FINLAND's INFORMATIVE INVENTORY REPORT 2024

Air Pollutant Emissions 1980-2022

under the UNECE CLRTAP and the EU NECD

Part 2 – Energy

March 2024

FINNISH ENVIRONMENT INSTITUTE

Climate solutions unit

Air pollution group

PART 2 ENERGY

ENERGY (NFR 1)

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Sub-chapters included under each NFR subcategory:

Source category description
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ENERGY (NFR 1)

Changes in chapter	
March 2024	KS, TF, JM

1 Overview of the sector

Sources included

The stationary combustion and fugitive emission sources included under the Energy sector are presented in Figure 2.1 and under Chapter 2.2 Energy Industries and Manufacturing Industries and Construction. The NFR subcategories and air pollutants reported from these sources are listed in Table 2.1.

Transport sector sources and emissions are presented under Chapter 2.3

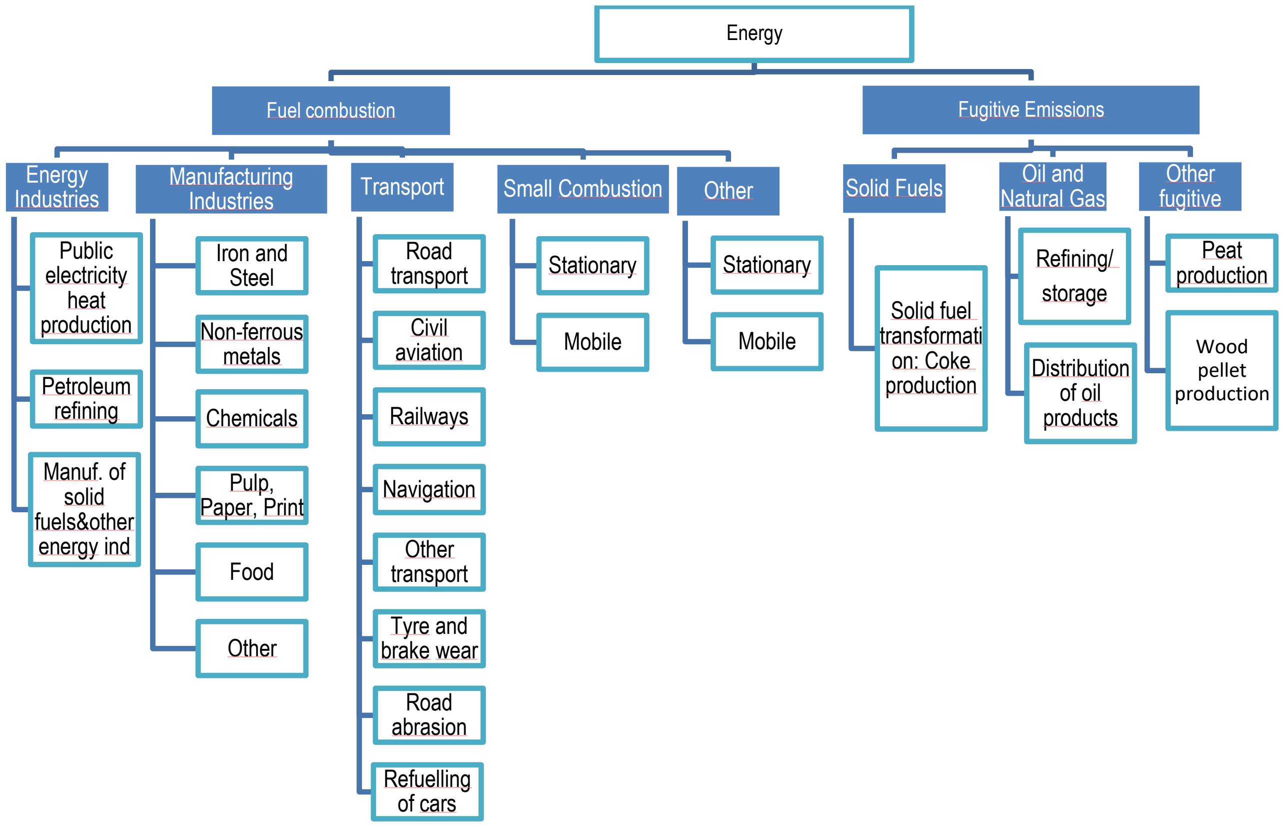


Figure 2.1. Emission sources included under the Energy Sector in the Finnish air pollutant inventory.

NFR 1.A.1 Energy industries and NFR 1.A.2 Manufacturing industries and Construction cover emissions from fuel combustion in point sources in the energy production and industrial processes sectors.

NFR 1.A.4 Other sector, NFR 1.A.5 Other and also partly NFR 1.A.2 Manufacturing Industries and Construction (Other – Stationary) cover all the remaining fuel combustion activities that are not covered by the categories 1.A.1–1.A.3.

NFR 1B, Fugitive emissions from fuels, covers emissions from peat production, oil refineries as well as storage and distribution of chemicals and oil. There is no exploration or production of oil and natural gas nor hard or brown coal mining in Finland.

Key categories in the Energy sector and the related Tier level of methods are presented in Table 2.1

Table 2.1. Key categories and tier level of methods for the Energy inventory.

NFR	Fuel	NO_x	Tier	NMVOC	Tier	SO_x	Tier	NH_3	Tier	CO	Tier
1A1a	Biomass	L1, T1	3	L1	3	L1, T1	3			L1, T1	3
1A1a	Gaseous	T1	3								
1A1a	Liquid					L1, T1	3				
1A1a	Other	L1	3								
1A1a	Solid	L1, T1	3			L1, T1	3				
1A1b	Gaseous					L1, T1	3				
1A1b	Liquid					L1, T1	3				
1A2a	Solid	L1	3			T1	3				
1A2b	Liquid					L1, T1	3				
1A2b	Solid					L1, T1	3				
1A2d	Biomass	L1, T1	3			L1, T1	3				
1A2d	Liquid					T1	3				
1A2d	Solid					T1	3				
1A2e	Liquid					T1	3				
1A2gviii	Liquid					T1	3				
1A4ai	Liquid					L1	3				
1A4bi	Biomass	L1, T1	3	L1, T1	3					L1, T1	3
1A4ci	Solid					T1	3				
1A5a	Biomass	L1, T1	2			L1, T1	2			L1, T1	2
1A5a	Liquid	L1	2			L1	2				
1B2aiv				L1	2						
1B1b						L1, T1	3				
NFR	**Fuel**	**$PM_{2.5}$**	**Tier**	**PM_{10}**	**Tier**	**TSP**	**Tier**	**BC**	**Tier**		
1A1a	Biomass										
1A1a	Liquid	T1	3	T1	3						
1A1a	Solid	T1	3	L1, T1	3	L1, T1	3				
1A2d	Biomass	L1, T1	3	L1, T1	3	L1, T1	3				
1A2d	Liquid					T1	3				
1A2f	Solid					T1	3				
1A4bi	Biomass	L1, T1	3	L1, T1	3	L1, T1	3	L1, T1	2		
1A5a	Biomass	L1, T1	2	L1, T1	2	L1, T1	2	L1	2		
1B1c		L1	3			T1	3				
NFR	**Fuel**	**Pb**	**Tier**	**Cd**	**Tier**	**Hg**	**Tier**	**As**	**Tier**	**Cr**	**Tier**
1A1a	Biomass	L1	3	L1, T1	3	L1, T1	3				
1A1a	Solid	L1	3			L1, T1	3	L1, T1	3	L1, T1	3
1A1b	Liquid	L1, T1	3	L1	3	L1	3	L1, T1	3	L1, T1	3
1A2d	Biomass	L1, T1	3	L1, T1	3	L1, T1	3	L1	3		
1A2d	Solid									T1	3
1A2f	Solid	L1	3					L1	3		
1A2gviii	Other					T1	3				
1A4bi	Biomass	L1	3	L1, T1	3	L1	3			L1, T1	3
1A4ci	Solid							L1	3		
1A5a	Biomass	L1, T1	2	L1, T1	2	L1, T1	2			L1, T1	2
NFR	**Fuel**	**Cu**	**Tier**	**Ni**	**Tier**	**Se**	**Tier**	**Zn**	**Tier**		
1A1a	Biomass			L1, T1	3			L1, T1	3		
1A1a	Liquid			L1	3						
1A1a	Solid			T1	3						
1A1b	Liquid			T1	3			L1	3		
1A2c	Liquid			L1, T1	3						
1A2d	Solid			T1	3						
1A2f	Solid			L1, T1	3						
1A4ai	Liquid			L1	3						
1A4bi	Biomass			L1, T1	3	L1, T1	3	L1, T1	3		
1A4ci	Biomass			T1	3	L1	3	L1	3		
1A5a	Biomass	L1, T1	2	L1, T1	2			L1, T1	2		
1A5a	Liquid			L1	2						

NFR	Fuel	PCDD/F	Tier	PAH-4	Tier	HCB	Tier	PCB	Tier		
1A1a	Biomass	L1, T1	3	T1	3						
1A1a	Other	L1, T1	3	T1	3						
1A1a	Solid	L1	3								
1A2a	Solid							T1	1		
1A2d	Biomass	L1	3	L1	3						
1A2d	Solid							T1	1		
1A2f	Solid							T1	1		
1A2gviii	Other			T1	3						
1A4bi	Biomass	L1, T1	3	L1, T1	3			L1, T1	3		
1A4bi	Liquid			T1	3						
1A5a	Biomass	L1, T1	2	T1	2						
1B1b		T1	3					L1, T1	1		

Emissions from Energy Industries

Emissions reported are presented in Table 2.2.

Table 2.2. Emissions in 2022 reported under NFR 1A and 1B.

NFR	Source	Pollutants reported
1A1	**Energy industries**	
	a Public electricity and heat production	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
	b Petroleum refining	NO_X, NMVOC, SO_X, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4
	c Manufacture of solid fuels and other energy industries	IE for coke production emissions allocated under 1A2a
1A2	**Manufacturing industries and construction, stationary sources**	
	a Iron and steel	NO_X, NMVOC, SO_X, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
	b Non-ferrous metals	NO_X, NMVOC, SO_X, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
	c Chemicals	NO_X, NMVOC, SO_X, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
	d Pulp, Paper and Print	NO_X, NMVOC, SO_X, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
	e Food processing, beverages and tobacco	NO_X, NMVOC, SO_X, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
	f Non-metallic minerals	NO_X, NMVOC, SO_X, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
	gviii Other - stationary	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
1A4	**Small combustion, stationary sources**	
	ai Commercial and institutional - stationary	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
	bi Residential - stationary	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
	ci Agriculture, Forestry, Fishing - Stationary	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB
1A5	**Other**	
	a Stationary	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB
1B1	**Fugitive emissions from solid fuels**	
	a Coal mining and handling	NA
	b Solid fuel transformation: coke production	NMVOC, SO_x, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, PCB
	c Other fugitive emissions from solid fuels: wood pellet, peat production	TSP, PM_{10}, $PM_{2.5}$
1B2	**Oil and gas**	
	aiv Oil - Refining / storage	NMVOC, TSP, PM_{10}, $PM_{2.5}$
	b Natural gas – distribution + transport	NMVOC
	c Venting and flaring	IE (NMVOC and particle emissions are reported under 1B2aiv)

Data used in the inventory

Changes in chapter	
March 2024	KS, TF, JM

As a summary, data used in the calculation of energy sector emissions at SYKE include:

1. Detailed bottom-up data for point sources covers approximately 2/3 of the total annual fuel combustion collected from the Emission Trading Registry and YLVA database (Tables 2.2-2.8)
2. Aggregate sectoral (sub-sectoral) data for other sources, such as small combustion, partly energy industries, residential and others, covers approximately the rest 1/6 of the total fuel combustion. This data is based on the national Energy Statistics, greenhouse gas inventory data by fuels, and on the energy balance difference. Currently, the energy balance difference is allocated under NFR 1.A.5.a (apart from peat which is allocated under 1.A.1.a).

Energy sources

Changes in chapter	
February 2024	KS, TF

Similarly to other industrialised countries, the largest source of most air pollutants in Finland is the energy sector. Finland does not have domestic sources of fossil energy and therefore imports substantial amounts of petroleum, natural gas, and other energy resources. The main domestic energy sources include wood fuels, peat and hydropower, which cover about 30% of the energy demand. (Figure 2.2).

Energy consumption has not increased in the 2000s due to improved energy efficiency and decreased volume of heavy industries. In the period of 2000-2022 the share of industry of the total energy use decreased from 52% to 44%. (Statistics Finland, energy supply and consumption, 2024)

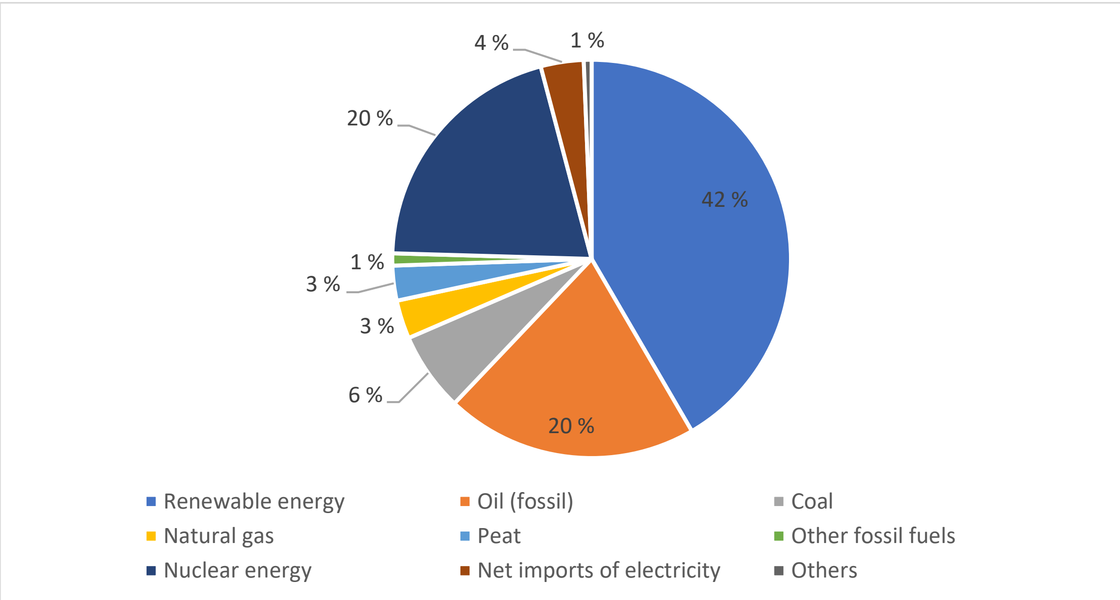


Figure 2.2. Total Energy consumption by energy source 2022 (Statistics Finland, energy supply and consumption, 2024).

National characteristics related to energy use

National characteristics that are reflected in the emissions include (1) cold climate, (2) long distances, (3) energy-intensive industries, (4) increasing use of renewable energy and (5) strong annual variations in energy use and energy sources.

(1) Cold climate

The annual mean temperature in the south of the country is around 5 ºC and 0 ºC in the north. The population-weighted average number of heating degree days for Finland is 5000, considerably more than in Sweden and Norway (4000)[1]. The Finnish climate is the coldest in the EU and, consequently, a large share of the energy (27 % in 2022) is used for the heating of buildings. The high demand for energy also forces the production and use of energy to be efficient. Finland is one of the world's leading countries in the production of combined heat and power (CHP), by which the same power plant produces both electricity for the local grid, and heat to warm buildings and run industrial processes. This district heating system includes a network of insulated pipes used to deliver heat, in the form of hot water or steam, from the point of generation to an end user and provide a means to transport heat efficiently. This makes good use of heat energy that would be wasted in facilities only generating electricity.

(2) Long distances (see closer in the Transport Chapters)

(3) Energy-intensive industries

Almost half of all energy consumed is still used by industry where the heaviest users are pulp and paper industry, metal industry, oil refining and chemical industry. Much of the energy consumed by the manufacturing industries and construction is produced by themselves, e.g. black liquor, peel and branches are used by the forest industry itself in creating its own energy. The use of biofuels is increasing and the industries have also outsourced power plants from industry to the energy sector.

