–2022.

Source specific planned improvements

- For 2027 submission, tyre and break wear emission estimates produced by Copert will be investigated. Based on the results and comparisons with the current estimates, it will be decided if Copert will be implemented to the inventory to produce the tyre and break wear emissions.
- Inclusion of calculation of PAH-4 emissions, when information is available.

3.8 Road abrasion

1 A 3 b vii	**Road transport: Automobile road abrasion**

Changes in chapter	
March 2026	AL, TF

Source category description

The contribution of the category to total emissions is presented below in Table 3.21.

Table 3.21 Contribution of NFR 1A3bvii in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
$PM_{2.5}$	0.454	Gg	3.6
PM_{10}	5.356	Gg	21.6
TSP	10.712	Gg	28.7
BC	0.089	Gg	2.9

Emission trend

The emissions are slightly increasing due to increased kilometrage of vehicles as seen in Figure 3.9. The road abrasion trend follows the vehicle kilometrage trend (Tables 3.7. and 3.10).

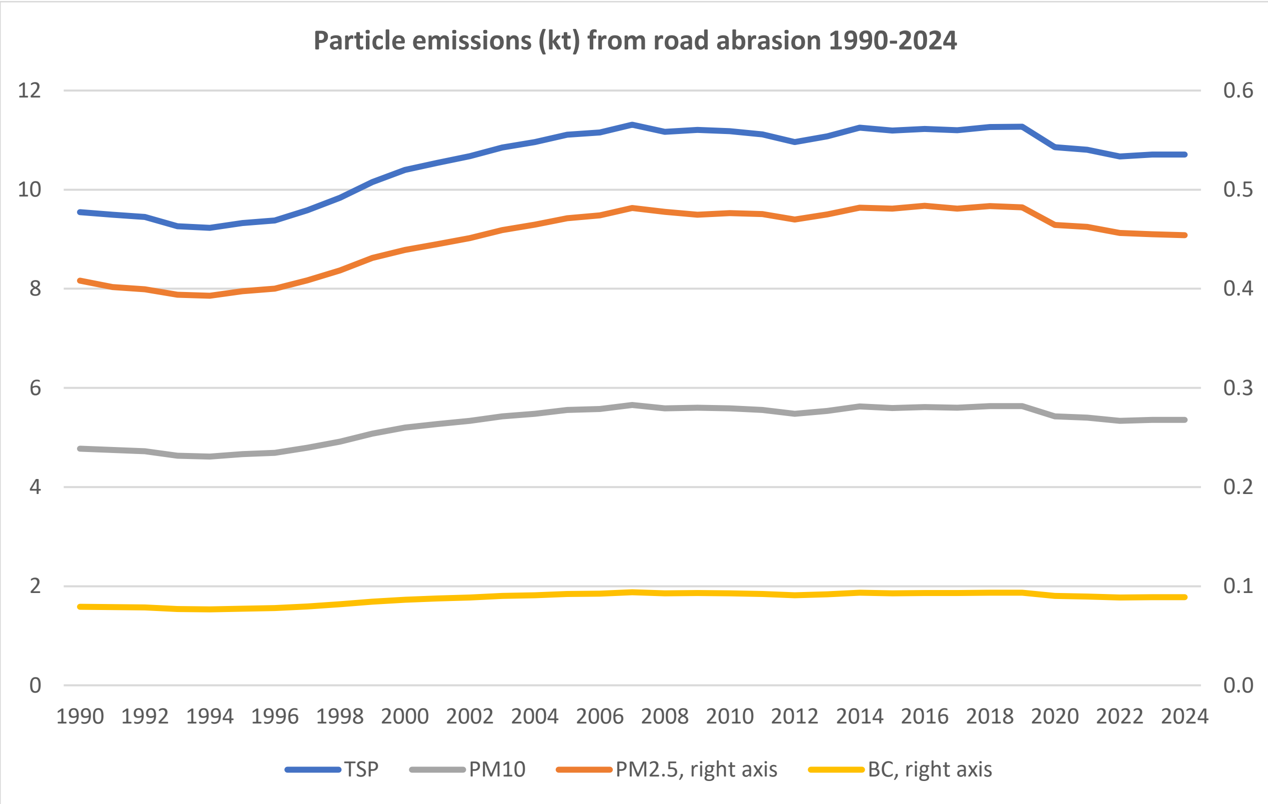


Figure 3.9. Emissions from road abrasion 1980-2024.

Methodological issues

Particle emissions

Particle emissions are estimated with the Tier 2 methodology presented in the 2023 EMEP/EEA Guidebook. The effect of studded tyres is taken into account based on Swedish data that has been adopted to the Finnish conditions.

Activity data

Activity data as driven kilometres are according to the LIISA sub-model and is presented in Tables 3.7. and 3.10.

Emission factors (Table 3.22)

Non-studded tyres
- TSP emission factors for road abrasion presented in Table 3.22 are from the Guidebook 2023. In the case of passenger cars, the EF 'ICE – Medium' is applied, and in the case of light-duty vehicles, the EF 'N1 – II, III' is applied. Table 3-8 and the fraction factors for PM_{10} and $PM_{2.5}$ from TSP are calculated according to the Guidebook 2023 Table 3-9.

Studded tyres
- Emission factors for studded tyres based on Swedish IIR 2008. The emission factors are adopted for Finnish conditions and are thus slightly higher than for Sweden, due to a longer period for use of studded tyres. The following assumptions have been made for the calculation of particle emissions from the use of studded tyres:
  - studded tyres are used only in passenger cars and light duty vehicles
  - studded tyres are used during 4.5 months per year in Finland
  - 80% of the passenger cars and light duty vehicles use studded tyres

$$\frac{4.5}{12} x 0.80 = 0.30 \Rightarrow 30\%$$

Applying the method presented in the Swedish IIR 30% of vehicle kilometres of passenger cars and light duty vehicles are driven with studded tyres, and 70% with non-studded tyres. For the studded tyres a correction factor of 50 x PM_{10} is used.

The same particle size fraction factors are used for both studded and non-studded tyres.

Black carbon

Black carbon emissions are calculated using the emission factor 0.83% of TSP emissions (Aasestad, 2013).

Table 3.22. Emission factors used for particle emissions from road abrasion.

Road abrasion EFs Vehicle category	Non studded tyres EF (g/km) GB 2023			Studded tyres EF (g/km) Swedish IIR 2008		
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Passenger cars	0.015	0.0075	0.0041	0.75	0.375	0.01875
Light duty vehicles	0.021	0.0105	0.0057	0.75	0.375	0.01875
Heavy duty vehicles	0.076	0.038	0.021	-	-	-
Mopeds & Motorcycles	0.006	0.003	0.0016	-	-	-

Particle emissions from road abrasion are presented in Table 3.23.

Table 3.23 Particle and black carbon emissions from road abrasion.

Year	Road abrasion emissions (kt)			
	TSP	PM10	PM2.5	BC
1980	6.0	3.0	0.27	0.050
1985	7.4	3.7	0.33	0.062
1990	9.5	4.8	0.41	0.079

Year	Road abrasion emissions (kt)			
	TSP	PM10	PM2.5	BC
1995	9.3	4.7	0.40	0.077
2000	10.4	5.2	0.44	0.086
2001	10.5	5.3	0.45	0.088
2002	10.7	5.3	0.45	0.089
2003	10.9	5.4	0.46	0.090
2004	11.0	5.5	0.46	0.091
2005	11.1	5.6	0.47	0.092
2006	11.2	5.6	0.47	0.093
2007	11.3	5.7	0.48	0.094
2008	11.2	5.6	0.48	0.093
2009	11.2	5.6	0.47	0.093
2010	11.2	5.6	0.48	0.093
2011	11.1	5.6	0.48	0.092
2012	11.0	5.5	0.47	0.091
2013	11.1	5.5	0.48	0.092
2014	11.3	5.6	0.48	0.093
2015	11.2	5.6	0.48	0.093
2016	11.2	5.6	0.48	0.093
2017	11.2	5.6	0.48	0.093
2018	11.3	5.6	0.48	0.094
2019	11.3	5.6	0.48	0.094
2020	10.9	5.4	0.46	0.090
2021	10.8	5.4	0.46	0.090
2022	10.7	5.3	0.46	0.089
2023	10.7	5.4	0.45	0.089
2024	10.7	5.4	0.45	0.089

Uncertainties

Uncertainties are presented in Annex 6.

QA/QC and verification

Normal statistical QA/QC procedures have been carried out.

Source specific recalculations

2009
- The calculation method was changed as a result of Nordic co-operation.

2018
- The particle emission factors for road abrasion were revised based on the recommendation from the 2017 NECD Technical Review. Earlier all emission factors were from Swedens' IIR, in the 2018 submission Guidebook 2016 emission factors were adopted.

2019
- The kilometrage was checked according to the LIPASTO calculation model and the activity data for 1992 changed slightly while the other years were not impacted.

2020
- Particles in 1980-2017 were recalculated leading to slight decrease of emissions, but strong decrease of PM2.5 emissions in 1980-1989. The reason was correction of kilometrage data in the calculation sheets.

2025
- Guidebook 2023 presented more detailed EFs for road surface wear than previous Guidebooks. The EF for vans was changed to EF for LCV classes N1 – II,III (0.021 g/km) because according to Finnish open vehicle fleet data, ~80% of registered vans in Finland belong to class N1 – III.

Source specific planned improvements

- For 2027 submission, road abrasion emission estimates produced by Copert will be investigated. Based on the results and comparisons with the current estimates, it will be decided if Copert will be implemented to the inventory to produce the road abrasion emissions.

3.9 Railways

1 A 3 c Railways

Changes in chapter	
March 2026	AL, TF

Source category description

In Finland railway transportation is a minor emission source in the transport sector and comprises railway transport operated by diesel locomotives. The railway lines are mainly electrified.

In 2024 electric locomotives ran 91% of railway transportation. The total number of train-kilometres was 48.6 million train-kilometres in 2024. The train-kilometres increased by 3% compared to the previous year (Finnish Railway Statistics 2025). Emissions from producing electricity used in electric trains are not included this category, but in category 1.A.1. In 2024 the volume of freight transport in Finland totalled 26.6 million tonnes. The volume of freight transported fell by 2 per cent from 2023 (Finnish Railway Statistics 2025).

The contribution of the category to total emissions is presented in Table 3.24.

Table 3.24. Contribution of NFR 1A3c in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	0.900	Gg	1.0
NMVOC	0.053	Gg	<0.1
SOx (as SO_2)	<0.001	Gg	<0.1
NH_3	<0.001	Gg	<0.1
$PM_{2.5}$	0.018	Gg	0.1
PM_{10}	0.019	Gg	<0.1
TSP	0.020	Gg	<0.1
BC	0.012	Gg	0.4
CO	0.144	Gg	<0.1
Cd	<0.001	Mg	<0.1
Cr	<0.001	Mg	<0.1
Cu	0.026	Mg	<0.1
Ni	0.001	Mg	<0.1
Se	<0.001	Mg	<0.1
Zn	0.015	Mg	<0.1
PAH-4	0.001	Mg	<0.1

Emission trend

Most railway lines are nowadays electrified and transportation in minor railway lines operated by diesel locomotives has ceased. The recession and the rapid restructuring in Finland’s forest industry significantly reduced freight carryings in 2008 and 2009. The recession still continued in 2014 and in 2015 there was a significant reduction in the transport volume compared to 2014 and since then the trend has levelled off (Figure 3.10). In 2022, transport activity dropped significantly, especially in diesel-powered freight (-15%) due to economic sanctions against Russia. This trend persisted in 2023. Between 2023 and 2024, the freight transport increased by 5%, while passenger transport increased by 3%.

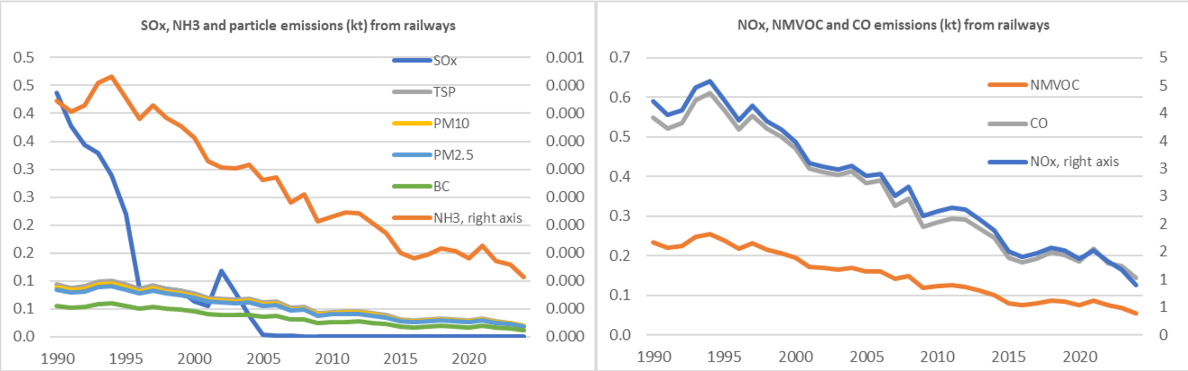


Figure 3.10. Emissions from railroad transportation 1980-2024.

Methodological issues

Railway transport emissions for 1980 – 2019 were calculated with the RAILI model developed by VTT Technical Research Centre of Finland Ltd. 2020-2024 emissions are calculated with railway model maintained by Statistics Finland. In these models, almost all calculation methods, activity data and emission factors are the same and time series can be considered to be consistent.

The emission factors comply with the EMEP/EEA 2023 Guidebook and the calculation is carried out on Tier 3 level.

Gross tonne kilometres for each train and locomotive type and rail section (in total 602 sections) are used as activity data. Activity data is needed in determining the regional emissions and in the detailed calculation of consumption of trains by weight category. Fuel consumption of a train is calculated by multiplying activity data with the specific fuel consumption of the locomotive. In Finland there are three railway operators. The calculated fuel consumption figures are calibrated to be consistent with the total reported consumption by the operators. This ensures that the consumption results are consistent with reality. Calibration is particularly important as the specific consumption figures for new locomotive types can only be obtained from the technical specifications given by the manufacturers.

The amount of fuel used is calculated separately for passenger transport, freight transport and locomotives without wagons, and for rail yard operations. To include the mobilisation time of the fleet, preparation and finishing times, extra transfer, wagon heating and use of aggregates for electricity production the amount of fuel is multiplied by factors defined by the main operator in Finland. In Finland, all diesel locomotives use gasoil for non-road use, which is technically the same product as sulphur free diesel oil.

The models calculate SO_2, CO, NMVOC, CH_4, NO_2 and PM emissions by multiplying the amount of fuel used (kg) with emission factors (g/kg fuel).

Activity data

The activity data in the railway models consisting of gross tonne kilometres of all operators is collected by the Finnish Transport Infrastructure Agency (the national authority) and stored in their database. In detail, the gross tonne kilometre data used in the models is segregated by train type, locomotive type, train weight (10 weight categories) and gross tonne kilometres hauled by rail section (in total 602 rail sections). Also, information on locomotives driving without wagons is included. Shunting locomotive use is expressed as time (h/a) in all rail yards. In addition, railway operators' reports on their fuel consumption are essential for the calibration (described above).

Table 3.25 Gas oil consumption in railway transportation in 1980 - 2024.

Gas oil consumption		Gas oil consumption	
Year	**[kt]**	**Year**	**[kt]**
1980	88.62	**2013**	29.11
1985	60.75	**2014**	26.55
1990	60.40	**2015**	21.51

Gas oil consumption		Gas oil consumption	
Year	**[kt]**	**Year**	**[kt]**
1995	61.12	**2016**	20.08
2000	50.82	**2017**	21.04
2005	40.15	**2018**	22.57
2006	40.85	**2019**	21.99
2007	34.41	**2020**	20.14
2008	36.51	**2021**	23.22
2009	29.40	**2022**	19.38
2010	30.67	**2023**	18.40
2011	31.78	**2024**	15.15
2012	31.54		

Emission factors

The emission factors are based on national measurements for CO, HC, NOx and TSP. The rest of emission factors are based on EMEP/EEA Guidebook 2023.

PM_{10} and $PM_{2,5}$ size fractions, black carbon, ammonia and heavy metal (Cd, Cr, Cu, Ni, Se and Zn) emissions are calculated with the Tier 1 emission factors of the EMEP/EEA Guidebook 2023. PAH-4 emissions are the sum of emissions of benzo(a)pyrene and benzo(b)fluoranthene, for which Tier 1 emission factors are given in EMEP/EEA Guidebook 2023.

The formula below has been used in calculation of emissions from diesel trains in RAILI model:

$$E^c = \sum_{x=1}^{2}\left(\left(\sum_{l=1}^{4}\sum_{w=1}^{10} d_{x,l,w} f^d_{x,l,w}\right) g_x e_x^{c,f} + d_x\left(f_x^h e^{c,h} + f_x^a e^{c,a}\right) + \left(\sum_{r=1}^{N}\sum_{l=1}^{4} t_{x,l,r} f^t_{x,l}\right) e_x^{c,f} + \left(\sum_{l=1}^{4} k_l f_l^k\right) e_x^{c,f}\right)$$

where

E^c	total emissions of compound c
c	compound
x	train type: person/freight train
l	type of locomotive (4 types)
w	train weight class (10 classes)
d	gross tonne kilometre
g	a factor for extra fuel consumption of non-line driving *
r	rail yard
N	number of rail yards
t	shunting time
k	locomotive kilometre
f^d	specific fuel consumption per gross tonne kilometre
f^t	specific fuel consumption per hour
f^h	specific fuel consumption of heating per gross tonne kilometre
f^a	specific fuel consumption of aggregate per gross tonne kilometre
f^k	pecific fuel consumption per locomotive kilometre
$e^{c,f}$	emission factor of compound c per fuel used
$e^{c,h}$	emission factor of compound c per fuel used for wagon heating
$e^{c,a}$	emission factor of compound c per fuel used for aggregates
*	mobilisation time of the fleet, preparation and finishing times and extra transfer of the fleet

Uncertainties

Uncertainties are presented in Annex 6.

QA/QC and verification

The calculated fuel consumption results are calibrated to be consistent with the operators' yearly consumption reports. This ensures that the consumption calculations are consistent with the reality.

Source specific recalculations

2021

- All emissions for 2018 were recalculated due to update of fuel consumption data.