(4) Renewable energy

The share of renewable energy in total energy consumption was 42% in 2022. The share of wood fuels in Finland's total energy consumption was 28%. EU targets for renewable energy are calculated relative to total final energy consumption. Finland's target set in the EU's Renewable Energy Directive for increasing the use of renewable energy is to achieve a share of at least 38% of the total final energy consumption of renewable energy by 2020. Calculated in this way, the share of renewable energy sources in Finland rose to 44.6 per cent in 2020. The target was clearly exceeded (Energy supply and consumption, Statistics Finland[2]). Also, in the transport sector there is increased use of biofuels, for instance in the road traffic the share of biofuels was around 15% in 2022.

Wood fuels are the largest source of energy. Most firewood is by-product of other uses of wood. Peat is one of the main fuels after wood, hard coal and natural gas and it is a domestic energy source. The world's largest bio power plant with a capacity of 265 MW is situated in Pietarsaari in Finland.

Wood is also used directly for heating. In total around 6 million m^3 or 50 PJ of firewood are used annually for space heating.

(5) Annual variations

Energy sector emissions show strong annual variation in accordance with (1) the amount of energy used and (2) the proportion of imported electricity.

Fluctuations in the *amount of energy used* depend on the economic trend, the energy supply structure and climate conditions:

- In the 1990s, first the *economic depression* and later the recovery up to the early 2000s especially in the energy intensive export industries, have impacted the demand of energy. Between 2001 and 2006 the economy did not grow and the worldwide economic downturn that began in 2008 impacted energy consumption (see Chapter 1.1.1 of IIR General Part 1A)

- The *availability of hydro power in the Nordic electricity market* influences significantly the electricity supply structure and hence the emissions. If the annual precipitation in the Nordic

1 Heating degree days https://en.ilmatieteenlaitos.fi/heating-degree-days

2 https://www.stat.fi/til/ehk/2020/ehk_2020_2021-12-16_tie_001_en.html

countries is lower than usual, hydro power becomes scarce and Finland's net imports of electricity decrease. During such years, additional electricity is generated using wood fuels, coal and peat in condensing power production for its own needs and also to be sold on the Nordic electricity market. Finland's condensing power generation is reduced in years when electricity imports from the Nordic electricity market are increased due to a good water situation in the Nordic countries (Figure 2.3). Coal-fired condensing power production has varied between 4.8 TWh in 2015 and 17.9 TWh in 2003.

- In the integrated Nordic electricity market, the annual rainfall and accordingly the availability of cheap hydropower. The shortage of hydro power in the Nordic market increases coal and peat-fuelled condensing power generation in Finland (Figure 2.3).

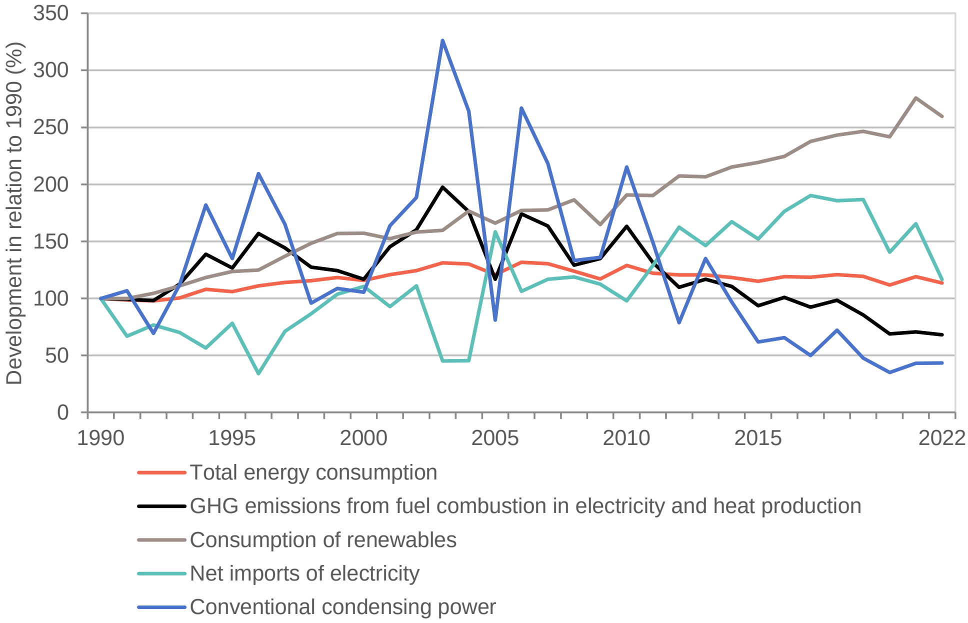


Figure 2.3. Net imports of electricity and conventional condensing power 1990-2020 in relation to 1990 (Finnish NID, 2024).

Energy use of waste

Changes in chapter	
March 2024	KS, TF

All waste incineration/combustion plants are equipped with energy recovery and are mostly combined heat and power production units. Therefore, no emissions from waste incineration are reported under the Waste sector but the activity is completely allocated under NFR 1A1a or NFR 1A2gviii.

Note, that one waste incineration plant with no energy recovery has actually been in operation between the years 1969-1983 and these emissions are reported as IE under NFR 5C for the years 1980-1983. These emissions are based on data that the plant reported to the supervising authorities' data system YLVA.

Waste incineration with energy recovery

Energy use of waste was not common in the earlier years (only one plant as described above) but is currently increasing as waste incineration has become the preferred treatment system to landfilling of municipal waste.

Most of the waste incineration capacity has been built since 2012. There were eleven waste incineration plants in operation in Finland at the end of 2022 with total waste incineration capacity of about 1.7 million t/a. The first incineration plant was built in 2007 and the latest one in 2022. Waste incineration is increasing because of the (1) cost of other fuels is believed to rise, (2) due to the tightening regulations and (3) increase in costs for landfilling. (Finnish Energy, 2023)

Waste co-incineration with energy recovery

Waste is also co-incinerated in boilers which are typically using peat and/or biomass as primary fuel. The annual amount of waste co-incinerated is annually about 300,000 – 400,000 tonnes. There are 24 co-incineration plants[3].

Different types of waste are used in incineration and co-incineration plants: the incineration plants typically use source separated municipal solid waste while the co-incineration plants use high quality industrial waste, solid recovered fuels and recovered wood (Finnish Energy, 2023).

As waste incineration/combustion plants are equipped with energy recovery, and are mostly combined heat and power production units, no emissions from incineration are allocated under the Waste sector NFR 5.

Energy and electricity trends

Total electricity consumption in 1990-2022 is presented in Figure 2.4, electricity consumption by sector in Figure 2.5 and electricity supply in Figure 2.6. Energy statistics is available online at [Statistics Finland - Tilastot aiheittain - Energy supply and consumption].

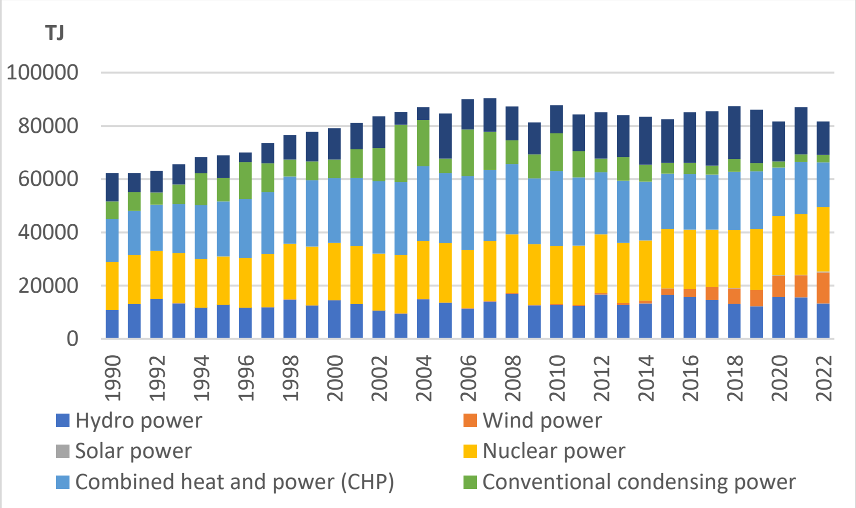


Figure 2.4 Total electricity consumption 1990-2022 (Statistics Finland, Energy statistics, 2023)

Year 2005 which is the base year of the Revised NECD was unusual warm. Then, 2010 which was the target year of the Old NECD (as also e.g. 2008) was colder than the neighbouring years.

Figure 2.4. Total energy consumption in 1990-2022.

[3] https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162690/VNTEAS_2021_08.pdf

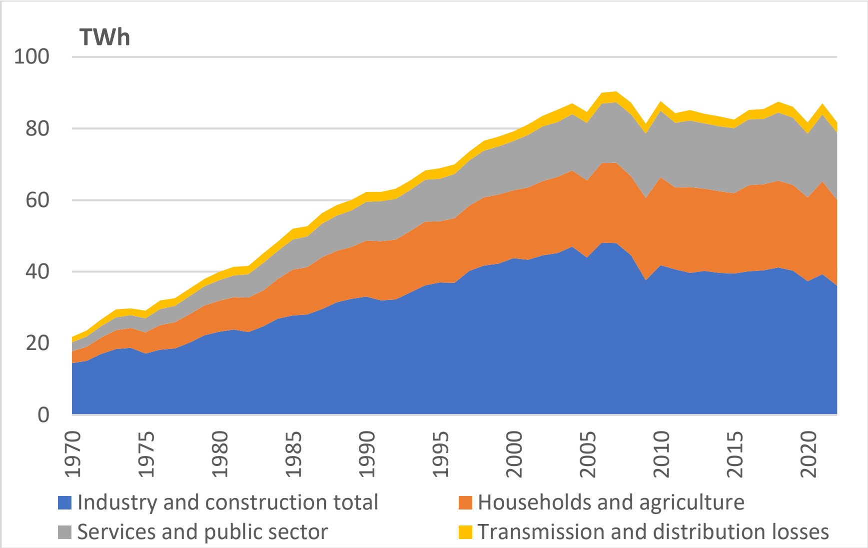


Figure 2.5 Electricity consumption by sector 1980-2022 (Statistics Finland, Energy statistics, 2023).

Year 2005 which is the base year of the Revised NECD was unusual warm. Then, 2010 which was the target year of the Old NECD (as also e.g. 2008) was colder than the neighbouring years.

Figure 2.5. Electricity consumption by sector.

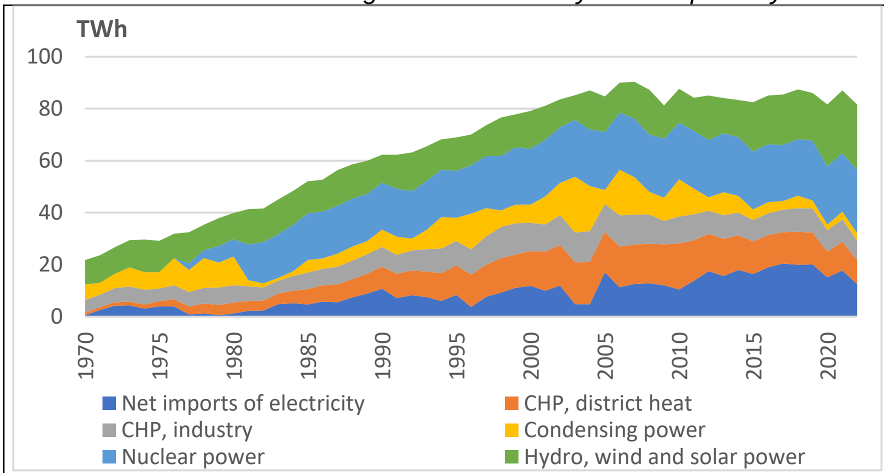


Figure 2.6. Electricity supply 1970-2022 (Statistics Finland, Energy statistics, 2023).

Year 2005 which is the base year of the Revised NECD was unusual warm. Then, 2010 which was the target year of the Old NECD (as also e.g. 2008) was colder than the neighbouring years.

Figure 2.6. Electricity supply.

Energy production and consumption

Changes in chapter	
March 2024	KS, TF

Total consumption of energy

Total consumption of energy in Finland amounted to 1.29 million terajoules (TJ) in 2022, which was 5% lower compared to the year 2021 (Figure 2.4). The use of renewable energy sources decreased by 6% from 2021 but their share of total consumption remained at 42%. The use of fossil fuels and peat also decreased by 6% in total from the previous year. (Statistics Finland, Energy statistics, 2023)

Several significant changes took place on the energy market in 2022. At the beginning of the year, a strike in the Finnish forest industry reduced the use of wood fuels and disrupted the growth trend of renewable energy. In reaction to Russia's large-scale attack on Ukraine, the European Union imposed various restrictions on trade with Russia. The share of energy imported from Russia in total energy consumption was 18 % in 2022, while it had been 32 % in 2021. The import of electricity and pipeline gas from Russia to Finland ceased completely in May. Imports of liquefied natural gas (LNG) from Russia increased by 31 % in 2022. (Statistics Finland, Energy statistics, 2023)

The market prices of gas and electricity rose exceptionally high in Europe in the fall of 2022, which was also reflected in the price of energy in Finland. The high price in Europe was caused by a decrease in natural gas imports from Russia and the need to store natural gas, as well as a dry summer and maintenance shutdowns of French nuclear power. Domestic production of electricity remained on level with the previous year, but the structure of production changed. Wind power grew by 41 per cent and nuclear power by seven per cent. Fuel-based production fell by 13 per cent. (Statistics Finland, Energy statistics, 2023)

Final energy consumption decreased by 5 per cent because of savings measures, high prices, mild weather and weakened economic outlook.

Total energy consumption by source in 1990-2022 is presented in Figure 2.7 (Energy supply and consumption, Statistics Finland).

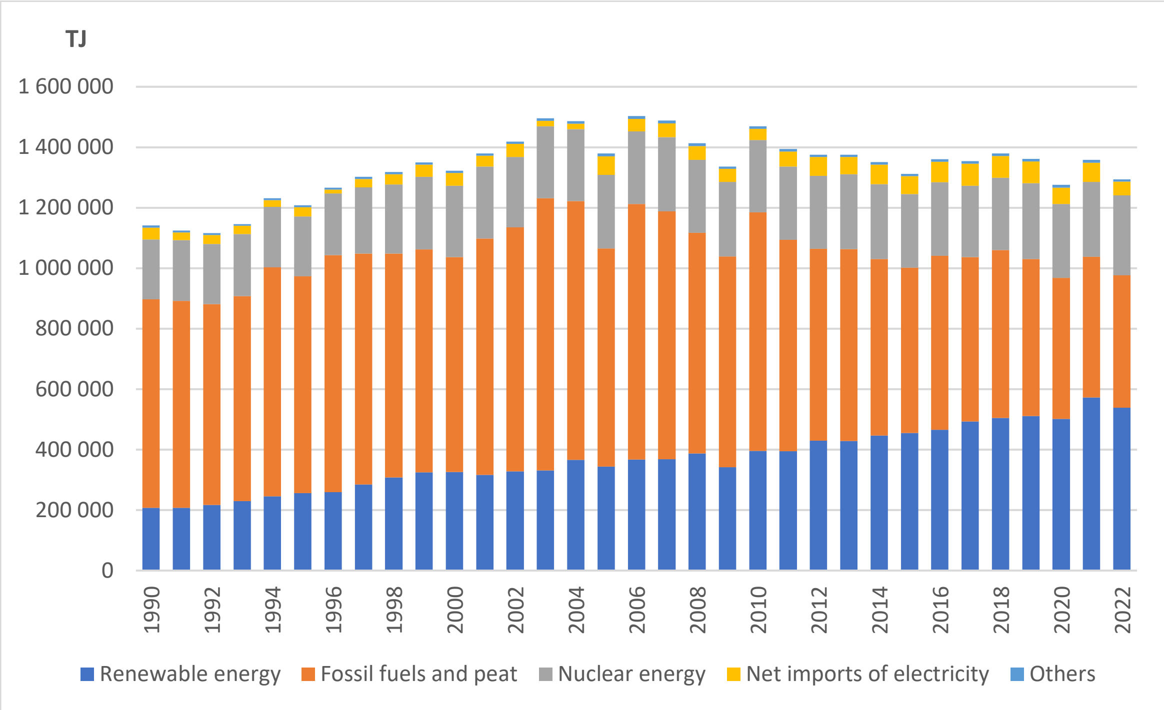


Figure 2.7. Energy consumption by source 1990-2022 (Statistics Finland, Energy statistics, 2023).

Trends of renewable energy

The use of renewable energy sources decreased by 6% in 2022 compared to the previous year but their share of total consumption remained at 42% (Figure 2.8).