2022

- For the years 1990-2016, emissions from railway transportation have been calculated using the RAILI model developed by VTT and based on the activity data of VR-Group Ltd (the only operator in Finland at that time). Since 2018 VR-Group Ltd no longer has reported their activity data in the format used in the RAILI model. Due to this change in data, for the years 2018 and 2019, the calculations were made using a temporal simple method based on VR-Group Ltd's fuel consumption reports and the average emission factors from the RAILI model. In addition, two new railway operators started operations, Fenniarail in 2017 and Operail in 2020, both using a new type of locomotive fleet. All these changes in data led to the renewal of the RAILI model for the 2022 submission.
- The renewal of the model mainly concerned pre-processing of the activity data, specifically gross tonne-kilometres, as basically the same activity data as used in the old RAILI model are also available in the new database maintained by the authority (the Finnish Transport Infrastructure Agency). The renewal process included, e.g. a precise selection and definition of the information to be included in the database. Calibration of the calculated fuel consumption results to be consistent with operators' yearly consumption reports is a new feature in the model.
- A comparison between the results of the old and renewed RAILI model for the year 2017 showed that the renewed model produced results that were very close to the results of the old model, and thus the calculations with the old and renewed model could be considered to produce consistent timeseries. Recalculations were made for the years 2017–2019 (+ 3 kt CO2-eq. in 2019). The renewed RAILI model is used also for the calculation of emissions in 2020.

2026

- As the emission calculation system operated at Statistics Finland was implemented to the inventory, small adjustments were made to the activity data for the years 2020-2023. In addition, the sulphur content of gasoil was also slightly adjusted for these years. As a result, all emissions were recalculated for 2020-2023.

Source specific planned improvements

None.

3.10 Navigation

1 A 3 d ii National navigation (Shipping)

Changes in chapter	
March 2026	AL, TF

Source category description

Domestic navigation includes sea-going ships, icebreakers, working boats, cruisers, ferryboats and leisure boats. Fishing boat emissions are included in the Agriculture, forestry and fisheries' sectors. Details on the inventory are presented in Chapter 3.11.

Domestic navigation is a minor emission source and the trends of all emissions are declining due to the decreased activity.

The contribution of the category to total emissions is presented in Table 3.26.

Table 3.26. Contribution of NFR 1A3dii in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	4.119	Gg	4.5
NMVOC	2.313	Gg	3.1
SOx (as SO_2)	0.052	Gg	0.3
NH_3	<0.001	Gg	<0.1
$PM_{2.5}$	0.223	Gg	1.8
PM_{10}	0.230	Gg	0.9
TSP	0.230	Gg	0.6
BC	0.041	Gg	1.3
CO	19.959	Gg	6.8
Pb	0.007	Mg	<0.1
Cd	<0.001	Mg	<0.1
Hg	0.002	Mg	0.4
As	0.005	Mg	0.3
Cr	0.006	Mg	<0.1
Cu	0.048	Mg	0.1
Ni	0.189	Mg	1.9
Se	0.006	Mg	1.6
Zn	0.063	Mg	<0.1
PCDD/ PCDF	0.008	g I-Teq	<0.1
HCB	0.002	kg	<0.1
PCBs	0.004	kg	<0.1

Emission trend

Emission trends from navigation are included in the inventory and presented in Figure 3.11.

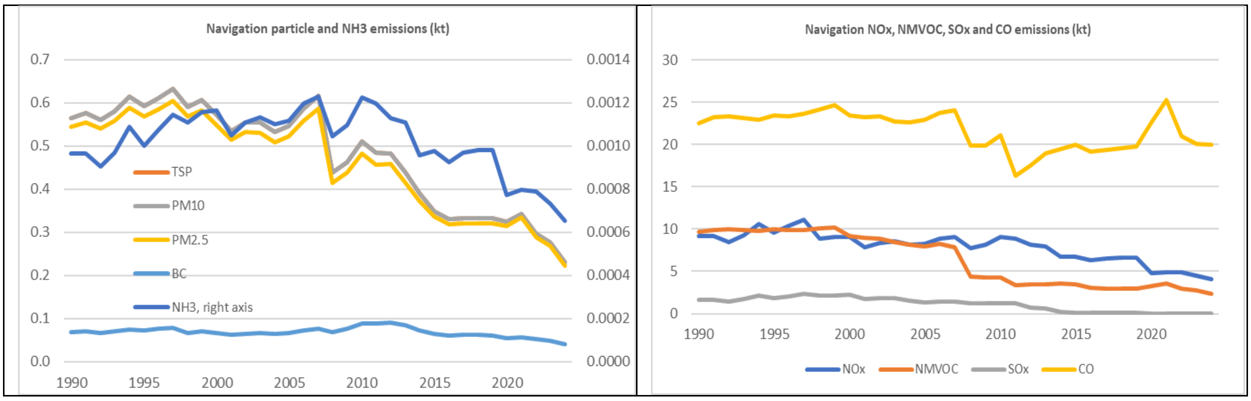


Figure 3.11. Emissions in 1980-2024 from National navigation.

The amount of leisure boats increased strongly throughout the 1980s, as well as visits of ships in ports. The increase was folded by the recession in the beginning of the 1990s. The number of visits in ports has been fluctuating during the whole time series. In 2008, two contemporaneous changes concerning leisure boating took place: there was a significant increase in fuel price and a change in legislation stating that all diesel driven boats had to use higher taxed diesel fuel, which together led up to a clearly lower use of leisure boats. Particulate emissions, as well as sulphur dioxide emissions, decreased significantly after the entry into force of the sulphur limits for marine fuels (0.1%, SECA) in 2015.

The significant reduction in most emissions of waterway traffic for the year 2020 is due to COVID-19. CO and NMVOC emissions traffic are increased because leisure boat traffic dominates the emission shares for these emissions and leisure boating did not suffer from COVID restrictions in Finland and increased during the pandemic. In 2021, the leisure boating increased further, while cargo vessel traffic decreased. In 2022, the registration numbers of leisure boats began to stabilize towards the pre-pandemic levels and decreased further in 2023.

Ferryboats are used to transport road vehicles across narrow water straits on the public road network and small ferries are used for transport connections between islands in the Finnish Archipelago. Emission from ferry boats show a stable increasing trend for the whole time series, while for cargo vessels the upward trend since 1990 changed to a downward trend in 2012 due to the prolonged economic downturn.

Passenger ships show a stable trend, while cargo vessels have a downward trend due to the prolonged economic downturn.

Depending on the ice conditions at the Baltic Sea, the fuel consumption of icebreakers can vary substantially as can be seen in Table 3.27.

Methodological issues

Waterborne traffic methods depend on the vessel category and emissions are calculated with the MEERI sub-model of the LIPASTO calculation system for 1980–2023. Most of the 2024 emissions (fishing boats, leisure boats, ferryboats and icebreakers) are calculated with new navigation model maintained by Statistics Finland. Emissions from cargo vessels, cruisers, passenger ships and working boats are estimated based on 2023 data or estimates based on other statistics.

In the MEERI model, the activity data of ships driving in shipping channels outside ports (km/a) are calculated using the number of port visits and the distances between the ports (km). The total energy use (kWh) is calculated for every ship type using the data on engine power (kW), engine load (%) and speed (km/h). There are nine different ship types in the model. Ships are further divided into different engine types (two-stroke and four-stroke). These are further divided into different emission levels, at the moment from Tier 0 to Tier 2. Ships have seven size categories. Emissions are calculated based on the fuels ships are using: Heavy fuel oil (HFO), HFO + scrubber, Marine diesel oil / Marine gas oil (MDO/MGO), Diesel and LNG.

For calculating emissions in ports, the time (h) of manoeuvring and berthing is determined. Using engine power (kW), engine load (%) and time (h) taken for manoeuvring and berthing, the total energy use in ports (kWh) is calculated for every ship type. Total emissions are obtained by multiplying the total energy use (kWh) of ships by the emission factors (g/kWh) of different engine types (2-stroke and 4-stroke and auxiliary engines) (g/kWh).

The detailed and accurate database from the Finnish Transport Infrastructure Agency is analysed to produce power and speed classes for the ships. The Boat Register is the best available source for boats. In addition, origin-destination matrices are produced using the data.

The formula below has been used in calculation of emissions from all ships in the except icebreakers:

$$E^c = \sum_{x=1}^{2}\sum_{l=1}^{9}\sum_{w=1}^{7}\Bigg(\frac{\sum_{i=1}^{N_{l,w}} d_{l,w,i}}{v_{l,w}^a} g_{l,x}^d p_{l,w,x}^a \sum_{y=1}^{10}\sum_{f=1}^{5}\left(r_{x,y} s_{x,f} e_{x,l,w,y,f}^{c,d}\right) + N_{l,w}\Bigg(t_{l,w}^m g_{l,x}^m p_{l,w,x}^a \sum_{y=1}^{10}\sum_{f=1}^{5}\left(r_{x,y} s_{x,f} e_{x,l,w,y,f}^{c,m}\right) + t_{l,w}^b g_{l,x}^b p_{l,w,x}^a \sum_{y=1}^{10}\sum_{f=1}^{5}\left(r_{x,y} s_{x,f} e_{x,l,w,y,f}^{c,b}\right)\Bigg)\Bigg)$$

where

E^c	total emissions of compound c
c	compound
x	engine function type (2 types): main engine / auxiliary engine
l	type of ship (9 types)
w	gross register ton (GRT) class (7 classes)
N	number of trips / port visits
d	distance of an individual trip
v^a	average design speed
p^a	average nominal engine power
g^d	engine load factor during driving
g^m	engine load factor during manoeuvre
g^b	engine load factor during berthing
y	engine type by two/four-stroke engine and emission standard level (Tier) (10 combined types)
r	share of engines by engine type
f	fuel type of engine (5 types)
s	share of engines by fuel type
t^m	time used for manoeuvre
t^b	time used for berthing
$e^{c,d}$	emission factor of compound c for driving
$e^{c,m}$	emission factor of compound c for manoeuvre
$e^{c,b}$	emission factor of compound c for berthing

Data on total fuel consumption of ferryboats and small ferries are acquired from road authorities.