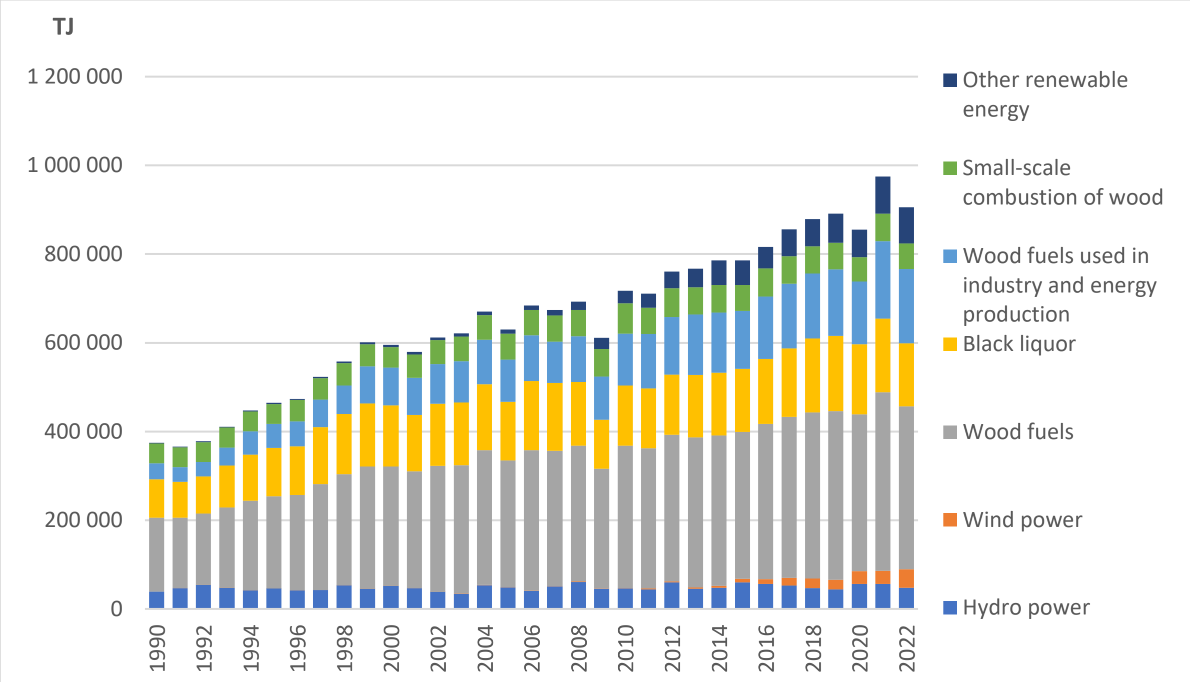


Figure 2.8. Development of renewable energy sources in 1990-2022 (Statistics Finland, Energy statistics, 2023).

The consumption of wood fuels decreased by 9% from 2021. Wooden fuels remained the largest energy source in Finland with the share of 28%. The development of energy consumption of wooden fuels and other biomass is presented in Figure 2.9. The growth is due to combustion of by-products of the forest industries other industrial wood residues. The main by-products/wood residues are black liquor, sawdust and bark. Also, the consumption of logging residues or other low value biomass from silvicultural and harvesting operations has increased (Energy supply and consumption, Statistics Finland).

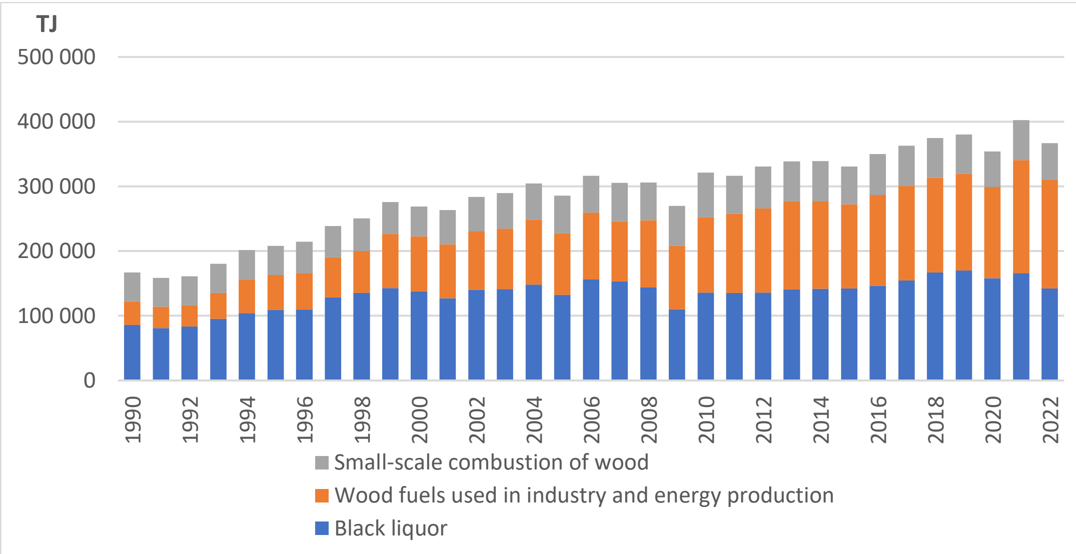


Figure 2.9 Energy consumption of wooden fuels and other biomass 1990-2022 (Statistics Finland, Energy statistics, 2023)

Transport

The total use of energy in transport decreased by 4% in 2022 compared to the previous year. Liquid fuels in road transport had the biggest effect on the decrease. The consumption of petrol and diesel declined by 6% and 5% respectively. The share of biofuels in diesel and petrol declined compared to previous year. The consumption of alternative energy sources in road transport rose by 47%. Annual variation in the consumption of biofuels is caused by Finland's biofuel legislation, which allows the distributors to fulfil the bio-obligation flexibly in advance. (Statistics Finland, Energy statistics, 2023)

Electricity consumption and production in 2022

In 2022, the production of electricity in Finland amounted to 69.1 TWh and the total electricity consumption to 81.7 TWh, thus the difference of 12.6 TWh was net imports. The production of electricity was the same level compared to 2021. Imports of electricity from Russia ceased in May 2022, and net imports of electricity fell by 30% from the previous year (Figure 2.10). Concerns about the sufficiency and high price of electricity rose in Finland during 2022. This resulted in more economical use of electricity than usual as electricity consumption decreased by 6%, which compensates for the drop in imports. (Statistics Finland, Energy statistics, 2023)

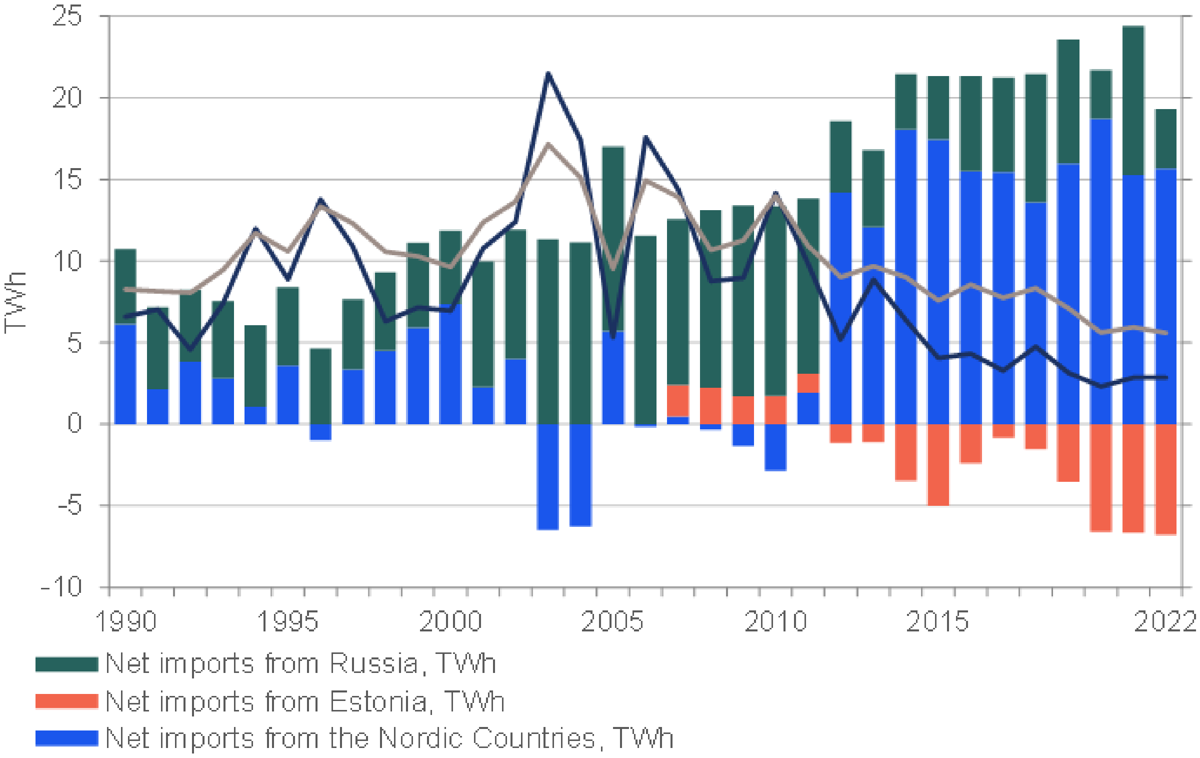


Figure 2.10. Imports and exports of electricity (Statistics Finland, Energy statistics, 2023)

Renewable energy sources and nuclear energy covered 89% of electricity production in 2022. Electricity produced with fossil fuels and peat decreased 23% from the previous year. Electricity produced with natural gas decreased 76% due to ceased import of pipeline gas from Russia. Production of wind power increased by 41% and production of nuclear power by 7% when Olkiluoto 3 nuclear power plant started production. (Statistics Finland, Energy statistics, 2023)

District heating

Production of district heat totalled in 38.3 TWh in 2022. The production decreased 6% from the year before due to the warmer weather compared to 2021. Most of district heat was produced with wood fuels (43%). The second largest energy source in district heat production was hard coal (16%). The third most important source of energy for district heat production was the other energy sources group (13%). This group consist of district heat produced with flue gas scrubbers and other waste heat, including heat pumps. Utilisation of excess heat has grown clearly in the recent years. (Statistics Finland, Energy statistics, 2023)

The use of fossil fuels and peat in the production of district heat decreased by 9% from 2021. The use of natural gas decreased by 69% and peat by 10%. The use of coal increased 22% and use of oil by 77% from 2021. The share of renewable fuels in the production of district heat decreased 3% from the year before. 38% of district heat was produced with fossil fuels and peat and 49% with renewable fuels. (Statistics Finland, Energy statistics, 2023)

The residential and commercial sectors have strongly substituted direct oil heating with district heating and electricity after the 1990s.

Energy production and use in industry

Manufacturing industries and construction produce much of the energy they use by themselves, especially the pulp and paper industries. The trend in manufacturing industries is increased use of biofuels in the forest industry and outsourcing of power plants from industry to the energy sector. The share of wood fuels in energy sources used by manufacturing has grown considerably during the last decade. (Statistics Finland, Energy statistics, 2023)

The production of industrial heat was 47.5 TWh in 2022. Production declined by 9% from the year before. 78% of heat produced for the needs of industry was based on renewable fuels. The biggest user of industrial heat is the forest industry, which uses its own fuels in production, like black liquor and other wood fuels. 51% of heat produced for the needs of manufacturing comes from black liquor. In the chemical, forest and metal industries, part of the use of heat is considered as direct fuel use, and is thus not visible in the production figures on heat. (Statistics Finland, Energy statistics, 2023)

2A Energy industries (NFR 1A1)

Changes in chapter	
March 2024	KS, TF, JM

Source category description

1A1a Public electricity and heat production
1A1b Petroleum refining
1A1c Manufacture of solid fuels and other energy industries (Included elsewhere, IE)

The contribution of NFR categories 1A1a – 1A1b to total emissions, and the shares of emissions under these categories that are reported by the plants, in the year 2022 inventory are presented in Tables 2.11 – 2.12.

NFR 1A1a

Table 2.11. Contribution of NFR 1A1a in 2022 to total emissions and shares reported by the operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NOx (as NO_2)	17.171	Gg	17.3	94.2
NMVOC	1.963	Gg	2.6	14.3
SOx (as SO_2)	7.535	Gg	33.2	89.9
NH_3	0.016	Gg	<0.1	100
$PM_{2.5}$	0.166	Gg	1.2	0
PM_{10}	0.672	Gg	2.5	0
TSP	1.639	Gg	3.9	32.8
BC	0.008	Gg	0.3	0
CO	15.992	Gg	5.2	17.9
Pb	1.800	Mg	14.4	13.5
Cd	0.119	Mg	15.3	18
Hg	0.140	Mg	27.8	70.0
As	0.528	Mg	27.5	11.6
Cr	1.404	Mg	9.4	12.6
Cu	2.328	Mg	6.1	14.4
Ni	1.823	Mg	18.4	23.6
Zn	18.688	Mg	14.2	10.1
PCDDF	2.981	g I-Teq	31.4	13.7
PAH-4	0.476	Mg	2.6	36.3

HCB	0.455	kg	1.6	0
PCB	0.318	kg	1.6	0

NFR 1A1b

Table 2.12. Contribution of NFR 1A1b in 2022 to total emissions and shares reported by the operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NOx (as NO_2)	1.586	Gg	1.6	99.8
NMVOC	0.071	Gg	<0.1	48.0
SOx (as SO_2)	2.500	Gg	11.0	99.8
$PM_{2.5}$	0.016	Gg	0.1	0
PM_{10}	0.022	Gg	<0.1	0
TSP	0.081	Gg	0.2	99.0
BC	<0.001	Gg	<0.1	0
CO	0.761	Gg	0.2	0
Pb	3.125	Mg	25.0	0
Cd	0.071	Mg	9.1	0
Hg	0.015	Mg	2.9	0
As	0.514	Mg	26.8	0
Cr	3.956	Mg	26.5	0
Cu	1.385	Mg	3.6	0
Ni	0.011	Mg	0.1	62.1
Zn	5.936	Mg	4.5	0
PCDDF	0.040	g I-Teq	0.4	0
PAH-4	0.008	Mg	<0.1	0

NFR 1A1c

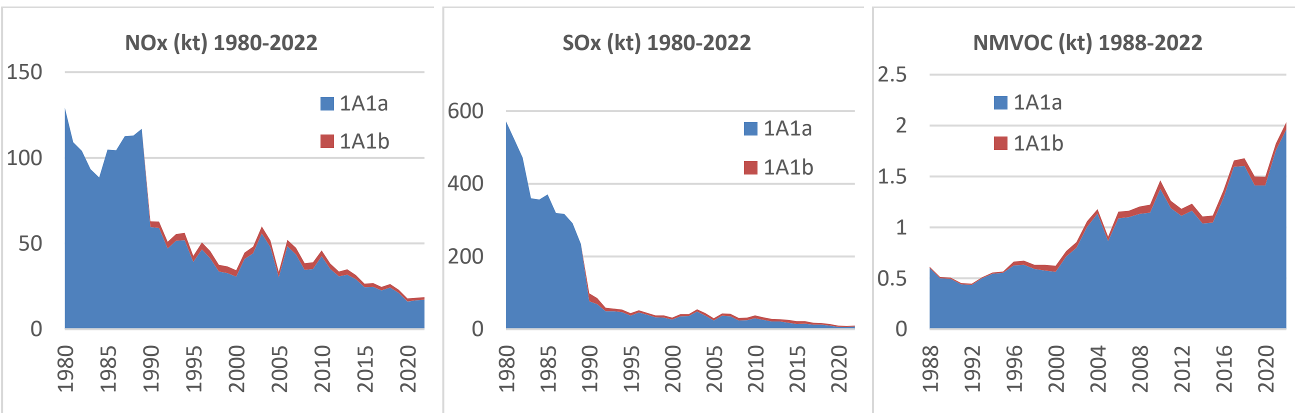
Emissions from NFR 1A1c Manufacturing of solid fuels were earlier reported as “NO” instead of “IE” due to the CLRTAP 2018 S3 review recommendation. The coking plant is part of a very large steel factory complex and all fuel-based emissions from that complex are allocated under the category 1A2a. The notation key change makes the Finnish air pollutant inventory more aligned with the greenhouse gas inventory, where emissions from the plant are reported under 1A1c.

Emission trends

Emission trends in NFR 1A1 subcategories are presented in Figures 2.11.

Please note that the blue bar (1A1a) in 1980-1989 also include 1A2 subcategories as it has not yet been possible to retrospectively split these emissions between 1A1 and 1A2.
Some detailed trend explanations:

- NH3 comes from SCR/SNCR systems and is reported by the plants (also the 2002 peak)
- CO emissions increase in relation to increase of biofuels.



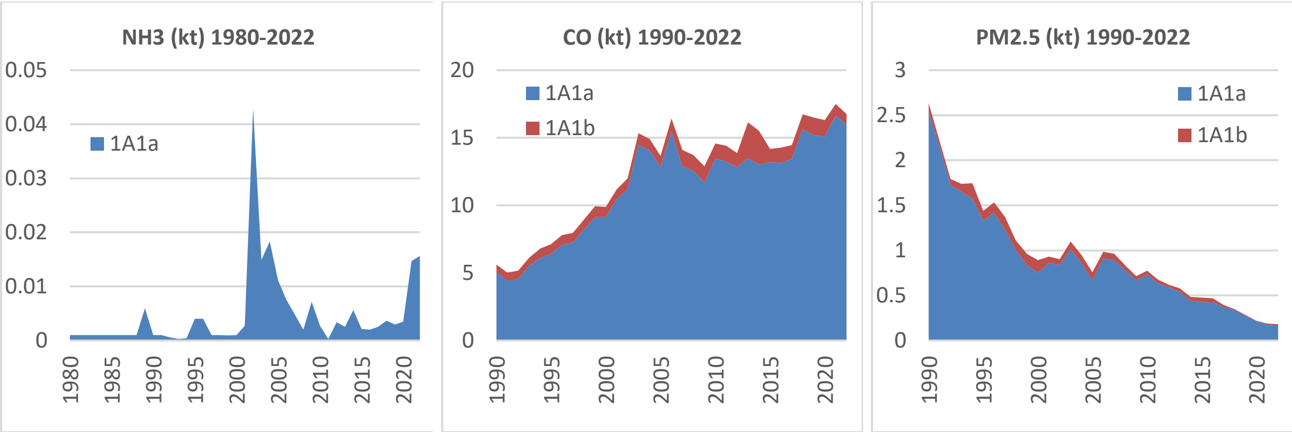


Figure 2.11. Emission trends in 1A1.

Information on circumstances that impact the emission trends is provided under Chapter 1.1.1 in the IIR General Part 1A. Existence of energy intensive industries combined with changes in the economic development and annual fluctuations in the temperature or availability of hydro power from the Nordic electricity market all have large impacts on emissions from NFR 1A1.

Drivers specific to the Energy sector emissions are largely related to energy consumption trends. Changes and development in fuels used and development in combustion and abatement techniques since the early 1980s decreased especially sulphur, particle and heavy metal emissions. Fuel and energy consumption related issues are explained above under the chapters “National characteristics related to energy use” starting from page 8 and “Energy and electricity trends” starting from page 10 of this section of the IIR (i.e. IIR Part 2 Energy).

For the years 1980-1989 the emissions are reported more or less aggregated as it has not been possible to retrospectively split the data back in the day compiled by the main SNAP categories into the later used NFR subcategories, as the NFR category format has been developed much later than the original emission data from that period of time.

2B Manufacturing Industries and Construction (NFR 1A2)

Changes in chapter	
March 2024	KS, TF, JM

Source category description

1A2a	**Stationary combustion in manufacturing industries and construction: Iron and steel**
1A2b	**Stationary Combustion in manufacturing industries and construction: Non-ferrous metals**
1A2c	**Stationary combustion in manufacturing industries and construction: Chemicals**
1A2d	**Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print**
1A2e	**Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco**
1A2f/1A2gviii	**Stationary combustion in manufacturing industries and construction: Other (Please specify in your IIR)**

The contribution of NFR categories 1A2 subcategories to total emissions, and the shares of emissions under these categories that are reported by the plants, in the year 2022 inventory are presented in Tables 2.13 – 2.18.

Table 2.13. Contribution of NFR 1A2a in 2022 to total emissions and shares reported by the operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NOx (as NO_2)	2.968	Gg	3.0	100
NMVOC	0.014	Gg	<0.1	0
SOx (as SO_2)	0.224	Gg	1.0	99.8
$PM_{2.5}$	0.001	Gg	<0.1	0
PM_{10}	0.005	Gg	<0.1	0
TSP	0.014	Gg	<0.1	98.9
BC	<0.001	Gg	<0.1	0
CO	0.668	Gg	0.2	0.2
Pb	<0.001	Mg	<0.1	0
Cd	<0.001	Mg	<0.1	0
Hg	<0.001	Mg	<0.1	0
As	<0.001	Mg	<0.1	0
Cr	<0.001	Mg	<0.1	0
Cu	<0.001	Mg	<0.1	0
Ni	<0.001	Mg	<0.1	0
Zn	0.008	Mg	<0.1	0
PCDD/F	0.006	g I-Teq	<0.1	0
PAH-4	<0.001	Mg	<0.1	0
HCB	<0.001	kg	<0.1	0
PCB	0.093	kg	0.5	0

Table 2.14. Contribution of NFR 1A2b in 2022 to total emissions and shares reported by the operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NOx (as NO_2)	0.163	Gg	0.2	90.1
NMVOC	0.001	Gg	<0.1	28.9
SOx (as SO_2)	2.468	Gg	10.9	99.5
$PM_{2.5}$	0.003	Gg	<0.1	0
PM_{10}	0.006	Gg	<0.1	0
TSP	0.009	Gg	<0.1	74.5
BC	<0.001	Gg	<0.1	0
CO	0.087	Gg	<0.1	76.2
Pb	<0.001	Mg	<0.1	0
Cd	<0.001	Mg	<0.1	0
Hg	<0.001	Mg	<0.1	0
As	<0.001	Mg	<0.1	0
Cr	0.123	Mg	0.8	0
Cu	<0.001	Mg	<0.1	0
Ni	0.035	Mg	0.3	0
Zn	<0.001	Mg	<0.1	0
PCDD/F	<0.001	g I-Teq	<0.1	0
PAH-4	0.002	Mg	<0.1	0
HCB	<0.001	kg	<0.1	0
PCB	0.021	kg	0.1	0

Table 2.15. Contribution of NFR 1A2c in 2022 to total emissions and shares reported by the operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	1.183	Gg	1.2	97.9
NMVOC	0.008	Gg	<0.1	5.0
SOx (as SO2)	0.430	Gg	1.9	79.9
PM2.5	0.024	Gg	0.2	0
PM10	0.054	Gg	0.2	0
TSP	0.064	Gg	0.2	75.5
BC	0.005	Gg	0.2	0
CO	0.284	Gg	<0.1	9.8
Pb	0.025	Mg	0.2	0
Cd	<0.001	Mg	<0.1	0
Hg	<0.001	Mg	<0.1	0
As	0.002	Mg	0.1	0
Cr	0.001	Mg	<0.1	0
Cu	0.003	Mg	<0.1	0
Ni	0.298	Mg	3.0	0
Zn	0.016	Mg	<0.1	0
PCDD/F	0.007	g I-Teq	<0.1	0
PAH-4	0.004	Mg	<0.1	0.5
HCB	<0.001	kg	<0.1	0
PCB	<0.001	kg	<0.1	0

Table 2.16. Contribution of NFR 1A2d in 2022 to total emissions and shares reported by the operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	12.930	Gg	13.0	97.4
NMVOC	0.293	Gg	0.4	3.9
SOx (as SO2)	1.645	Gg	7.3	73.7
PM2.5	0.734	Gg	5.5	0
PM10	1.204	Gg	4.5	0
TSP	1.380	Gg	3.3	95.8
BC	0.013	Gg	0.4	0
CO	13.452	Gg	4.3	12.1
Pb	1.843	Mg	14.7	6.8
Cd	0.119	Mg	15.3	6.0
Hg	0.079	Mg	15.7	42.3
As	0.104	Mg	5.4	15.9
Cr	0.145	Mg	1.0	80.0
Cu	0.402	Mg	1.0	88.7
Ni	0.379	Mg	3.8	46.2

Zn	1.194	Mg	0.9	35.3
PCDD/F	0.664	g I-Teq	7.0	37.1
PAH-4	0.281	Mg	1.5	73.5
HCB	0.120	kg	0.4	0
PCB	0.026	kg	0.1	0

Table 2.17. Contribution of NFR 1A2e in 2022 to total emissions and shares reported by the operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	0.280	Gg	0.3	91.8
NMVOC	0.014	Gg	<0.1	0
SOx (as SO2)	0.233	Gg	1.0	86.3
PM2.5	0.004	Gg	<0.1	0
PM10	0.011	Gg	<0.1	0
TSP	0.019	Gg	<0.1	60.0
BC	<0.001	Gg	<0.1	0
CO	0.252	Gg	<0.1	0.2
Pb	0.101	Mg	0.8	3.0
Cd	0.002	Mg	0.3	3.1
Hg	0.002	Mg	0.4	12.5
As	0.042	Mg	2.2	3.9
Cr	0.084	Mg	0.6	1.2
Cu	0.115	Mg	0.3	0.8
Ni	0.134	Mg	1.4	20.8
Zn	0.267	Mg	0.2	6.2
PCDD/ PCDF	0.024	g I-Teq	0.2	0
PAHs	0.004	Mg	<0.1	0
HCB	0.002	kg	<0.1	0
PCBs	0.033	kg	0.2	0

Table 2.18. Contribution of NFR 1A2f in 2022 to total emissions and shares reported by the operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	2.113	Gg	2.1	95.3
NMVOC	0.017	Gg	<0.1	0
SOx (as SO2)	0.432	Gg	1.9	90.1
PM2.5	0.011	Gg	<0.1	0
PM10	0.034	Gg	0.1	0
TSP	0.073	Gg	0.2	87.3
BC	0.002	Gg	<0.1	0
CO	2.998	Gg	1.0	8.8
Pb	0.646	Mg	5.2	7.1
Cd	0.017	Mg	2.1	17.6
Hg	0.023	Mg	4.5	87.7
As	0.099	Mg	5.2	1.2
Cr	0.768	Mg	5.2	1.8
Cu	0.273	Mg	0.7	2.7
Ni	0.656	Mg	6.6	1.1
Zn	4.159	Mg	3.2	0
PCDD/F	0.019	g I-Teq	0.2	53.2
PAH-4	0.009	Mg	<0.1	0
HCB	0.002	kg	<0.1	0
PCB	0.350	kg	1.8	0

Emission trends

Changes in chapter	
March 2024	KS, TF, JM

Emission trends in 1A2 NFR subcategories are presented in Figure 2.12.

Information on circumstances that impact the emission trends is provided under Chapter 1.1.1 in the IIR General Part 1A. Existence of energy intensive industries combined with changes in the economic development and annual fluctuations in the temperature or availability of hydro power from the Nordic electricity market all have large impacts on the emissions.

Drivers specific to the Energy sector emissions are largely related to energy consumption trends. Changes and development in fuels used and development in combustion and abatement techniques since the early 1980s decreased especially sulphur, particle and heavy metal emissions. Fuel and energy consumption related issues are explained above under the chapters “National characteristics related to energy use” starting from page 8 and “Energy and electricity trends” starting from page 10 of this section of the IIR (i.e. IIR Part 2 Energy).

Emissions for the years 1980-1989 are included under NFR 1A1a (see above) as it has not been possible to split the data compiled by the main SNAP categories into the NFR subcategories, which have been developed much later than the original emission data from that period of time.

Some detailed trend explanations:

- NO_x and NMVOC – 1A2d Pulp and paper production decreased by 20% during 2009-2010 (closer information under NFR 2H1)
- NMVOC fluctuations especially in NFR 1A2d are due to fuel changes between the years.
- NH_3 emissions come from SCR/SNCR systems. Under NFR 1A2gviii the emissions start from 2012 because a new boiler using the SCR techniques started operation then. Under this same category, also a new biogas plant started operation in 2021. The increase in NH_3 emissions from this category is thus due to the emissions reported by this plant.

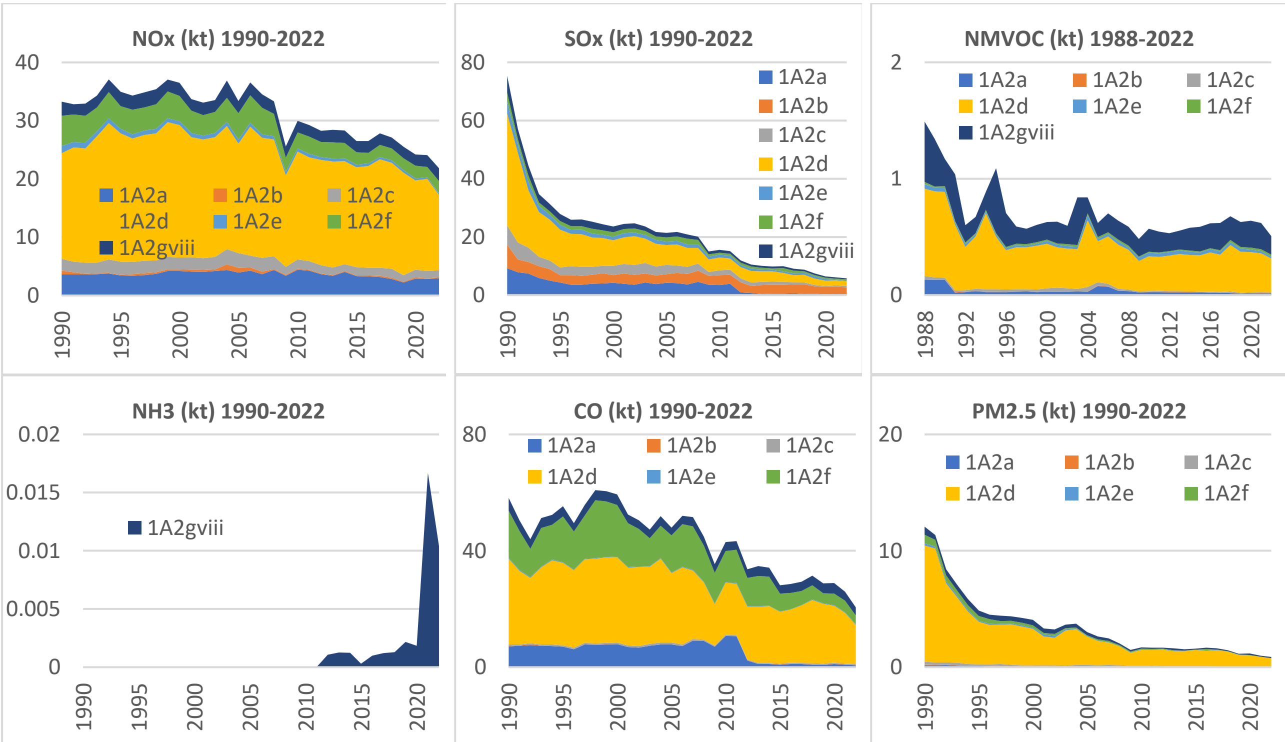


Figure 2.12. Air pollutant emission trends from Manufacturing industries (NFRs 1A2).

Changes in chapter	
February 2021	KS, TF, JM

Overview of the calculation of emissions

The inventory is carried out at Tier 3 level and is a combination of emission data reported by the operators according to their monitoring programs under their environmental permits, and default emission values calculated from fuel consumption reported by the operators at the level of individual boilers, for those emissions not reported by the plants. All emissions are calculated in the same way and emissions are thereafter allocated under the NFR categories.

The calculation of emissions follows the following main phases:

1. Calculation of emissions for all boilers (all point sources) based on fuel use data (data sources for fuel use: EU ETS or YLVA)
2. Combination of calculated emissions data to the emissions data reported by the plants according to their environmental permits (principle: if reported data exists, it is used in the inventory reporting over the calculated emissions)
3. Allocation of emissions into the NFR and SNAP classifications

Details of the emission calculation process are presented in the below chapters.

Emission data, activity data and emission factors

The calculation of emissions is based on detailed information on the technologies, abatement techniques and consumption of fuels for each boiler. The emission factors are country or plant specific for all pollutants, except for HCB and PCB emission factors, which are from Guidebook 2019. The calculation methods are consistent with the EMEP/EEA Emission Inventory Guidebook.

The default emissions calculated for each boiler are used in the inventory when no emission data reported by the operators are available, and, as verification of emission data reported by the operators, or when the data is assessed to be erroneous.