Icebreakers and ferries

Icebreaker and ferryboat emissions are calculated using total fuel consumption (from operator statistics, icebreaker consumption from Arctia Shipping Oy and ferryboat consumption from FinFerries Oy) and corresponding emission factors.

The formula below has been used in calculation of emissions from icebreakers:

$$E^c = \sum_{f=1}^{N^f} S_f e_f^c$$

where

E^c	total emissions of compound c
c	compound
f	fuel type
N^f	number of fuel types
S	total fuel use by fuel type
e^c	emission factor for compound c

Data on total fuel consumption of icebreakers are obtained from Arctia Shipping Ltd.

Leisure boats

Leisure boat emission estimations are based on the use of energy (kWh) and corresponding emission factors (g/kWh). Energy use is calculated by boat category (six), engine type (four), average engine power class (10) (kW), engine load (%) and average operation time per year (h/a). Total emissions are calculated by multiplying total energy use (kWh) of engine types with corresponding emission factors (g/kWh).

Formula for leisure boats:

$$E^c = \sum_{l=1}^{6} \sum_{y=1}^{3} \sum_{r=1}^{10} N_{l,y,r} p_r \, g_{l,y,r} t_l e_y^c$$

Where

E^c	total emissions of compound c
c	compound
l	type of leisure boat (6 types)
y	engine type & fuel: gasoline two/four-stroke engine and diesel engine (3 combined types)
r	engine power class (10 classes)
N	number of boats
p	nominal engine power (class centre)
g	engine load factor
t	activity (hours in use per year)
e^c	emission factor for compound c

The number of bigger leisure boats is received from the Boat Register, the number of smaller boats is an estimation based on a thorough study made by VTT in 2004 and further estimated yearly based on the number of boats in the register. The Boat Register data include information on the type of engine(s), engine power and age.

Working boats and cruisers

Total emissions of working boats and cruisers (sightseeing) are calculated by multiplying the total fuel use (kg/a) of boats by emission factors (g/kg fuel). Fuel consumption of these boats is calculated using the number of boats in different boat categories, engine power classes (kW) and average fuel consumption of a corresponding boat per year (kg/boat/a).

The formula below has been used in calculation of emissions from working boats:

$$E^c = \sum_{l=1}^{3} N_l s_l e^c$$

where

E^c	total emissions of compound c
c	compound
l	type of working boat (3 types)
N	number of working boats
s	average fuel use of a working boat per year
e^c	emission factor for compound c

The number of working boats is obtained from different official organisations (e.g. customs, sea rescue). The number of cruisers (sightseeing boats, etc.) comes from the Finnish Transport Infrastructure Agency.

2024 emissions from cargo vessels, working boats, cruisers and passenger ships are estimated based on 2023 data or estimates based on other statistics. The new navigation model is under development (see category-specific planned improvements).

Emission factors

MEERI model and the navigation model maintained by Statistics Finland use emission factors from the EMEP/EEA Emission Inventory Guidebook versions 2016 and 2023. CO, HC, NOx, and PM emissions are calculated based on energy use (kWh), which is described in chapters two and three of methodological issues. Due to the complexity of recalculating historical years for these emissions in MEERI, and with the introduction of a new model for national navigation in 2025, the inventory years 2023 and 2024 were calculated using Guidebook 2016 EFs. Other (non-GHG) air pollutants are calculated based on fuel consumption and Guidebook 2023 EFs are used.

STEAM model

The Finnish Meteorological Institute has a world leading ship emission model STEAM, where the ship emission calculations are based on data from AIS (Automatic Identification System) on the entire Baltic Sea. The detailed results of this model have been used to estimate characteristics of ships, auxiliary engines, speeds and fuel types.

Ferry traffic between Finland and Sweden

Ferry traffic between Finland and Sweden is frequent. Since 1999, all ferries have been put in at the ports of Åland (which is an archipelago between Sweden and Finland belonging to Finland) but only a very small portion of passengers on these ferries are actually travelling between the mainland and Åland (e.g. 0.2% of all passengers using the Helsinki to Sweden lines travel between Helsinki and Åland in 2015).

The method used to separate domestic ferry traffic from international traffic to Sweden is to define domestic ship kilometres according to the share of passengers travelling to the archipelago of Åland.

Channels outside ports

The activity data of ships driving in shipping channels outside ports (km/a) are calculated using the number of port visits and the distances between the ports (km). The total energy use (kWh) is calculated for every ship type using the data on engine power (kW), engine load (%) and speed (km/h). In the model there are 9 different ship types. Ships are further divided into different engine types (2-stroke and 4-stroke). These are further divided into different emission levels, at the moment from Tier 0 to Tier 2. Ships have 7 size categories. Emissions are calculated according to the fuels ships are using: Heavy fuel oil (HFO), HFO + scrubber, Marine diesel oil / Marine gas oil (MDO/MGO), Diesel and Gas (LNG).

Port visits

For the MEERI model, a detailed database on every ship visit in Finnish ports is obtained from the Finnish Transport Infrastructure Agency. The database includes data on ship type, age, size (GT = gross tonnage), engine power, speed, engine load, port, previous port, destination, nationality, and trip type (domestic/international).

Fuel consumption

Amount of fuels (TJ) per ship type (Table 3.27) have been partly used as activity data to calculate emissions of domestic navigation. In 2024 bio-shares of gasoline and diesel oil were 9.0% and 16.0% respectively (calculated from TJ). The bio-share of gasoil was 4.9% in 2024.

Liquefied natural gas (LNG) data (consumption, import and export) for the energy balance are collected by Statistics Finland directly from the terminals, from the information on related fuel taxes and from point sources in energy and manufacturing industries. This, the best available data, is also used for LNG consumption in domestic and international navigation as activity data.

Table 3.27. Amount of fuels in domestic navigation by vessel type 1990-2024 (PJ).

	Leisure boats	Icebreakers	Ferryboats	Passenger ships (domestic)	Cargo ships (domestic)	Cruisers (sightseeing)	Working boats
1990	2.25	0.48	0.27	0.16	1.19	0.10	1.42
1995	2.35	0.58	0.31	0.12	1.39	0.10	1.27
2000	2.43	0.82	0.29	0.42	1.63	0.15	1.26
2005	2.40	0.98	0.28	0.47	1.24	0.12	1.26
2006	2.47	1.19	0.27	0.36	1.51	0.12	1.27
2007	2.48	1.16	0.27	0.39	1.68	0.12	1.27
2008	2.03	0.54	0.26	0.36	1.64	0.12	1.27
2009	2.10	0.86	0.26	0.36	1.52	0.12	1.27
2010	2.24	1.28	0.27	0.34	1.69	0.12	1.27
2011	1.78	1.11	0.26	0.45	1.89	0.12	1.27
2012	1.88	0.78	0.34	0.57	1.58	0.12	1.27
2013	2.00	0.85	0.31	0.64	1.33	0.12	1.27
2014	1.84	0.49	0.28	0.52	1.18	0.12	1.27
2015	1.92	0.56	0.31	0.52	1.25	0.09	1.28
2016	1.84	0.40	0.29	0.54	1.23	0.08	1.27
2017	1.83	0.57	0.29	0.53	1.33	0.08	1.27
2018	1.84	0.60	0.27	0.52	1.38	0.08	1.27
2019	1.85	0.42	0.27	0.51	1.64	0.08	1.27
2020	2.12	0.23	0.27	0.18	0.88	0.08	1.27
2021	2.33	0.46	0.27	0.23	0.62	0.08	1.27
2022	1.92	0.67	0.27	0.22	0.60	0.08	1.26
2023	1.83	0.49	0.28	0.18	0.57	0.08	1.26
2024	1.90	1.64	IE	0.18	0.48	0.08	IE

IE = Included in Icebreakers in 2024

Note on the time series consistency in the 2026 submission

Two different models for the estimation of emissions from navigation has been used during the time series. For the 2026 submission 2024 data on leisure boats, ferryboats, icebreakers and fishing boats has been reported with the new navigation model maintained by Statistics Finland. However, calculations are also performed for 2023 and energy consumptions and emissions are compared with MEERI model. Differences in leisure boats, ferryboats, icebreakers have been found to be small (mainly 10% in diesel for leisure boats), therefore timeseries for those vessels can be considered consistent.

In working boats, the difference is higher. Very preliminary estimates for working boats shows that emissions are clearly lower than the results of previous MEERI model for 2023. 2024 emissions have been estimated using 2023 data as a starting point, since final data for 2024 has not yet been available. Revised stock data seems to be the main reason for differences between previous calculation and new calculation system, judged by results for 2023. We will investigate whether recalculation of time series is needed as a result of more representative stock data.

Uncertainties

Uncertainties are presented in Annex 6.

QA/QC and verification

Statistics Finland crosschecks the fuel consumption data calculated within the navigation models.

Source specific recalculations

2020
- Guidebook 2019 emission factors are used in the submission to replace the earlier country-specific EFs for $PM_{2.5}$ and PM_{10} (1980-2017). The differences were small (in the third decimal of the EF) and resulting changes in emissions thus negligible.
- BC 2008-2017 recalculated due to correction of EF for diesel oil (Guidebook 2019)
- NO_x, NMVOC, SO_x, NH_3, $PM_{2.5}$, PM_{10}, TSP, CO in 1980-1989 were corrected in the NFR table.
- NMVOC 2015, recalculated due to correction of fuel use data for ice breakers, only a minor decrease in emissions

2021
- $PM_{2.5}$ emissions were recalculated for 1990-2018 due to correction of EFs in the calculation sheet
- All emissions were recalculated for 2016-2018 due to correction of EFs for ferryboats in the calculation sheet

2022
- As, Cu and Se emissions for 2018 to 2019 were recalculated due to update of emission factors of heavy fuel oil and gasoil. The explanation for the choice of the EFs will be included in the 2023 IIR.