For the large plants data from the Energy Authority (ETS data) has been the main source for fuels. Energy Statistics and bottom-up data for emissions, fuels and technological information available from the Environmental Authorities' database (YLVA; former VAHTI) are used. The YLVA data is based on information required according to the environmental permits and annual emission reports by the operators according to the emission monitoring programmes under the environmental permits

Environmental authorities' database

Boiler and process level data is available in the environmental authorities' database, formerly VAHTI, from 2018 YLVA. The detailed data on boiler/process technologies, abatement techniques, fuel consumption and fuel properties allow calculation of emissions using technology-specific emission factors for non-CO_2 emissions. In addition to fuel consumption, the plants annually report emission data according to the monitoring and reporting requirements in their environmental permits, mainly set for SO_2, NO_x and TSP emissions, in some cases also for NMVOCs, ammonia, heavy metals and POPs.

The number and distribution of Finnish energy plants in 2022 in the YLVA database is presented in Table 2.19. These point sources cover together a well over two thirds of the total annual fuel combustion, in 2022 almost 90%. The total number of installations in YLVA is approximately one thousand. These installations include around 2 000 boilers or industrial processes.

Note for a comparison between the CRF and NFR tables:

In the Finnish industries it is typical, that there are a lot of CHP plants and heat boilers at the industrial sites, producing steam for manufacturing industry. In some cases these heat and power plants are owned by the industrial companies, and sometimes by energy companies. There may be changes in the ownership during the time series, for example a power plant belonging to industrial company may be outsourced to an energy company or vice versa. Due to these ownership changes the allocation of plants with different technologies to CRF categories may change (1.A.1a versus 1.A.2x). In the Finnish air pollutant emissions inventory, the allocation of plants in the NFR categories is kept unchanged in spite of the ownership changes.

Table 2.19 Number of boilers included in the year 2022 inventory.

Category	Number of boilers in 1A1	Number of boilers in 1A2
Combustion plants > = 300 MW (boilers)	11	5
Combustion plants > = 50 and < 300 MW (boilers)	78	45
Combustion plants > = 20 and < 50 MW (boilers)	69	76
Combustion plants < 20 MW (boilers)	573	321
Gas turbines	43	1
Stationary engines	33	14
Process ovens and other	8	152
Total	815	614

A. Use of ETS data

The availability of EU ETS started from 2005, the second period from 2008, the third period from 2013 and the fourth period from 2021. The ETS data is considered reliable data regarding both the consumed volumes and properties of fuels. Since the submission in 2015 ETS has been used as the primary data source for the fuel consumption for point sources for years when the data has been available. For verification and complementary purposes ETS data has already been used a decade. In the recalculation of the time series 1990-2016 in submission 2018, ETS data was used as the primary data source for years available. The fuel consumption data reported to the Emission Trading Registry has in the later years generally not been on the level of individual boilers/processes but on a more aggregated level. However, in the energy sector calculation model, all the data are distributed to the detailed boiler/process level used in YLVA database.

In the preparation of the inventory, NCVs and fuel consumption data for the ETS plants are compared to the corresponding data in the inventory. If there are significant differences, corrections are carried out to the inventory data. Generally, for the most common fuels, the differences in aggregated NCVs and EFs on a facility level are less than +-1%. For the different wood fuels the differences in NCVs can be somewhat larger (+-2-10%) for individual facilities due to difficulties of plant operators in disaggregating the wood residues to the fuel code system, but also due to variations in the moisture content of wood fuels.

Information compiled from YLVA database and Emission Trading Registry is completed and cross-checked against fuel data from the energy statistics and comparisons are made with data in CRF tables prepared by Statistics Finland, at the aggregation level allowed for statistical confidentiality.

No subtraction of confidence intervals

Finland does not subtract any confidence intervals referred to in the IED because the subtractions are meant to be used only in comparing the emissions against ELVs (emission limit values) and not in reporting annual emissions or in emission inventories. Finland also provides national guidance to operators and authorities on the issue to ensure any subtraction is made. This statement is made due to the question presented to Finland in the 2017 NECD Technical Review.

Fuels

Changes in chapter	
January 2021	KS, TF, JM

Information on the main fuels are provided below and a full list of definitions and classifications for fuels used in Finland is available at Statistics Finland's website at https://www.tilastokeskus.fi/en/luokitukset/polttoaineet/

Solid fuels
Solid fuels include imported hard coal, coke and other fuels (BFG, coke oven gas) derived from coal. Coal is mainly imported from Poland, Russia, the USA and Great Britain.

Wood fuels
Wooden fuels are domestic and include about 20 subgroups in the categories of forest fuelwood, industrial wood residue, by-products from wood processing industry, recovered wood, wood pellets and briquettes. *Black liquor and other concentrated liquors* is one of the categories under wood fuels.

Peat
Peat is domestic fuel and represents in the stationary combustion typically 4-7% of total primary energy supply and 6-10% of combustible fuels but may vary considerably between the years. Also, the quality of the peat varies depending on weather conditions as can be seen from the measured plant level caloric values.

Natural gas
Natural gas used in Finland consists almost totally (>98%) of methane. The use in power plants became common since the end of the 1980s. The distribution network for natural gas covers Southern Finland. The range of NCV has been 35.8 to 36.5 MJ/m^{3}n. Historically all natural gas used in Finland was imported from Russia since 1974. However, in May 2022, the pipeline gas from Russia to Finland ceased completely due to Russia's large-scale attack on Ukraine.

Oil
Oil is still an important energy source as reserve and back-up fuel in many power plants.

Mixed fuels
This category consists of different types of wastes and waste-derived fuels.

Refinery gas

There have been changes in the refinery processes towards lighter products (gasoline, LPG, diesel oil), which affect the properties of refinery gases. In the earlier years CO and NMVOC EFs are based on the compilation of research data by Prosessikemia Oy (Boström et al. 1992; Boström 1994) and have since been revised using the results of a measurement programme (Tsupari et al. 2005; Tsupari et al. 2006; Tsupari et al. 2007) during longer periods to cover start-ups, partial loads and other exceptional conditions as well.

The main properties of fuels are presented in Table 2.20. The operators report both fuel quantities as well as energy contents of the fuels used to the YLVA system. Thus, in the bottom-up data, there are some variations in the NCVs.

Table 2.20. Properties of fuels: heating values, density and sulphur contents

Fuel	Heating values (per mass)		Heating values (per volume)		Density		Default S content
	Value	Unit	Value	Unit	Value	Unit	%
Heavy fuel oil (S<1%)	41.10	GJ/t	40.07	GJ/m3	0.98	t/m3	0.9
Light fuel oil (S=0.0915%)	42.80	GJ/t	36.17	GJ/m3	0.85	t/m3	0.0915
Diesel oil (S=0.001%)	42.80	GJ/t	35.95	GJ/m3	0.84	t/m3	0.001
industrial gasoline	44.30	GJ/t	31.01	GJ/m3	0.70	t/m3	0.005
Aviation fuel	43.30	GJ/t	34.42	GJ/m3	0.80	t/m3	0.04
Coal, bituminous (S=0.8%)	25.00	GJ/t	20.00	GJ/m3	0.80	t/m3	0.8
Coke (S=1.0%)	29.30	GJ/t	21.98	GJ/m3	0.75	t/m3	1
Milled peat	10.10	GJ/t	3.23	GJ/m3	0.32	t/m3	0.1
Sod peat	12.30	GJ/t	4.67	GJ/m3	0.38	t/m3	0.11
Natural gas	49.79	GJ/t	36.00	GJ/1000m3	0.72	kg/m3	0.0001
LPG	46.20	GJ/t	23.42	GJ/m3	0.51	t/m3	0.00002
Blast furnace gas	2.95	GJ/t	3.80	GJ/1000m3	1.29	kg/m3	0.000001
Coke oven gas	34.79	GJ/t	16.70	GJ/1000m3	0.48	kg/m3	0.05
Refinery gas	50.00	GJ/t	35.00	GJ/1000m3	0.70	kg/m3	0.01
Other fossil fuel	46.20	GJ/t	32.34	GJ/1000m3	0.70	kg/m3	0.004
Black liquor	11.50	GJ/t	16.56	GJ/m3	1.42	t/m3	5
Wood residue or chips	9.50	GJ/t	2.38	GJ/im3	0.25	t/im3*	0.008
Sawdust, cutter chips etc.	8.00	GJ/t	1.40	GJ/im3	0.18	t/im3*	0.0075
Board	7.50	GJ/t	2.48	GJ/im3	0.31	t/im3*	0.0165
Non specified industrial wood residues (other	7.50	GJ/t	1.68	GJ/im3	0.21	t/im3*	0.012
Biogas from wastewater treatment	19.40	GJ/t	23.00	GJ/1000m3	1.16	kg/m3	0.01
Smelling gases	5.99	GJ/t	20.00	GJ/1000m3	3.34	kg/m3	15
Other biogas (other non-fossil gas)	19.83	GJ/t	20.00	GJ/1000m3	1.16	kg/m3	0.01
Recycled and waste oil	41.00	GJ/t	39.98	GJ/1000m3	0.98	kg/m3	0.9
Product gas (other gas)	11.68	GJ/t	13.30	GJ/1000m3	1.14	kg/m3	0.003
Wood residue or wood chips	10.00	GJ/t	3.25	GJ/im3	0.33	t/im3*	0.01
Motor gasoline (S=0.001%)	41.70	GJ/t	31.28	GJ/m3	0.75	t/m3	0.001
Other petrols	43.10	GJ/t	34.91	GJ/m3	0.81	t/m3	0.07
Convert gas	2.95	GJ/t	3.80	GJ/1000m3	1.29	kg/m3	0.000001
Wood pellets and brickets (refined wood fuels)	16.00	GJ/t	10.40	GJ/m3	0.62	t/m3	0.008
Landfill gas	11.94	GJ/t	17.00	GJ/1000m3	1.34	kg/m3	0.01
Hydrogen	120.00	GJ/t	10.80	GJ/1000m3	0.09	kg/m3	0.000001
HFO (normal, S>1%)	40.50	GJ/t	39.97	GJ/m3	0.99	t/m3	1.4
Special oils corresponding to HFO	40.20	GJ/t	39.97	GJ/m3	0.99	t/m3	2.7
Other medium heavy oils	42.70	GJ/t	35.01	GJ/m3	0.82	t/m3	0.12
Nafta	42.80	GJ/t	35.95	GJ/m3	0.84	t/m3	0.001
Aviation gasoline	43.70	GJ/t	31.03	GJ/m3	0.71	t/m3	0.002
Motor petrol	43.10	GJ/t	34.91	GJ/m3	0.81	t/m3	0.07
Kerosene	43.10	GJ/t	34.91	GJ/m3	0.81	t/m3	0.02
Town gas	14.66	GJ/t	16.90	GJ/1000m3	1.15	kg/m3	0.00001
Industrial biogas	27.32	GJ/t	20.00	GJ/1000m3	0.97	kg/m3	0.01
Refined recycled or waste oil	41.00	GJ/t	39.98	GJ/m3	0.98	t/m3	0.9
Oil products	42.12	GJ/t	35.28	GJ/m3	0.84	t/m3	0.21

Fuel consumption

Changes in chapter	
March 2024	TF

The Environmental authorities' database and the Emission Trading Registry contain records for 140 fuel types. An overview of the consumption of different fuels in 1990-2022 in NFRs 1A1 and 1A2 is presented in Table 2.21.

Table 2.21. Fuel consumption in NFR 1A1 (a) and 1A2 (b) in 1990-2022 (PJ) (Source: IPTJ Finnish Environment Institute 2024).

(a) Fuel consumption under NFR 1A1

		1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
Liquid fuels	Heavy fuel oil	18.7	21.8	17.3	11.5	13.0	7.9	6.1	5.1	3.4	2.9	1.3	1.8	1.8
	Light fuel oil	1.3	1.1	0.8	0.7	0.5	0.4	0.9	1.0	1.9	1.5	1.0	2.4	3.4
	Refinery gases	15.6	18.3	15.1	17.3	23.1	20.4	25.6	25.2	25.1	35.3	31.0	14.1	18.9
	Other liquid fuels	2.6	3.7	4.2	8.9	8.3	4.8	5.7	5.5	6.4	7.3	6.9	6.9	10.7
Solid fuels	Hard coal	102.8	103.6	86.5	71.5	137.3	59.2	78.0	68.4	66.8	53.4	31.8	36.6	42.5
	Other solid fuels	NO	NO	0.0	0.0	0.3	0.7	3.0	3.8	4.4	3.8	3.2	4.9	3.7
Peat	Peat	42.7	64.0	45.6	54.2	80.9	44.2	43.7	41.4	49.3	44.4	33.8	29.3	30.0
Gaseous fuels	Natural gas and other gaseous fuels	48.3	66.4	84.4	96.1	100.5	49.9	41.5	34.2	44.9	42.3	43.7	46.5	15.7
Biomass	Wood fuels	7.0	13.0	27.1	45.5	66.0	78.3	78.9	82.3	90.8	89.2	83.5	97.6	89.6
	Other non-fossil fuels	0.6	0.2	0.2	1.4	2.6	2.7	2.5	2.8	5.5	3.3	5.1	5.0	4.1
Other fuels	Other fuels	0.05	0.8	1.8	4.6	5.2	13.0	15.4	14.4	15.8	14.4	14.5	14.8	13.3

b) Fuel consumption under NFR 1A2

		1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
Liquid fuels	Heavy fuel oil	29.4	25.3	23.3	18.9	11.3	7.6	8.0	7.2	7.9	6.2	5.7	5.3	6.3
	Light fuel oil	2.2	2.3	2.6	2.3	1.5	1.0	1.0	1.0	1.7	2.5	2.6	1.3	1.7
	Refinery gases	5.5	6.2	7.3	8.6	10.0	10.8	10.9	10.0	4.3	11.9	11.8	9.0	8.9
	Other liquid fuels	3.5	4.9	9.1	12.4	12.2	12.0	12.3	11.5	12.1	8.6	9.3	10.6	8.6
Solid fuels	Hard coal	26.3	17.0	11.8	9.0	7.3	2.6	3.4	3.1	3.0	2.5	1.8	1.7	1.6
	Coke	2.4	4.9	5.3	5.6	4.5	1.1	1.1	0.9	1.1	1.0	1.0	0.9	1.5
	Other solid fuels	14.1	20.3	24.0	26.0	20.7	20.9	20.2	18.4	15.4	6.6	13.1	17.4	15.3
Peat	Peat	11.4	14.4	16.4	14.3	14.3	11.3	10.2	9.8	10.1	9.7	7.7	7.3	5.1
Gaseous fuels	Natural gas and other gaseous fuels	38.4	44.0	48.6	46.4	40.6	25.8	24.8	23.9	26.9	28.8	28.4	31.1	24.2
Biomass	Wood fuels	45.8	43.8	51.9	36.5	33.3	33.6	36.5	37.9	39.7	34.0	32.4	35.5	35.3
	Black liquor	88.7	108.7	139.9	133.5	135.9	142.1	145.7	153.0	155.7	158.6	158.0	165.6	133.5
	Other non-fossil fuels	4.3	5.0	6.3	4.6	6.5	5.7	6.2	7.5	9.8	6.7	5.8	7.1	10.5
Other fuels	Other fuels	2.3	4.3	3.4	3.5	6.0	8.6	8.0	9.8	9.4	7.4	7.8	10.6	8.2

Calculation processes of emissions for combustion plants based on fuel use

Changes in chapter	
May 2018	KS, JM and TF

The process of calculating emissions from combustion plants is presented in Figure 2.13.