2025
- As, Cu and Se emissions were recalculated for the whole timeseries due to update of EFs of heavy fuel oil and gasoil in Guidebook and are now based on the current version (12/2024) of EMEP/EEA Guidebook 2023.
- Guidebook 2023 did not have Tier 1 $PM_{2.5}$ emission factors for bunker fuel oil. Because using PM_{10} and $PM_{2.5}$ values from different Guidebook lead to discrepancy, we used PM_{10} EF from the Guidebook 2023 and applied the ratios from the Guidebook 2016, where PM_{10} = TSP and $PM_{2.5}$ = 0.9 x PM_{10}. This causes a slight decrease in PM2.5 emissions for the entire time series.

Source specific planned improvements

Development project of the navigation calculation model in Statistics Finland is ongoing concerning especially cargo vessels, cruisers and passenger ships. Therefore, 2024 emissions from these vessel types are estimated based on 2023 data or estimates based on other statistics. In addition, time series consistency and need for possible time-series recalculation of other vessel types will be further studied. Results from the projects will be reported in the 2027 submission.

3.11 Off-road mobile sources

Changes in chapter	
March 2026	AL, TF

1 A 2 g vii Mobile Combustion in manufacturing industries and construction
1 A 4 a ii Commercial / institutional: Mobile
1 A 4 b ii Residential: Household and gardening (mobile)
1 A 4 c ii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery
1A 4 c iii Agriculture/Forestry/Fishing: National fishing
1 A 5 b Other, Mobile (including military, land based and recreational boats)

Source category description

This chapter covers emissions from mobile combustion in commercial, institutional and residential sectors for NFR categories 1A4aii, 1A4cii, 1A4ciii and 1A5b (Table 3.29) including machinery types in the Finnish Off-Road machinery model presented in Table 3.30. The contributions of the categories are presented in Tables 3.28 (a-f).

Table 3.28 (a). Contribution of NFR 1A2 g vii in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	3.901	Gg	4.2
NMVOC	0.859	Gg	1.2
SOx (as SO_2)	0.004	Gg	<0.1
NH_3	0.003	Gg	<0.1
$PM_{2.5}$	0.177	Gg	1.4
PM_{10}	0.177	Gg	0.7
TSP	0.177	Gg	0.5
BC	0.108	Gg	3.5
CO	6.184	Gg	2.1
Cd	0.004	Mg	0.5
Cr	0.018	Mg	0.1
Cu	0.619	Mg	1.5
Ni	0.025	Mg	0.3
Se	0.004	Mg	1.0
Zn	0.364	Mg	0.3
PAH-4	0.029	Mg	0.2

Table 3.28 (b). Contribution of NFR 1A4 a ii in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	0.875	Gg	1.0
NMVOC	0.389	Gg	0.5
SOx (as SO_2)	0.001	Gg	<0.1
NH_3	<0.001	Gg	<0.1
$PM_{2.5}$	0.058	Gg	0.5
PM_{10}	0.058	Gg	0.2
TSP	0.058	Gg	0.2
BC	0.014	Gg	0.5
CO	14.759	Gg	5.0
Cd	<0.001	Mg	0.1
Cr	0.005	Mg	<0.1
Cu	0.157	Mg	0.4
Ni	0.006	Mg	<0.1
Se	<0.001	Mg	0.3
Zn	0.092	Mg	<0.1
PAH-4	0.007	Mg	<0.1

Table 3.28 (c). Contribution of NFR 1A4 b ii in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	0.868	Gg	0.9
NMVOC	1.661	Gg	2.2
SOx (as SO_2)	<0.001	Gg	<0.1
NH_3	<0.001	Gg	<0.1
$PM_{2.5}$	0.106	Gg	0.8
PM_{10}	0.106	Gg	0.4
TSP	0.106	Gg	0.3
BC	0.022	Gg	0.7
CO	31.687	Gg	10.8
Cd	<0.001	Mg	<0.1
Cr	0.003	Mg	<0.1
Cu	0.089	Mg	0.2
Ni	0.004	Mg	<0.1
Se	<0.001	Mg	0.1
Zn	0.052	Mg	<0.1
PAH-4	0.004	Mg	<0.1

Table 3.28 (d). Contribution of NFR 1A4 c ii in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	1.477	Gg	1.6
NMVOC	1.021	Gg	1.4
SOx (as SO_2)	0.003	Gg	<0.1
NH_3	0.002	Gg	<0.1
$PM_{2.5}$	0.128	Gg	1.0
PM_{10}	0.128	Gg	0.5
TSP	0.128	Gg	0.3
BC	0.055	Gg	1.8
CO	7.417	Gg	2.5
Cd	0.002	Mg	0.3
Cr	0.012	Mg	<0.1
Cu	0.395	Mg	0.9
Ni	0.016	Mg	0.2
Se	0.002	Mg	0.7
Zn	0.232	Mg	0.2
PAH-4	0.019	Mg	0.1

Table 3.28 (e). Contribution of NFR 1A4 c iii in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %
NOx (as NO_2)	1.512	Gg	1.6
NMVOC	0.073	Gg	<0.1
SOx (as SO_2)	<0.001	Gg	<0.1
NH_3	<0.001	Gg	<0.1
$PM_{2.5}$	0.036	Gg	0.3
PM_{10}	0.040	Gg	0.2
TSP	0.040	Gg	0.1
BC	0.013	Gg	0.4
CO	0.243	Gg	<0.1
Pb	0.004	Mg	<0.1
Cd	<0.001	Mg	<0.1
Hg	<0.001	Mg	0.2
As	0.001	Mg	<0.1
Cr	0.002	Mg	<0.1
Cu	0.027	Mg	<0.1
Ni	0.030	Mg	0.3
Se	0.003	Mg	0.9
Zn	0.036	Mg	<0.1
PCDD/ PCDF	0.004	g I-Teq	<0.1
PAH-4	<0.001	Mg	<0.1
HCB	0.002	kg	<0.1
PCSs	0.001	kg	<0.1

The mobile sources covered by the inventory are presented in Table 3.29 and the breakdown of the different machine types in Table 3.30.

Table 3.29. Mobile sources reported under NFR 1A2gvii, 1A4aii, 1A4bii, 1A4cii and 1A5a.

NFR	Source	Emissions
1A2gvii	Manufacturing industry – off-road vehicles and machinery	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Cd, Cr, Cu, Ni, Se, Zn, PAH-4
1A4aii	Commercial/ Institutional combustion - mobile	
1A4bii	Household and gardening (mobile)	
1A4cii	Agriculture/Forestry/Fishing – Stationary- off-road vehicles and	
1A4ciii	National Fishing	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, PAH-4, HCB, PCB
1A5a	Other stationary (including military) Note: military mobile sources included in this category.	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, PAH-4, HCB

Emission trend

The emission reduction requirements have been tightened during the last decade. Efficient reduction of emissions may increase fuel consumption. Particle, sulphur and nitrogen oxide emissions have come down, however, for instance the decrease in CO emissions during the latest years is expected to turn into an increase along with the growth of the fleet/fuel consumption.

The emission trend of off-road vehicles and other machinery follows the overall trend of emissions; economic depression at the beginning of 1990s decreased emissions. After that time, emissions from specifically leisure time activities have increased (gasoline; ATV (all-terrain vehicle), snowmobiles) while emissions from business activities have decreased (gasoil/diesel).

The economic depression that started in 2008 in Finland lowered the leisure time activity and hence the emissions in 2008. During 2009 the use of off-road vehicles and machinery was at lowest level in the total time series. In 2010 the market began to recover, and the use of vehicles and other machinery increased. Prolonged economic downturn has again turned the trend downwards. The greatest increase was in off-road vehicles and other machinery using gasoil/diesel. The use of biofuels started in 2008 and in 2010 the use was doubled. From 2013 until 2020 the bio-share of gasoil decreased to 0.1-0.2%. Because the share was so low, Statistics Finland decided to allocate this bio-share into road transport instead of non-road use. In 2024, the bio-share of gasoline was 9.0% and diesel oil 16.0% (calculated from TJ). The bio-share of gasoil was 4.3% in 2024.

NOx emissions began to decrease in the early 2000s as diesel working machines came under the control of emissions.

The rapid reduction in NMVOC emissions in the 1A4aii group is the result of the significant replacement of 2-stroke gasoline engines (high hydrocarbon emissions) with 4-stroke engines, especially for professional use, and the general development of 2-stroke technology to reduce hydrocarbon emissions.

SO_2 emissions practically ended from 2005 onwards as a consequence of the transition to sulphur-free fuel oil (from 0.175% to 0.0006% S by weight) and sulphur content was lowered in gasoline, too.

Emission and fuel consumption trends are presented in Figure 3.12 and fuel consumption in in Table 3.29.