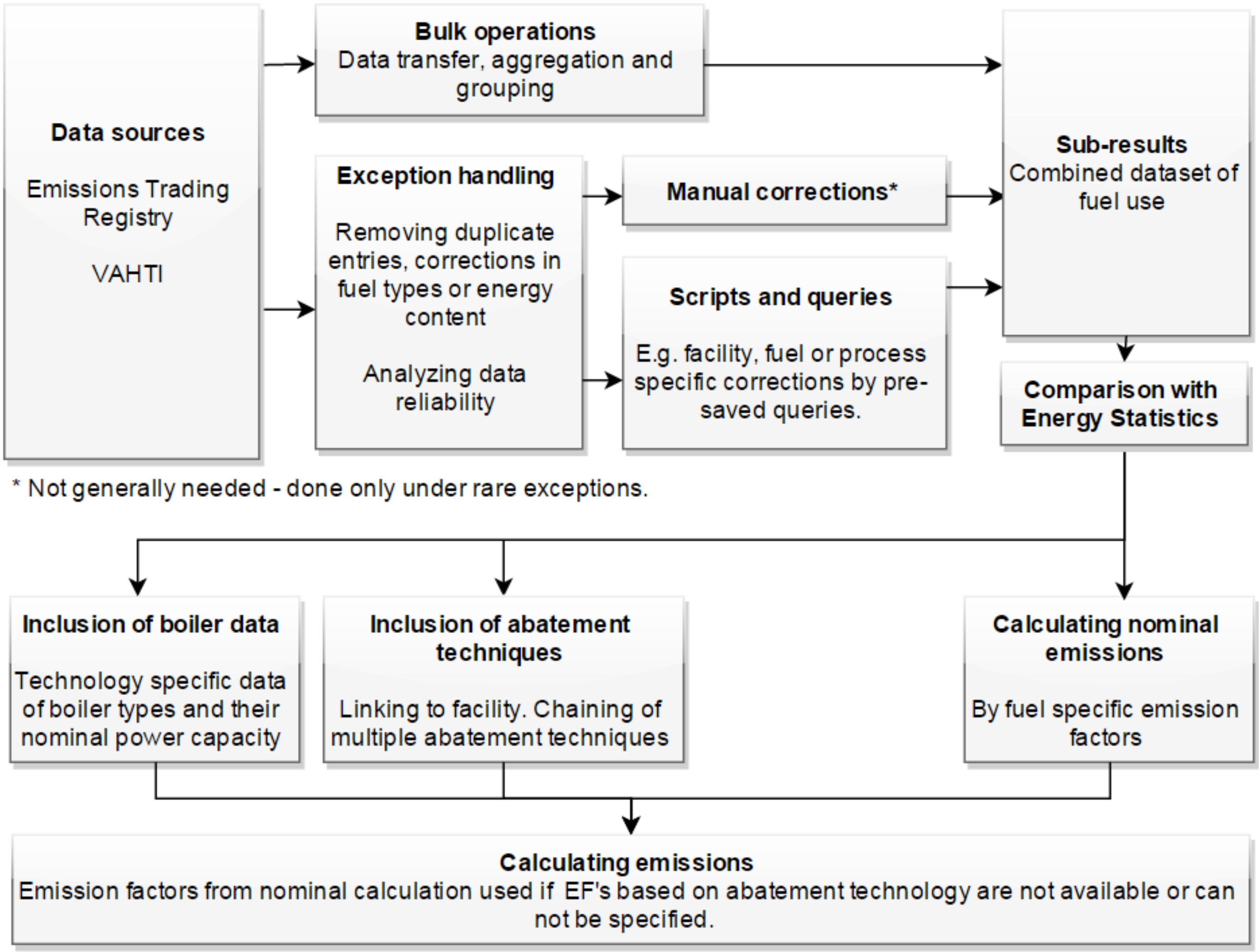


Figure 2.13. The process of calculating emissions from combustion plants

Phase 1 – Compiling data of fuel use

The main data sources in the energy sector emissions inventory are YLVA and Emissions Trading Registry, which has been the primary data source for fuel consumption for point sources since the 2015 inventory. The fuel data in the Emission Trading Registry is generally considered to be more reliable than YLVA data due to the extensive verification measures that are performed to the reported data. The fuel consumption data reported to the Emission Trading Registry is generally on a more aggregated (plant) level compared to the boiler level data reported to the YLVA system.

The gathered data on fuel use is prepared by removing duplicate rows for accidental multiple entries, identifying data in rows with large deviation or changes in comparison to the previous years, and/or errors in the volumetric allocation of the data. For example, some volumetric errors of LPG precede from the reporting unit being changed from cubic metres to tons. Erroneous rows are inspected separately by plant-specific queries in the energy calculation model. For large emission sources, some uncertain values are separately verified by inquiries to Regional Environmental Centres or in some cases, by contacting the plant directly.

The most common corrections made to the data before using it in the inventory are:

1. Correcting the energy content of the fuel
2. Reassigning reported fuel types (typically from main category of fuels to a specific fuel)
3. Relocating the point data of fuel use to the correct boilers
4. Correcting the value of fuel use where two or more boilers within a facility share the exact same value of fuel use
5. Distributing a sum value of plant specific fuel use to the corresponding boilers and removing the original sum value in order to prevent duplication

Corrections numbers 1 to 4 are carried out to correct inaccuracies in the data reported by plant operators. As an example, two or more boilers within a facility sharing the exact same fuel use is usually an indicator of a facility-level fuel use being duplicated to each unique boiler, thus correction number 4 is made after assessing the case in detail. Correction number 5 is a detail-increasing operation and carried out when more accurate data of the facility configuration is available but not available in the data systems. This kind of information is usually based on expert knowledge of the plant.

In the case of plant specific data being available in both registers (YLVA and Emissions Trading Registry), the entries with varying values for any relevant parameter are checked with specified queries which aim to select the values of greater reliability. A recurring error to be corrected is a unit conversion error in powers of ten. Lesser errors are revealed by comparing the calculated heat of combustion based on the reported fuel data. The value from the data source possessing a more exact match to the calculated value or a stronger correlation to other reported data is selected as the value for further calculations. In some cases, differing identification properties of the two data sources enable an aggregate value for a facility to be divided into its corresponding combustion units if a plant is known to possess multiple units.

To assess fuel data reliability, a comparison is made to fuel data provided by Statistics Finland on CRF (Common Reporting Format) level. If notable differences occur, the sources of the differences are investigated and corrected. The detail-increasing assumptions are based on expert knowledge of operational principles of a specific facility or a process and may take into account such variables as used fuel type and ratio, sulphur content, abatement technology or other boiler specific details. More information on the use of ETS data and inter-comparison with the Finnish greenhouse gas inventory is provided under Chapter 2.2.4.

Phase 2 – Calculating nominal emissions

The calculation of nominal emissions follows the equation:

$$E_{pollutant} = AR * EF_{fuel}$$

Where
E = Emissions of a pollutant
AR = Activity rate (e.g. energy value by fuel combustion)
EF_{fuel} = Fuel specific emission factor

Energy value from fuel combustion to be used as the activity rate (AR) is derived by the following equation (point sources only):

$AR = \Delta H_c * Fb$

Where ΔH_c = Heat of combustion [GJ/t]
F_b = Fuel consumption (boiler or facility) [t]

Nominal emissions are calculated for all points from fuel consumption with fuel specific emission factors. This gives an estimation of emissions without the effect of abatement techniques or technology specific details. The figure will be used as the default value of emissions per boiler. For boilers with applicable information of boiler and abatement technologies, the emission value is recalculated in phases 3-4 taking this information into account.

Phase 3 – Inclusion of boiler data

Boiler details are extracted from YLVA and completed with expert knowledge of the plants. Technology specific emission factors are currently available for the following technologies with the listed classifications of capacities:

- grate 50-500 MW
- grate and combined 1-5 MW, 15-50 MW, 5-10 MW, 5-15 MW, 50 MW, 500 MW, 15-50 MW, 5-50 MW
- grate >500 MW,
- grate etc 1-15 MW, 1-50 MW, 15-150 MW, 50-150 MW, 50-300 MW, >300 MW
- grate combined and burner etc. 1-5 MW, 1-50 MW, 5-50 MW, 1 MW, >50 MW
- grate, combined >i 1 MW
- asphalt station
- BFB 15-50 MW, 5-15 MW, 5-50 MW, > 1 MW
- CFB 15-50 MW, 5-15 MW, 5-50 MW
- CFB > 1 MW
- diesel motor (working machines), all, < 50 MW, > 50 MW
- diesel power plant, all, < 50 MW, > 50 MW
- waste combustion boiler, all, 50-150 MW, 15-300 MW
- GT (and combined) < 5 MW, < 50 MW, < 500 MW, > 5 MW, > 50 MW, > 500 MW
- gasification 50-500 MW, 5-50 MW, > 50 MW, > 500 MW
- gasification, burner etc. 1-15 MW, 1-50 MW, 15-150 MW, 50-150 MW
- Boilers 0,2-1 MW, 10-15 MW, 1-15 MW, 1-5 MW,1-50 MW,150-500 MW,15-150 MW,15-50 MW, 50-150 MW, 50-300 MW, 50-500 MW, 5-10 MW, 5-15 MW, 5-50 MW, < 0,2 MW, < 1 MW
- Boilers and processes
- Boilers and processes
- residential buildings
- coking plant
- fluidized bed 50-500 MW, > 500 MW
- fluidized bed 1-15 MW, 1-50 MW, 15-150 MW, 50-150 MW
- fluidization, 150-200 MW, 200-300 MW, 300-400 MW, <150 MW
- fluidization and gasification 1-5 MW, 5-50 MW, > 50 MW, > 400 MW
- fluidization etc 1-5 MW, 5-10 MW
- blast furnace
- recovery boiler
- other and unknown combustion
- other combustion 150-200 MW, 200-300 MW, 300-400 MW, < 150 MW, > 400 MW
- other ovens ym.
- pulverized fuel firing (corner) 50-500 MW
- pulverized fuel firing (corner) > 500 MW
- otto motor (working machines)
- otto motor power plant
- burner 15-50 MW, 50-300 MW, 50-500 MW, 5-15 MW, > 1 MW, > 300 MW, > 500 MW
- clinical waste incineration oven, all,1-50 MW
- pulverized fuel firing (wall) 50-500 MW, > 500 MW
- cement and lime
- sintering
- recovery boiler
- recovery boiler 50-150 MW, 50-300 MW, < 50 MW, > 150 MW, > 300 MW
- melting furnace
- unknown and other combustion
- furnaces.
- combined 50-500 MW, > 500 MW

Phase 4 – Inclusion of abatement techniques

YLVA contains information of the following abatement techniques in use with combustion plants. For approximately a hundred boilers, the abatement technology is added retrospectively based on expert review. The efficiency of the abatement technique is used in determination of the emission factor for the boiler:

- abatement of air emissions
- scrubber
- ESP
- fiber filter
- cyclone
- multicyclone
- LOW-NOx burners
- feeding of upper air
- other staging of combustion air
- recycling of flue gases
- staging of fuel
- SCR
- SNCR
- wet method
- semi-dry method
- absorbent feed
- adsorber
- incineration
- condensor
- abatement of particles
- abatement of NOx emissions
- abatement of SOx emissions
- abatement of VOC emissions

The use of abatement techniques is not exclusive of each other. A facility can have a combination of multiple abatement techniques in use. Therefore, all points are checked for all techniques and further grouped into five categories based on their abatement capability. A corresponding emission factor is given for each combination of combustion technology, abatement capability classification and fuel.

Phases 3 and 4 are not done on an annual basis and as of the submissions of 2020 and 2021 no updates have been introduced to the technology data. New technology data, especially on the abatement techniques, was collected in a specific project that will be finalized in the spring 2024. The new data will correct the data gaps in the current inventory related especially to the abatement techniques. The new data and the recalculations following this will be included in the inventory in the future submissions. The updates are likely to have a relatively small effect in the emission levels.

Emission factors

Changes in chapter	
March 2023	KS, JM, TF

In general, the calculation of emissions follows the equation:

$$E_{pollutant} = AR * EF_{technology,fuel}$$

Where
E = Emissions of a pollutant
AR = Activity rate (energy value by fuel combustion)
$EF_{technology,\ fuel}$ = Technology and fuel specific emission factor including abatement technique efficiency/ efficiencies

The technology specific emission factors are implied emission factors based on technological information in varying levels of detail. The emission factors are defined by boiler type, fuel, abatement technique or a configuration of multiple abatement techniques. Currently this creates a space of approximately 15 000 emission factors, with the possibility to reduce the actual amount to approximately 2500 EF's by listing only the existing combinations of abatement techniques and boiler details and grouping the EF's accordingly. Updating the emission factors is problematic due to the cross-linking of data tables for boilers, abatement techniques and default emission factors. The list of implied emission factors are provided in Annex 1 of Part 7 of the IIR as well as the national general emission factors that are given as default factors to facilities reporting to E-PRTR when they do not use measured data (Annex 2 of Part 7 of the IIR).

Comparison of default values with data reported by the plant operators and allocation of the emissions into NFR and SNAP categories

The fuel consumption based calculated emission values are compared to the facility-reported emission values from YLVA. Calculated and reported emission data is collected into a single table. If a point source does not contain reported YLVA data for emissions, calculated values are used. YLVA emissions are distributed between fuels in the same ratio as with the calculated values. All the emissions reported to the YLVA system are classified as fuel or process-based emissions. The NFR and SNAP classifications are connected to the emission data after the combination of calculated and reported emissions. Every single point source is linked to some NFR and SNAP code in the calculation system. If the point source only has combustion-based emissions, it is linked to some NFR/SNAP code from the energy sector. If the point source only has process-based emissions (and therefore no fuel consumption), it is linked to some NFR/SNAP code from the IPPU sector. In some cases the facility-reported emission data contains both the combustion based emissions and the process based emissions. The vast majority of such cases are TSP emissions. In these cases, the point source has been linked to NFR/SNAP classifications both from the energy and from the IPPU sectors. The combustion-based emissions are allocated to the energy sector and process-based emissions to the IPPU sector. In the allocation, the following set of rules is used:

1. When the reported value is larger than the calculated value, the calculated value is considered to result from combustion. The calculated value is then subtracted from the reported value and the remainder is considered to be process based.
2. When the reported value is lower than the calculated value, the reported value is solely considered to result from combustion.

The classification of fuel-/process-based emissions is done for all other reported compounds except for particulate matter and BC, which are calculated separately. Process based emissions of PM_{10} and $PM_{2.5}$ are calculated from TSP values using distribution factors presented under the IPPU sector.

Notes

Information on small and medium sized energy production units (1-MW) is not yet fully incorporated into the inventory. Information on small and medium sized boilers was gathered in a project in 2014. As a result of this project, a number of new boilers were added to the inventory as point source data.

The number of medium sized 1-50 MW energy production units in 2014 was 2349 (ISPA, 2014), excluding energy production units in greenhouses and other 15-50 MW units which fall under the IED (2010/75/EU) due to the common stack rule. Information is available from 262 municipalities covering 97.3% of population. For 10-20% of the energy production units, information is not available, but these are included in the inventory through the national energy balance.

In addition, information on fuel consumption is available for 373 energy production units of 1-5 MWs.

The shares of different sized small and medium size energy production units (1-50 MW) in 2014 is presented in Figure 2.14 and the shares according to size and hours of operation in Table 2.22.
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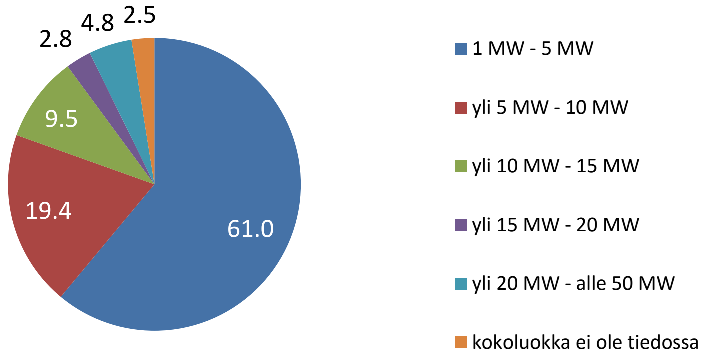

Figure 2.14. Shares (%) of small and medium sized energy production units by MWs
("yli" = above, "alle" = below; orange sector: capacity unknown)

Table 2.22. Small and medium sized energy production units by sizes and operation hours.

Hours of operation in 2014	**1 MW - 5 MW**		**5 MW - 20 MW**		**20 MW - MW**		**size not known**		**Total**	
	Number	%	Number	%	Number	%	Number	%	Number	%
< 500	615	43	238	32	25	22	8	14	886	38
500 - 1500	252	18	228	31	34	30		0	514	22
1500 - 4000	168	12	109	15	16	14	1	2	294	13
> 4000	299	21	149	20	35	31	1	2	484	21
unknown	100	7	20	3	2	2	49	83	171	7
Total	1434	100	744	100	112	100	59	100	2349	100

In 2014, as an example, there were 197 energy production units of 1-5 MWs in greenhouses, out of which one third uses wood or other biomass and one third HFO, while the rest use LPG, peat or NG, two use HFO. In addition, six energy production units of 5-10 MWs were used in the greenhouses, and half of these use NG and half coal.

Some notes related to boilers < 5 MW

Particle and heavy metal emissions from part of small and medium sized boilers are considerable uncertain due to the fact that the environmental authorities' database does not include information on abatement techniques for all these boilers.

Based on expert information
- heavy oil -fired boilers > 1 MW, for which no information is available on the applied abatement technique, are assumed to be equipped with electrostatic filters
- solid fuel boilers > 5 MW are assumed to be equipped with cyclones
- other boilers with no information available on the applied abatement technique are calculated as unabated, which may overestimate these emissions
- non-HFO boilers > 2 MW are not calculated as individual boilers, but are covered through the energy balance

Note on Emission factors

As the inventory is based on bottom-up data, it is not possible to present emission factors at a level that would enable reproduction of the energy sector inventory, as these emission factors are technology specific at many levels of detail. In the inventory, there are approximately 250 categories of boilers and processes. Instead, the annual implied emission factors are presented in Annex 1 Part 7 of the IIR. In addition, national default EFs developed for E-PRTR reporting to be used when no measured data is available, are presented in Annex 2 Part 7 of the IIR.

In the 2024 submissions under the CLRTAP and NECD, where emission factors from the Guidebook are used in the energy production emission estimation, all the emission factors are from the 2019 version of the EMEP/EEA Emissions Inventory Guidebook. The possible changes in the energy production (NFR 1A1a and 1A2) emission factors introduced in the 2023 version of the Guidebook will be studied during the preparation of the emission inventory for year 2023. Following this, the possible recalculations of emissions will be included in the 2025 submissions.

SO_2 and NO_x

SO_2 and NO_x emissions are mainly based on data reported by the operators according to their monitoring and reporting requirements. Fuel based emissions are allocated under NFR 1 and non-fuel-based (process) emissions under NFR 2. In cases where no emission data is available in YLVA but fuel data is known (e.g. from the Emission Trading Register), calculated values from the energy sector calculation model are used.

Particle emissions

Emission data on total suspended particles is mainly reported by the operators and recorded in YLVA. Fuel based emissions are allocated under NFR 1 and non-fuel-based (process) emissions under NFR 2. In cases where no emission data is available in YLVA but fuel data is known (e.g. from the Emissions Trading Register), calculated values from the energy sector calculation model using technology based emission factors for each boiler or process type are used. PM_{10} and $PM_{2,5}$ are calculated using national distribution factors (Karvosenoja, 2006).

Uncertainty of particle emissions from part of the small and medium sized boilers is affected by the fact that YLVA does not include information on abatement techniques for all these boilers. Heavy oil fired boilers > 1 MW, for which there is no information available on the applied abatement technique, are assumed to be equipped with electrostatic filters. Solid fuel boilers > 5 MW are assumed to be equipped with cyclones. Other boilers with no information available on the applied abatement technique are calculated as unabated, which may overestimate these emissions.

<u>NOTE on condensable particles:</u>

TSP emission concentrations are measured in the stack according to the agreed the EN standards (EN 13284-1), which is a gravimetric particle measurement and thus does not cover condensable particles. If the sampling and filtering temperatures would be changed when using this standard, semi-volatile particulates could be captured, but not all condensable particles. The US EPA 2002 method captures condensable particles, however, we do not consider this method to be reliable. Information on this matter has been received from Principal Scientist on Air Emissions, Ms Tuula Pellikka at VTT Technical Research Centre of Finland (Pellikka, 2019).

For those emission sources where TSP emission data or domestic TSP emission factors are used in the calculation of PM_{10} and $PM_{2.5}$ fractions, the condensable part of PMs is not included.

Black carbon

Average emission factors used in the preliminary inventory are presented in Table 2.23.

Table 2.23 Average emission factors in the Finnish BC inventory (Guidebook 2019)

Source	SNAP	EF	Unit	Reference
Boilers (solid)	010000-030000	3.3	% of PM2.5	GB19
Boiler (liquid)	010000-030000	72	% of PM2.5	Aasestad, 2013
Stationary engines (gas)	010000-030000	2.5-7	% of PM2.5	GB19, Aasestad 2013
Stationary engines (Liquid)	010000-030000	33.5-78	% of PM2.5	GB19
Gas turbines (gas)	010000-030000	2.5	% of PM2.5	GB19
Gas turbines 20-200 MW (liquid fuel)	010000-030000	33.5	% of PM2.5	GB19
Grate furnace (liquid)	010000-030000	33.5, 81	% of PM2.5	Aasestad,2013 GB19
Grate furnace (solid)	010000-030000	3.3	% of PM2.5	GB19
Fluidized bed (LFO	010000-030000	33.5	% of PM2.5	GB19
Other (liquid)	010000-030000	33.5	% of PM2.5	GB19
Other (solid)	010000-030000	2.2, 5.6	% of PM2.5	GB19
Other (gas)	010000-030000	2.5	% of PM2.5	GB19
Coke oven	040201	0.05	% of PM2.5	GB19
BOF	040206	0.36	% of PM2.5	GB19
Electric furnace steel plant	040207	0.36	% of PM2.5	GB19
Rolling mills	040208	0.36	% of PM2.5	GB19
Sinter and pelletizing plant	040209	0.17	% of PM2.5	GB19
Other (foundries)	040210	0.36	% of PM2.5	GB19
Ferro alloys	040302	10	% of PM2.5	GB19
Other (copper production)	040309a	0.1	% of PM2.5	GB19
Sulphuric acid	040401	1.8	% of PM2.5	GB19
NPK fertilizers	040407	1.8	% of PM2.5	GB19
Titanium Oxide	040410	1.8	% of PM2.5	GB19
Other (paper coatings)	040416	1.8	% of PM2.5	GB19
Ethylene	040501	1.8	% of PM2.5	GB19
Other (cleaning agents)	040527	1.8	% of PM2.5	GB19
Paper pulp (kraft process)	040602	2.6	% of PM2.5	GB19
Road paving with asphalt	040611	5.7	% of PM2.5	GB19
Glass (decarbonizing)	040613	0.062	% of PM2.5	GB19
Lime (decarbonizing)	040614	0.46	% of PM2.5	GB19

NMVOC and CO

NMVOC emission factors were revised in September 2006 and the earlier low emission rates were confirmed. The revised NMVOC emission factors are based on information from measurements of volatile organic compounds from the boilers (see Annexe 2 Part 7 of the IIR).

CO and NMVOC emissions are mainly calculated based on emission factors and annual fuel consumption data available in YLVA and in the Emission Trading Registry. Only in a few cases measured emissions values are available.

NH_3

Finland has received recommendations in the NECD inventory reviews to include NH_3 emissions from biomass combustion in categories 1.A.2 (e.g. Observation IDs FI-1A2-2022-0001 and FI-1A2d-2022-0001 in the 2022 review) since the 2019 EMEP/EEA Guidebook provide a Tier 1 methodology with a default emission factor. However, Finland finds the emission factor to be unsuitable for the Finnish conditions and does not include NH_3 emissions from biomass combustion under category 1.A.2.

NH_3 emissions in categories 1.A.1 and 1.A.2 originate only from the use of ammonia in SCR/SNCR reduction technologies (NO_x abatement). In these equipment, incomplete reaction of NH_3 additive can result in an ammonia slip. These ammonia slips are included in the Finnish inventory and the emissions are reported by the plants in categories 1A1a and 1A2gviii. The EMEP/EEA Guidebook 2019 states in chapter 1.A.1 Energy industries that emissions of ammonia are not related to the combustion process but result from the incomplete reaction of NH_3 additive in the denitrification process (ammonia slip from SCR/SNCR units). In addition, in table 1-1 in chapter 1.A.2 Manufacturing industries and construction (p. 4), guidance is given on the primary chapter of the Guidebook for combustion emissions under 1.A.2 activities. According to the guidance, where combustion activities in 1.A.2 essentially relate to the use of fuels in conventional boilers, furnace, gas turbine, engine or other combustion devices the user is guided to chapters 1.A.1 Energy industries and 1.A.4 Small combustion for information on technologies and emissions. In the Finnish inventory, the technologies applied are the same in these cases in category 1.A.2 as in source category 1.A.1. Hence, according to the Guidebook, the NH_3 emissions in these activities originate only from the ammonia slips. In the case of 1.A.4 Small combustion, NH_3 emissions from biomass combustion are included in the Finnish inventory. In the case of combustion activities where guidance provided in chapter 1.A.2 of the Guidebook should be applied according to the table 1-1, no biomass is used as a fuel in Finland. For that reason as well, the ammonia emissions in categories 1.A.2 from other sources than use of SCR/SNCR technologies are not relevant in the Finnish inventory.

The Finnish Energy industries also considers the default NH_3 emission factor in the 2019 Guidebook for biomass combustion to be unsuitable in the Finnish conditions and the NH_3 emissions only relate to the use SCR/SNCR technologies. A specific project related to the review of emission factors in the Finnish inventory regarding energy production has been carried out between 2022 and spring 2024. The possible ammonia emissions from biomass combustion in energy production boilers have also been considered in the project. The results in the project confirm that the emissions in the Finnish conditions are negligible and only relate to the use of SCR/SNCR technologies. In the project, data was collected from the Finnish plants, emission measurement companies and boiler manufacturers. In addition, a literature review was carried out in the project.

Heavy metals
Heavy metal emissions are partly based on data reported by the operators and partly on data calculated in the energy calculation model using domestic emission factors (Melanen, 1999, Hupa, 1988, Pohjola, 1983).

Uncertainty of heavy metal emissions from part of the boilers from all capacity ranges is affected by the fact that YLVA does not include information on abatement techniques for all these boilers. Emissions from heavy oil-fired boilers >1 MW, for which there is no information available on the applied abatement technique, are assumed to be equipped with electrostatic filters. Solid fuel boilers > 5 MW are assumed to be equipped with cyclones. Other boilers with no information available on the applied abatement technique are calculated as unabated, which may overestimate these emissions. With reference to NECD review questions 1A1b-2019-0001 and 1A2f-2019-0001, the current overestimations of Pb emissions in categories 1.A.1.b and 1.A.2.f have not yet been revised in the inventory. The overestimations are due to lack of information on abatement techniques for certain plants. A more comprehensive update on the missing abatement techniques will be carried out and following this, the necessary recalculations of heavy metal emissions in different categories will be made in the future submissions.

PCDD/F
PCDD/F emissions are calculated using fuel data and emission factors from the UNEP (UNEP, 1999) except for wood combustion for which the emission factors are taken from the USEPA database (USEPA, 1997) and peat, for which the emission factors are domestic (Ruuskanen, 2000).

PAH-4
PAH-4 emission factors for peat combustion are domestic (KTM, 1988). For the other fuels, emissions are calculated using emission factors from the EMEP/EEA Emission Inventory Guidebook (EEA, 2002), except for oil combustion, where the emission factors are taken from the UBA (UBA, 1998).

With reference to the 2019 and 2020 NECD reviews, questions FI-0A-2019-0002, the revised estimates of the 4 PAH indicator species for the energy sector categories 1A1 and 1A2 have been included in the 2021 submission. The methodology used in the division of the PAH-4 emissions into the 4 PAH indicator species is the same that was used during the 2020 NECD review when the preliminary results were calculated and provided to the TERT during the review, i.e. the emissions by fuel type were grouped into categories for which EMEP/EEA Guidebook EFs exist for the 4 PAH indicator species. PAH-4 emissions that are calculated using the current national PAH-4 emission factors and also those reported as PAH-4 by the plants were divided into the four indicator-PAH species using the relations of the indicator PAH species in the EMEP/EEA Emission Inventory Guidebook 2019 EF tables (more details provided in the file submitted with the answer to the review question FI-0A-2019-0002, FI-0A-2019-0002-REs B(a)P B(b)F B(k)F IP 1990-2018 submitted 8 June 2020.xlsx).

HCB and PCB
HCB and PCB emissions are calculated using fuel data from solid fuel and biomass combustion and Guidebook 2019 emission factors. The method is simplified Tier 1, i.e. the calculation does not take fuel specific information nor detailed boiler and abatement technique information into consideration.

PCP
PCP emissions from combustion of wood and bark are calculated with the emission factor 0.0219 µg/MJ according to the US EPA (AP-42). The calculation method is simplified and no detailed information on the applied boiler and abatement techniques is taken into consideration, neither does the emission factor depend on fuels used.

Uncertainty and time series' consistency

The results of the uncertainty analysis 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. The data obtained from YLVA is cross-checked against the summary data (by fuels and by CRF categories) reported to the UNFCCC as explained in Chapter 1.4.3.

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

Inter-comparison with greenhouse gas inventory data

The cross-checking with fuel and greenhouse gas emission data calculated by Statistics Finland is used as verification for the inventory. The calculation systems are separate but use mostly the same basic data sources for calculation of emissions from fuel combustion. These independent calculation systems are used as a verification tool for the energy sector inventories, and moreover, as source of additional corrections. Comparisons between the data in these two calculations systems are performed continuously during the inventory preparation. The annual calculation of air pollutant emissions at SYKE is performed a bit later than the GHG inventory at Statistics Finland and thus the source data set usually includes more updated data than one used in the preliminary EU GHG inventory at Statistics Finland. The thorough comparison between the air pollutant and GHG inventories in accordance with the EU Governance Regulation (2018/1999) is performed after 15 February and the differences are corrected to both inventories and reported according to both air pollutant and GHG reporting obligations.

Investigation of consistency in point level emissions

Parallel to the update of the time series in submission 2018, the boiler specific emission data was investigated for gaps or discontinuity events in the emission data of 1990-2015.

The routine checks for gaps in time-series where the following conditions are met:

- a point has more than one entry in time series per pollutant
- missing value exist in a range between two existing values (i.e. if a missing value exists in the beginning or the end of the series, it will not be revealed)
- Series connects the same point and pollutant

The method was able to programmatically reveal 518 events of discontinuity from nearly two million rows of emission data. The method does not disclose the reason for the missing value. Many or most of these might have been valid gaps due to e.g. stoppages at the plant. This analysis suggests a high level of consistency and accuracy in data.

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

2018

- The recalculation of the fuel consumption time series 1990-2016 was carried out for the first time in the 2018 submission and finalized only in April 2018. The recalculation covered
- an update of fuel combustion data based on new and corrected information in the data reported by the plants and in energy statistics.
- Allocation of emissions to energy and industrial processes was updated for the whole time series in a harmonized way to correct deviations in cases where the emissions reported by operators consist of both fuel combustion and process related emissions
- ETS data had already been used in the annual inventories since the start of the availability of the data in 2008, in addition to CRF data which has been used for comparison in all earlier inventories.

2019

- Further checking of the recalculated time series 1990-2016 was carried out and resulted in updating some EFs according to GB 2016 and reallocation of emissions between the Energy and Industry sectors. After the fine-tuning the emissions are consistently allocated over the years under the NFR categories. Detailed information of all corrections and recalculations are presented in Annex 9, which will be submitted by 1 May 2019.
- The need to update national emission factors was reconsidered by the energy sector branch organization Finnish Energy (ET) during 2018 to not be relevant, as no such changes that would impact the emissions levels have taken place.
- As expected, both of recalculations in 2018 and 2019 resulted in minor changes to emission levels, however, provided major improvement to the allocation of emissions. The time series is now organized according to the NFR 2014-2/2019-1 reporting codes in the IPTJ reporting tool, which enables a full review of the data.

2020

- NFR category 1A2a – PM2.5 and PM10 for 1990-1995, 2000-2003 and 2005-2017 were recalculated due to correction of facility reported emissions from two plants. Emissions from two plants were incorrectly reported both in the energy sector in category 1A2a and in the IPPU sector in category 2C1 in submission 2019. The emissions are process based emissions and reported in category 2C1. Therefore, the emissions from category 1A2a were deleted.
- NFR category 1A2a – PCDD/PCDF were recalculated for 2017 due to correction of facility reported emissions from one plant. Emissions from one plant were incorrectly allocated in the IPPU sector in category 2C7c in submission 2019. Emissions were reallocated to the correct category 1A2a in the energy sector.

2021

- Small NH3 emissions in 2018-2019 originating from process oven and earlier reported under NFR 1A2b were reallocated to NFR 2C6 in this submission.
- PAH-4 emissions are calculated for each component individually for the whole time series.
- PCDD/PCDF were recalculated for 2016 and 2008 in category 1A1a due to correction of erroneous facility reported emissions from one plant, and for in category 1A2c for 2005 due to correction of erroneous facility reported emissions from one plant.
- Cd emissions were recalculated for 2005 in category 1A2c due to correction of erroneous facility reported emissions from one plant
- SOx emissions for category 1A2e were recalculated for 2000 and 2001 due to correction of allocation of emissions from one plant. Emissions were previously allocated erroneously under category 2H2.