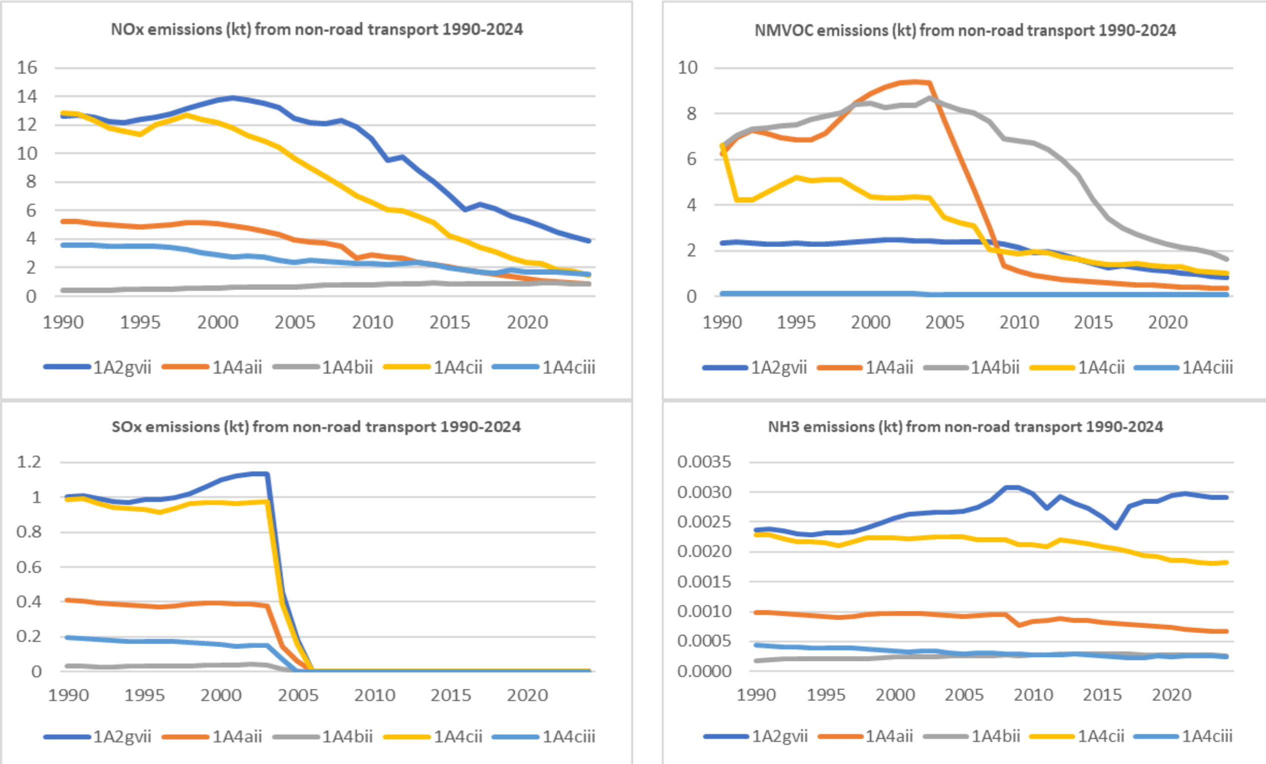


Figure 3.12 Emission trends of non-road transport 1980-2023.

Fuel consumption

Fuel consumption data in NFR categories 1A2gvii, 1A4aii, 1A4bii and 1A4cii are provided in Table 3.29.

Table 3.29. Fuel consumption (PJ) in non-road transport 1990-2024.

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Off-road working machinery															
Gasoil	29.4	28.3	30.4	30.7	31.1	29.5	28.2	29.9	30.0	29.8	29.9	29.0	28.3	27.8	27.7
Motor gasoline	3.1	3.2	3.6	3.8	3.3	3.4	3.2	3.1	3.0	2.8	2.7	2.6	2.5	2.4	2.4
Liquid gas	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Liquid biofuels	NO	NO	NO	NO	0.6	0.2	0.2	0.2	0.2	0.2	0.2	1.3	1.4	1.5	1.7

Methodological issues

Emissions from off-road vehicles and other machinery from 1990 to 2023 were calculated using the TYKO model developed by VTT Technical Research Centre of Finland Ltd. 2024 emissions are calculated with off-road vehicles and other machinery model maintained by Statistics Finland. In these models, same calculation methods and emission factors have been used and time series is consistent. Emissions and energy consumption of non-road machinery are estimated for five main categories: Drivable diesel, drivable gasoline, moveable diesel, moveable gasoline and handheld gasoline, totalling 51 different machine types.

In diesel-powered machinery and off-road vehicles, the term diesel refers to technology. There have been some changes in legislation and fuel tax decisions concerning the use of diesel oil and gasoil over time. In this report, we use the terminology “non-road-gasoil” to describe the use of gasoil in diesel engines in off-road vehicles and other machinery and domestic navigation (wherever it is allowed to use lower taxed gasoil instead of higher taxed diesel oil).

The breakdown of different machine types is presented in Table 3.30 and the properties of fuels used in working machines in Table 3.31.

Table 3.30 Breakdown of different machine types in in off-road machinery (updated in 2020).

NFR subcategory	Type of machine	NFR subcategory	Type of machine
1A2gvii Other / mobile	Backhoe loaders Bulldozers Compactors, diesel Compressors Cranes Dumpers Excavators, rubber tire Excavators, skid steer Forklift, gas Forklift, gasoline Generator sets, diesel Generator sets, gasoline Mini excavators, skid steer Other lifts, diesel Other moveable machines, diesel Wheel loaders	1A4ai Commercial/institutional	ATV, 2-stroke, professional ATV, 4-stroke, professional ATV, diesel Forklifts, diesel Graders Maintenance tractors Other drivable machines, diesel Skid steer loaders Snowmobiles, 2-stroke professional Snowmobiles, 4-stroke professional
1A4cii Agriculture/Forestry/Fishing	Farm tractors Forest harvesters Forwarders (forest tractors Professional chain saws Soil cultivators	1A4bii Residential: Household and gardening	ATV, 2-stroke, leisure ATV, 4-stroke,leisure Chain saws, hobby Lawn movers, handheld Lawn tractor, diesel Other drivable, gasoline Other handheld machines Other moveable machines, gasoline Other tractors Riding mowers, gasoline Snow blowers Snowmobiles, 2-stroke leisure Snowmobiles, 4-stroke leisure Trimmers

Table 3.31 Fuel properties of working machines (Statistics Finland, 2025)

Gasoline	
Specific weight	0.746 kg/l (density 746 kg/m^3)
Heating value	41.6 MJ/kg 31.06 MJ/ dm^3
Energy	1 kWh = 3.6 MJ
Sulphur content (S)	0.0136 g/kg SO_2
Carbon dioxide (CO_2)	1973.4 g/(dm^3 fuel) = 2645.4 g/(kg fuel)
Diesel	
Specific weight	0.832 kg/l (density 832 kg/m^3)
Heating value	43.2 MJ/kg
Energy	1 kWh = 3.6 MJ
Sulphur content (S)	0.012 g/kg SO_2
Carbon dioxide (CO_2)	2515.4 g/(dm^3 fuel) = 3024.9 g/(kg fuel)

Emissions are calculated separately for gasoline, diesel and LPG machinery. The main method is to sum up the product of the machinery population, engine power, load factor, activity hours and emission factors. Data on machine population are based on national estimations, machinery registrations, sales figures and knowledge on the life expectancy of machinery.

The Tier 3 calculation method is consistent with the EMEP/EEA Guidebook and is widely used, for example, in the U.S. EPA Nonroad model (1998) and CORINAIR Off-Road vehicle and Machines model (Andrias et al., 1994). Emissions are calculated with the formula below:

$$E^c = \sum_{l=1}^{N^l} g_l \sum_{r=1}^{4} p_{l,r} \sum_{x=1}^{3} \sum_{f=1}^{3} \sum_{s=1}^{6} \left(\sum_{u=1}^{3} \sum_{a=1}^{40} N_{l,r,x,f,s,u,a}^{m} t_{l,r,x,f,s,u,a} \right) e_{l,r,x,f,s}^{c}$$

where,

E^c	total emissions of compound c
c	compound
l	type of machinery
N^l	number of machinery types (presently 50)

g	engine load factor by machinery type
r	engine power class (4 classes)
p	nominal engine power (class centre)
x	engine type (presently 3: two/four-stroke gasoline and diesel engines)
f	fuel type (3 types)
s	emission standard level (Stage) by model year of machinery (6 classes)
u	type of usage (3 types: professional/leisure/both)
a	age of machine (max 40)
N^m	number of machines by detail (machinery fleet in the calculation year by age)
t	activity (hours in use per year)
e^c	emission factor for compound c

Formula for detailed machinery fleet calculations:

$$N_y^m = N_{y-1}^m\left(1 - w_y^m\right) + S_y^m$$

where

N^m_y	machinery fleet by type (detailed) in the year y
w^m_y	scrapping factor of machinery in the year y
S^m_y	new sales of machinery in the year y

Based on energy use (kWh) and emission factors (g/kWh) the following basic emissions are calculated: CO, HC/NMVOC, NOx, TSP, CH_4, N_2O, SO_2, CO_2, fuel consumption, energy and AdBlue.

- PM_{10} and $PM_{2,5}$ size fractions of particulate matter emissions are calculated from TSP emissions using fraction factors (TSP=PM_{10}=$PM_{2.5}$) from Guidebook 2023.
- Black carbon, ammonia and heavy metals (Cd, Cr, Cu, Ni, Se and Zn) emissions are calculated with the Tier 1 emission factors of the EMEP EEA Guidebook 2023.
- PAH-4 emissions are the sum of emissions of benzo(a)pyrene and benzo(b)fluoranthene, for which Tier 1 emission factors are given in EMEP EEA Guidebook 2023.
- NMVOC emissions are calculated by subtracting the CH_4 emission values from the HC values.

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 6 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to assessment of magnitude and trends has been carried out. At present, no verification has been carried out for the specific source-sector emissions. Statistics Finland crosschecks the fuel consumption data calculated within the off-road vehicles and other machinery models.

Source-specific recalculations including changes made in response to the review process

2018

- PM_{10} and $PM_{2.5}$ size fractions of particulate matter emissions were revised to correspond to the EMEP EEA Guidebook 2016. Therefore, the PM_{10} and $PM_{2.5}$ emissions were recalculated for the whole time series 1980-2015.

2020

- In the BC calculation the EF for LPG forklifts was corrected, recalculation done.
- In the NH3 calculation the EF for LPG forklifts and 2-stroke ATV were corrected, recalculation done (minor effects).
- Part of the small machines were corrected to be 2-stroke, recalculation done.
- Minor updates to the density of fuels for the years 2008 – 2017 were done, very small effect on emissions.

- The NFR classifications of different machines were cross-checked with the CRF classifications used in the ghg inventory. As a result, the classifications between air pollutant inventory and ghg inventory were harmonized which resulted in changes of the NFR classification of some machines (Table 3.32):

Table 3.32. NFR Category revision 2020 to align with the GHG reporting.

Type of machine	NFR category in submission 2020	Old NFR category
ATV, 2-stroke, leisure	1A4bii	1A4aii
ATV, 4-stroke, leisure	1A4bii	1A4aii
Chain saws, hobby	1A4bii	1A4aii
Forklift, gas	1A2gvii	1A4aii
Forklift, gasoline	1A2gvii	1A4aii
Mini excavators, skid steer	1A2gvii	1A4aii
Other drivable, gasoline	1A4bii	1A4aii
Other handheld machines	1A4bii	1A4aii
Other lifts, diesel	1A2gvii	1A4aii
Other moveable machines, gasoline	1A4bii	1A2gvii
Other tractors	1A4bii	1A4aii
Snowmobiles, 2-stroke leisure	1A4bii	1A4aii
Snowmobiles, 4-stroke leisure	1A4bii	1A4aii

2021

- CO emissions were recalculated for 2012 - 2018 due to correction of one EF of diesel working machines in the calculation sheet
- SO_x emissions were recalculated for 2012 – 2018 due to small update of sulphur content of gasoline
- The index on working hours used in the emission estimation of construction machinery was corrected for 2018, which resulted in the recalculation of emissions for all pollutants
- Recalculation of $PM_{2.5}$ under 1A4ciii is due to correction of EFs (the same as for 1A3dii). Guidebook 2023 did not have Tier 1 $PM_{2.5}$ emission factors for bunker fuel oil. Because using PM_{10} and $PM_{2.5}$ values from different Guidebook lead to discrepancy, we used PM_{10} EF from the Guidebook 2023 and applied the ratios from the Guidebook 2016, where PM_{10} = TSP and $PM_{2.5}$ = 0.9 x PM_{10}. This causes a slight decrease in PM2.5 emissions for the entire time series.

Source-specific planned improvements

None.

3.12 Other Mobile

No activities fall under this category.

3.13 International maritime navigation

1 A 3 d i (i) International maritime navigation

Changes in chapter	
March 2026	AL, TF

Emission trend

The trend of emissions in international navigation has fluctuated during most of the period. The most important reason for these fluctuations has been the variation in bunker fuel prices. Especially the ferries between Finland and Sweden can refuel in one or the other country depending on fuel prices. The Finnish currency was devalued in the early 1990s, which affected fuel prices strongly. This effect has disappeared due to Finland's EU membership and the common currency. Since the beginning of the 2000s refuelling in Finland diminished to a very low level until 2015. In 2015 marine bunker sales increased again and was approximately at the same level also in 2016 but 25% higher in 2017. In 2018 marine bunker sales decreased 8% compared to 2017. Emissions from use of LNG in international navigation were included into the inventory starting from 2016. The trend is presented in Figure 3.13.

In the biggest vessels there are already sulphur removal systems and removal of particles and sulphur is becoming mandatory in the next few years. The abatement systems will also remove heavy metal emissions.

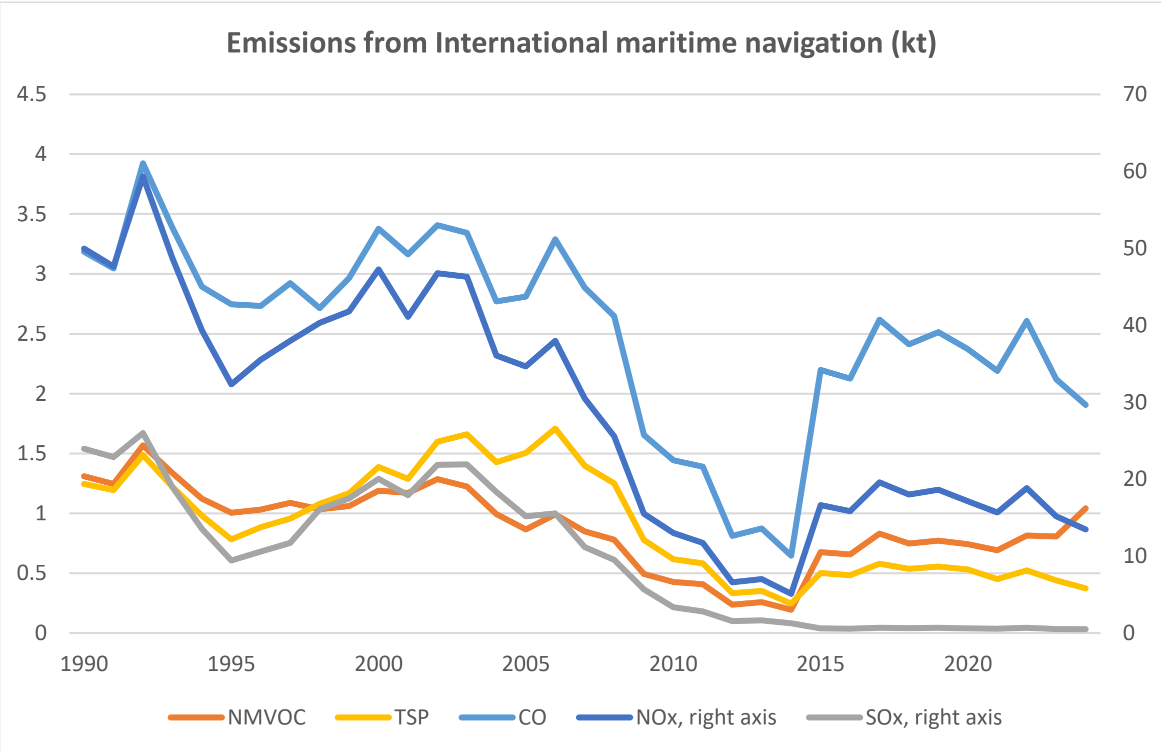


Figure 3.13. Emissions from international maritime navigation 1990-2024.

Methodological issues

In accordance with the reporting guidelines, international marine bunker fuel emissions are not included in national totals.

The international bunkers cover international aviation and navigation according to the IPCC Guidelines. The fuel use for international navigation is calculated according to the UNFCCC and CLRTAP reporting guidelines at Statistics Finland. The fluctuating fuel use includes fuel sales to ships and aircrafts traveling abroad, and is impacted by the fuel prices, especially the ferries between Finland and Sweden can refuel in one or the other country depending on fuel prices. The Finnish currency was devalued in the early 1990s, which affected fuel prices strongly. This effect has disappeared due to Finland's EU membership and the common currency. Since the beginning of the 2000s refuelling in Finland diminished to a very low level until 2015. In 2015 the marine bunker sales increased and was approximately at the same level also in 2016.

Regarding trips to Sweden via Åland, these are treated as international, because the number of passengers (or cargo) leaving or entering the ships in Åland is very low. A small share of Åland transport has been allocated to domestic navigation, according to the share of passengers travelling to the archipelago of Åland. The fuel volumes of the Åland correction (gasoil and residual fuel oil) are subtracted from bunkers and added to total domestic fuel consumption.

In the NFR tables emissions from international maritime navigation are the same as reported in the Finnish greenhouse gas inventory. The methodology for calculation of these emissions is explained in the Finnish NID.

Uncertainties

No uncertainty analysis has been carried out for these emissions.

QA/QC and verification

Statistics Finland crosschecks the fuel consumption data calculated within the MEERI model and against the data reported to the IEA Oil Questionnaire.

Source-specific recalculations and improvements due to review recommendations

None.

Source specific planned improvements

None.

3.14 International Inland waterways

1 A 3 d i (ii) International inland waterways

This source does not exist in Finland.

3.15 Pipeline compressors

Changes in chapter	
March 2026	JMP, TF

1A3 e i Pipeline compressors

Source category description

This chapter covers emissions from pipeline compressors. Emissions from pipeline compressors were reallocated under NFR 1A3ei in 2009 and cover both emissions from gas turbines and fugitive emissions at the compressor stations.

The contribution of the category to total emissions is presented in Table 3.33.

Table 3.33. Contribution of NFR 1A3ei in 2024 to total emissions.

Pollutant	Emissions in 2024	Unit	Share of total emissions %	% reported by the operators
NOx (as NO_2)	<0.001	Gg	<0.1	100
NMVOC	<0.001	Gg	<0.1	0
SOx (as SO_2)	<0.001	Gg	<0.1	0
CO	<0.001	Gg	<0.1	0
PCDD/F	<0.001	g I-Teq	<0.1	0

Emission trend

The trends of NOx, CO and NMVOC emissions are presented in Figure 3.14. The trends follow loosely the total consumption of natural gas: until the mid-2000s the consumption increased, and the transmission grid expanded, but then started to decrease as the running time of the compressors decreased. During the recent years, the levels of emissions have stabilized with some interannual fluctuation. In addition, also SOx and PCDD/F emissions are reported from category 1A3ei.

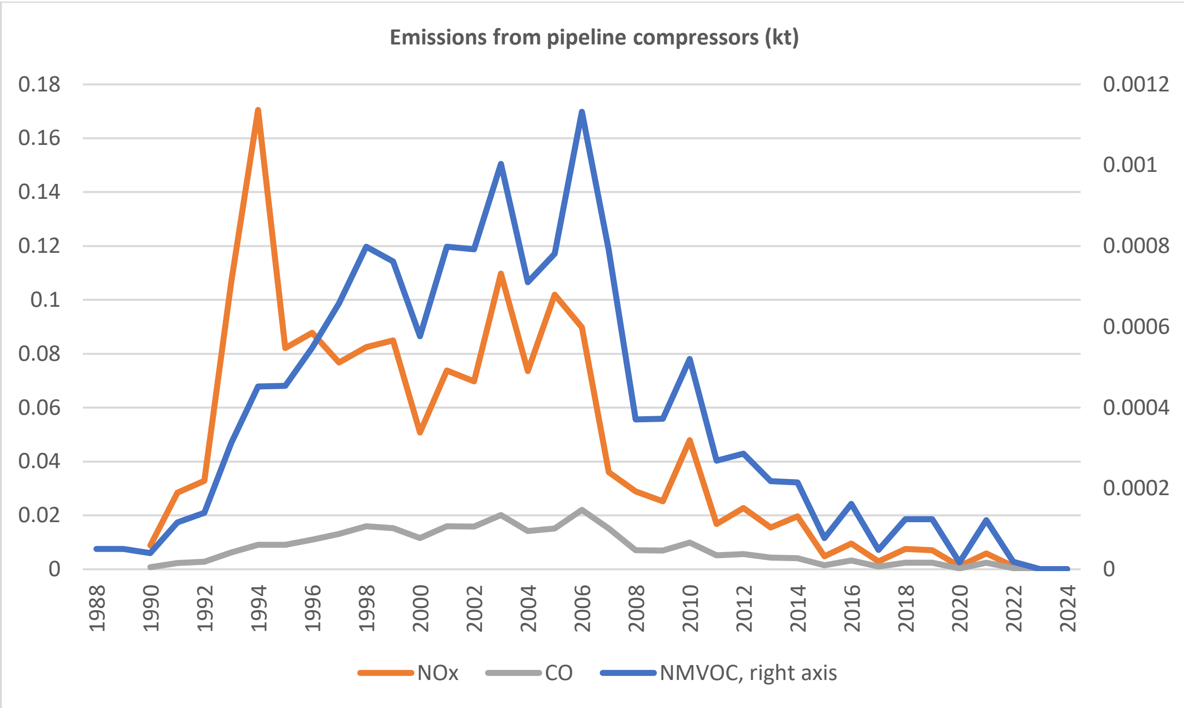


Figure 3.14. NOx and CO emissions (1990-2024) and NMVOC emissions (1988-2024) from pipeline compressors.

Methodological issues

NOx, CO, NMVOC, SOx and PCDD/F emissions in category 1A3ei are either reported by the plants (compressor station operators) according to the emission monitoring programmes under their environmental permits or calculated at Syke from their fuel use. All the compressor stations use good quality natural gas as a fuel. The reported emissions data are available in the YLVA system. Detailed methodological description of the emissions calculated at Syke are presented in IIR Part 2 Energy.

Particulate matter emissions from natural gas fired pipeline compressors are not reported. Emissions are strictly regulated in the Finnish environmental permits. None of the environmental permits of plants with natural gas fired gas turbines mention particles. Primary particulate matter emissions from gas turbines using good quality natural gas are considered negligible. In addition, the 2023 version of the Guidebook states that particulate matter emissions are not relevant for natural gas fired gas turbines.

Uncertainties

Uncertainties are presented in Annex 6 of the IIR.

QA/QC and verification

Normal statistical quality checking related to assessment of magnitude and trends has been carried out. At present, no verification has been carried out for the specific source-sector emissions.

Recalculations and improvements due to review recommendations

2009
- Emissions from pipeline compressors were included

2018
- NMVOC emissions from leaks in pipelines (reported under NFR 1B2b) were included in the inventory based on the recommendation from the 2017 NECD Technical Review.

Source specific planned improvements

Allocation of emissions to this NFR from the beginning of the 1980s will be studied out in the coming years.

3.16 Fugitive Emissions from oil and natural gas (NFR 1.B.2)

Changes in chapter	
March 2026	JMP, TF

The share of emissions from NFR 1B2av Oil and Natural Gas, i.e., in Finland from storage tanks at refinery sites and from distribution of oil products is presented in Table 3.34.

Table 3.34. Contribution of Distribution of oil products (NFR 1B2av) in 2024 to the total emissions.

Pollutant	Emissions from Fugitive emissions from solid fuels in 2024	Unit	Share of total emissions %	% reported by the operators
NMVOC	2.640	Gg	3.6	7.6
$PM_{2.5}$	<0.001	Gg	<0.1	0
PM_{10}	<0.001	Gg	<0.1	0
TSP	<0.001	Gg	<0.1	100

Distribution of oil products (1B2av)

Source category description and emission trend

Emissions from storage tanks at refinery sites are included in this category (without any fuel use linked to them). For gasoline distribution, see Chapter 3.17 below.

The emission trend is declining as storage of chemicals at the refineries has been improved to prevent fugitive emissions.

Methodological issues

NMVOC

All NMVOC emissions included in the inventory from this category are reported by plants into the YLVA system.

Particles

TSP emissions are reported by the operators according to the monitoring requirements in the environmental permits into the YLVA system. There are no particle emission factors in the Guidebook. Finland reports these emissions based on TSP data reported by operators and as no methods are available for particle fraction factors, we have assumed TSP:PM_{10}:$PM_{2.5}$ equal to 1:1:1.

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 6 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to assessment of magnitude and trends has been carried out. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

None.

Source-specific planned improvements

None.

3.17 Distribution of oil products (1B2av)

Changes in chapter	
February 2025	AL, JMP, TF

Source category description

NMVOC emissions from service stations are included in this category.

Emission trend

NMVOC emissions have been decreasing since 1988 when they were included in the inventory. Although the fleet of vehicles has increased, emissions are declining due to improved capture of gasoline fumes in the petrol distribution network and in refuelling of cars.

Methodological issues

NMVOC

The emissions are calculated based on a model developed in cooperation with Syke and the Finnish Oil and Gas Association (Pohjolainen, 2008).

The operation of Finnish Oil and Gas Association ceased in summer 2018 and the tasks has been taken over by Statistics Finland from autumn 2018 onwards. The model has been used from 2005 onwards and emissions estimates for 1990-2004 have been provided by Finnish Oil and Gas Federation by using the same model.

Sales of motor gasoline (m^3) (Table 3.36) are used as activity data in revised model and are provided by the Finnish Oil and Gas Association. In the model it is assumed that 90% of service stations had stage I equipment during 2007-2011 and that 10% of service stations had stage II equipment. The share of stage II equipment at service stations is increasing due the new directive (2009/126/EY) implemented in January 2012. As an expert estimate in the model, it was assumed that in 2012 onwards the share of stage II service stations is 30%.

In the model emissions are calculated for drop out and storage and for refuelling separately. It is also assumed that certain part (in percentage) of the filled-up gasoline evaporates as NMVOC (see Tables 3.35 and 3.36). The same assumptions are used for whole time series.

Table 3.35. Emission factors.

Type of station	no recovery	Stage 1 recovery	Stage 1+2 recovery
drop out+storage	0.16 %	0.03%	0.03%
Refuelling	0.18%	0.18%	0.10%

Table 3.36. The sales of petroleum in Finland 1992-2024 (Finnish Oil and Gas Federation, Statistics Finland).

Year	sales of motor gasoline (m³)	Year	sales of motor gasoline (m³)	Year	sales of motor gasoline (m³)	Year	sales of motor gasoline (m³)
1990		2000	2 379 600	2010	2 237 351	2020	1 787 867
1991		2001	2 412 400	2011	2 162 321	2021	1 828 460
1992	2 574 133	2002	2 508 667	2012	2 098 404	2022	1 719 756
1993	2 540 800	2003	2 469 067	2013	2 098 961	2023	1 736 336
1994	2 558 400	2004	2 508 677	2014	2 031 898	2024	1 775 703
1995	2 529 333	2005	2 501 333	2015	2 009 420		
1996	2 455 867	2006	2 482 667	2016	1 994 974		
1997	2 507 600	2007	2 481 366	2017	1 956 376		
1998	2 477 067	2008	2 347 344	2018	1 936 885		
1999	2 466 133	2009	2 285 349	2019	1 903 176		

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 6 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to assessment of magnitude and trends has been carried out.

At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2020

- NMVOC emissions 1990-2017 were recalculated due to update of sales data for motor gasoline resulting in slight decrease of emissions in the early 1990s and 1999, increase in emissions in 1996-1998 and 2002, and a minor increase in other years.

Source-specific planned improvements

The methodology provided in the Guidebook 2023 cannot be used due to lack of detailed data on gasoline fume collection systems at gas stations. Possibilities to collect this data will be studied in the near future.