Source-specific planned improvements

In the next 5 years

- A more comprehensive inclusion of small and medium sized boilers from national district heating statistics and other sources in the inventory at the level of individual boilers to improve the accuracy of data (the fuel data is naturally already included through the national statistics, but the district heating statistics provide more details)
- The need to review emission factors has been initiated with the energy industry and emission measurement communities. A specific project is underway and will be finalized in the spring 2024. The project also includes a comparison of the current emission factors with the default EFs

EMEP/EEA Guidebook. The project will identify the needs for emission factor updates. The possible changes to the inventory calculation will be implemented in the future submissions.

- Descriptions highlighting the domestic features of the industry will be improved in the future submissions. Forest industry is an example of industries that produce a significant share of the energy they use.

Stationary Combustion in Manufacturing industries and construction NFR 1A2gviii

Changes in chapter	
March 2024	KS, TF, JM

Combustion activities which cannot be allocated under any of the other NFR 1A2 categories are reported under NFR 1A2gviii. A complete list of activities included is presented in Table 1.11 on page 47 of Part 1A General of the IIR.

The difference between the energy balance and point source fuel combustion is allocated under 1A5a (apart from peat which is allocated under 1.A.1.a).

The contribution of the sector to total emissions and shares reported by the operators are presented in Table 2.24.

Table 2.24. Contribution of NFR 1A2gviii in 2022 to total emissions and shares reported by the operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NOx (as NO_2)	2.209	Gg	2.2	69.3
NMVOC	0.161	Gg	0.2	4.3
SOx (as SO_2)	0.318	Gg	1.4	58.5
NH_3	0.010	Gg	<0.1	100
$PM_{2.5}$	0.103	Gg	0.8	0
PM_{10}	0.246	Gg	0.9	0
TSP	0.412	Gg	1.0	43.9
BC	0.006	Gg	0.2	0
CO	2.775	Gg	0.9	12.7
Pb	0.111	Mg	0.9	2.3
Cd	0.013	Mg	1.7	8.1
Hg	0.013	Mg	2.7	74.7
As	0.005	Mg	0.3	26.9
Cr	0.285	Mg	1.9	72.1
Cu	0.139	Mg	0.4	10.0
Ni	0.116	Mg	1.2	5.1
Zn	2.687	Mg	2.0	0
PCDD/F	0.148	g I-Teq	1.6	9.4
PAH-4	0.161	Mg	0.9	7.7
HCB	0.162	kg	0.6	0
PCB	0.028	kg	0.1	0

Wood pellets

Emissions from the production of wood pellet are included under NFR 1A2gviii because the process-based emissions that could be reported under NFR 1A1c (Manufacture of solid fuels) could not be separated from combustion emissions.

Emissions from production of wood pellets are based on emission data reported by the plants according to their monitoring and reporting requirements in their environmental permits.

Uncertainty and time series' consistency

The results of the uncertainty analysis 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. The data obtained from YLVA is cross-checked against the summary data (by fuels and by CRF categories) reported to the UNFCCC as explained in Chapter 1.4.3 Part 1A General of the IIR.

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

2002

- The emissions were included in the inventory under the previous NFR category 1A2f

2007

- The allocation was changed to NFR 2G

2008

- The allocation was changed to NFR 1B1c.

2016/17

- Emissions were reallocated under NFR 1A2gviii for the latest years.

2018

- The emissions were reallocated under NFR 1A2gviii for the whole time series.

2019

- Further corrections to allocations under the Energy and IPPU sectors. All corrections and recalculations are in details presented in Annex 9, which will be submitted by 1 May 2019

2020

- 1A2giii/PCB emissions for 2017 were recalculated due to update of activity data for industrial waste incineration.
- 1A2gviii/Particle emissions for 2012-2017 were recalculated due to correction of facility reported emissions from one plant. Particle emissions for one plant were split between energy (1A2gviii) and IPPU (2I) for the whole time series. In submission 2019, the split was done only for the years prior to 2012.

2021

- In category 1A2gviii, the following recalculations were made due to correction of erroneous facility reported emissions:
  - CO for 2004
  - Pb and As for 1999 and 2001

2022

- Zn emissions in category 1A2d were recalculated for 2018-2019 due to correction of erroneous facility reported emissions
- Particle emissions in category 1A2gviii were recalculated for 1990-1999 and 2002-2019 due to correction of allocation emissions from two plants. Emissions were previously allocated under category 2D3e.

2024

- Particle emissions in category 1A2gviii were recalculated for 1991 due to correction of allocation emissions from one plant. Emissions were previously allocated under category 2D3e.

Source-specific planned improvements

None.

3 Commercial/Institutional and Residential Plants, Household, Gardening, Agriculture/Forestry/Fishing and Other Stationary sources (NFR 1A4 and NFR 1A5)

1 A 4 a i Commercial / institutional: Stationary
1 A 4 c i Agriculture/Forestry/Fishing: Stationary
1 A 5 a Other stationary (including military)

Changes in chapter	
March 2024	KS, TF

Source category description – other fuels than wood

This chapter covers emissions from stationary combustion in commercial, institutional and residential sectors for NFR categories 1A4ai, 1A4ci and 1A5a.

Combustion in residential buildings under NFR category 1A4bi is presented in Chapter 2.4.2.

Mobile sources (1A2gvii, 1A4aii, 1A4bii, 1A4cii, 1A4ciii) are documented in Chapter 3.11 in Part 3 Transport of the IIR.

Table 2.25 Activities and emissions reported under NFR 1A4 and 1A5a.

NFR	Source	Emissions	Chapter
1A4ai	Commercial/ Institutional combustion - stationary	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB	2.4.11
1A4bi	Residential combustion - Stationary plants	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB	2.4.2
1A4ci	Combustion in Agriculture/Forestry/Fishing - Stationary	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB	2.4.11
1A5a	Other stationary combustion (including military)	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB	2.4.11
1A2gvii, 1A4aii, 1A4bii, 1A4cii, 1A4ciii and 1A5a	Off-road, non-road, mobile sources (including military)	NOX, NMVOC, SOX, NH_3, TSP, PM_{10}, $PM_{2.5}$, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB	2.4.6.4

Fuel combustion in these sectors in 1990-2016 by subcategory are presented in Figure 2.15 and in 1990-2021 in Table 2.26

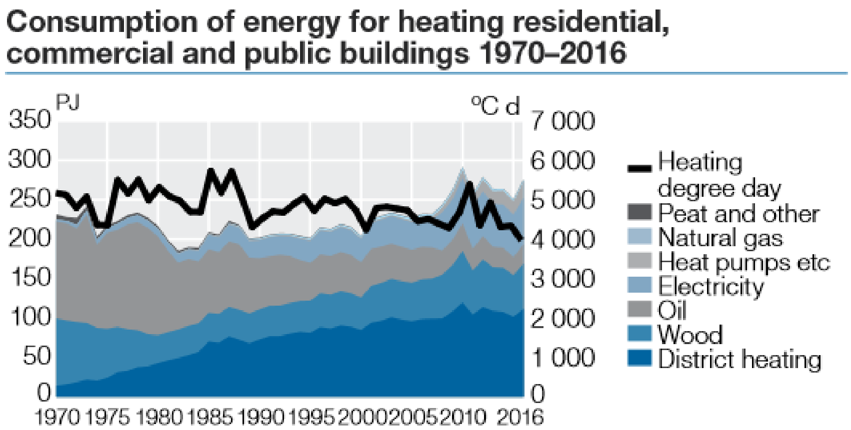

Figure 2.15. Energy consumption of heating in residential, commercial and public buildings NFR 1.A 4ai, 1.A 4bi and 1.A 4ci (Energy Statistics, 2018)

Table 2.26. Fuel consumption 1990-2022 in NFRs 1A4 and 1A5 stationary sources (IPTJ Finnish Environment Institute 2024).

		1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
Liquid fuels	Heavy fuel oil	21.2	9.1	7.9	7.8	6.6	3.5	3.6	3.4	2.9	3.1	3.2	2.4
	Light fuel oil	66.0	59.8	55.6	49.8	41.7	29.7	29.7	29.4	27.8	26.4	25.6	22.7
	Other liquid fuels	6.2	7.1	7.3	6.7	7.0	6.4	6.8	8.3	8.0	7.6	6.6	7.8
Solid fuels	Hard coal	0.6	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Peat	Peat	1.3	1.0	1.3	1.6	2.6	1.8	2.1	2.2	2.3	2.3	1.5	1.5
Gaseous fuels	Natural gas and other gaseous fuels	4.2	7.1	8.9	7.7	9.3	8.3	7.0	10.4	10.1	8.1	6.3	7.2
Biomass	Wood fuels and other non-fossil fuels	50.1	45.3	47.7	67.2	79.5	71.6	80.2	78.8	72.3	83.8	72.7	91.6
Other fuels	Other fuels	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Emission trends

Changes in chapter	
March 2024	KS, TF

The combined emission trends from NFRs 1A4 and 1A5 are presented in Figure 2.16.

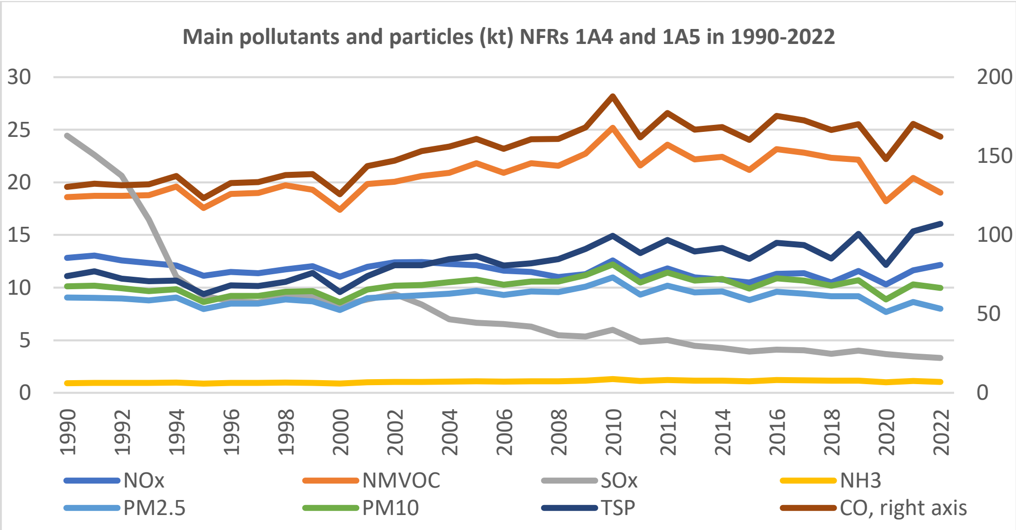

Figure 2.16 Emissions from stationary sources under NFRs 1A4 and 1A5 in 1990-2021

Fuel combustion under NFRs 1A4 and 1A5 has been decreasing since 1990 because of the increased use of district and electric heating in residential, commercial and public buildings. The peak in 2010 heating energy consumption is due to exceptionally high heating degree days.

As can be seen from Figure 2.16 the SO_2 emissions decreased considerably in the beginning of the 1990s. This was because the sulphur content of the heavy fuel oil used in heating of the commercial sector buildings is decreased to half of the earlier level between 1990 and 1994 (from 876 mg/MJ to 438 mg/MJ). In addition, the use of oil was cut more than by a half at the same period.

The increase in emissions in 2021 is related to the increased use of wooden fuels in energy production. In the emission calculation system, the total fuel use is aligned through the energy balance to be consistent with the Finnish greenhouse gas inventory. In the greenhouse gas inventory in 2021, the amount of wooden fuels allocated under categories 1A1 and 1A2 (point source data) is larger compared to the air pollutant inventory. Therefore, the amount of wooden fuels allocated under category 1A5a (fuel use in point sources in categories 1A1 and 1A2 subtracted from the total fuel use) is larger in the air pollutant inventory compared to previous years.

The high lead emissions around 1994 were due to significantly increased use of coal that year.

Methodological issues – other fuels than wood

The inventory for NFR 1A4 is based on dedicated national statistics for these sources and for NFR 1A5 on the difference in the consumption of fuels between the energy balance and fuel consumption in point sources plus the dedicated statistics (e.g. 1A4). The calculation methods are based on the EMEP/EEA Emission Inventory Guidebook 2019.

$$E_{pollutant} = AR * EF_{fuel}$$

Where
E = Emissions of a pollutant
AR = Activity rate (e.g. energy value by fuel combustion)
EF_{fuel} = Fuel specific emission factor

Activity rate is derived from the following equation:

$AR = \Delta H_c * F_s$ where ΔH_c = Heat of combustion [GJ/t]
F_s = Fuel consumption (source specific) [t]

Fuel consumption F_s is obtained from the Statistics Finland's energy statistics. Wood is the most common fuel about 3/4 followed by light fuel oil ¼ of fuel use in residential buildings. Fuel consumption for NFRs 1A4 and 1A5 is presented in Table 2.26.

Procedure of calculation (other than small scale <u>wood combustion</u>)

Changes in chapter	
March 2024	KS, TF

Phase 1 - collection of activity data

The calculation of emissions in NFR categories 1A4ai, 1A4bi, 1A4ci and 1A5a is carried out by using the same methodology as with the NFR category 1A1 (energy industries). In contrast to the calculation of 1A1, fewer assumptions and corrections are applied as no detailed information is available for many small combustion units. Activity data is primarily obtained from the energy statistics and made compatible with the data submitted to the UNFCCC calculated at Statistics Finland. The emissions are calculated using national emission factors. The implied emission factors are provided in Annex 2.

The number of active boilers under NFR 1A4 recorded into YLVA are presented in Table 2.28. Fuel consumption from the energy statistics is used when information on the fuel use at boiler level is not available.

Most of these are handled as non-point sources and the calculated value is derived from reducing known point source fuel use from the fuel-use-based statistics per source category. For non-point sources the activity data is currently available for the sources presented in Table 2.27. To balance the equation of calculation of fuel use, the residue of total fuel consumption minus known point sources minus known non-point sources is allocated between unspecified energy production, district heating and industry.

Table 2.27. Source categories for non-point emissions.

Type of facility	
Category	Source
Heating of residential buildings	Block houses
	Summer cottages
	Detached houses
	Row houses
Households	not heating, not off-road
Agriculture, forestry, fishing	not heating, not off-road
Agricultural buildings, heating	Agricultural buildings
Service buildings, heating	Service buildings, heating
Balance	Raw material energy use
	Balance, district heating
	Balance, other industry

The number of active boilers under NFR 1A4 in YLVA are presented in Table 2.28. Fuel consumption from the energy statistics is used when information on the fuel use at boiler level is not available.

The allocation of point sources under NFR 1A4 has been made consistent with the greenhouse gas inventory in submission 2018. The allocations are checked annually. Part of the non-point source emissions, currently allocated under NFR 1A5a, will be removed under 1A1 or 1A2 when the new information of district heating plants and other sources mentioned in the source-specific planned improvements of categories 1A1 and 1A2 has been utilized in the inventory.

Table 2.28 The number of boilers active in 2022 (YLVA, 2024).

Category	**Number of boilers in 1A4ai**	**Number of boilers in 1A4bi**	**Number of boilers in 1A4ci**	**Number of boilers in 1A5a**
Combustion plants > = 300 MW (boilers)	0	0	0	0
Combustion plants > = 50 and < 300 MW (boilers)	0	0	0	0
Combustion plants > = 20 and < 50 MW (boilers)	1	0	0	0
Combustion plants < 20 MW (boilers)	18	0	6	0
Gas turbines	0	0	0	0
Stationary engines	0	0	0	0
Process ovens	0	0	0	0
Other equipment	3	0	0	0
Total	22	0	6	0

Phase 2 - calculation of emissions

In general, the calculation of emissions follows the equation:

$$E_{pollutant} = AR * EF_{technology,fuel}$$

Where
E = Emissions of a pollutant
AR = Activity rate (e.g. energy value by fuel combustion)
$EF_{technology, fuel}$ = Technology and fuel specific emission factor

The technology specific emission factors are implied emission factors based on technology related information in varying levels of detail. The emission factors are defined by boiler type, fuel, and in some cases by abatement technique. In addition to the previous, for residential small combustion the emission factors are defined on a yearly basis.

Activity rates are derived by the following equations:

- Point sources $AR = \Delta H_c * F_b$

where ΔH_c = Heat of combustion [GJ/t]
F_b = Fuel consumption in a boiler [t]

- Non-point sources: AR = $\Delta H_c * F_t - F_p$,

where ΔH_c = Heat of combustion [GJ/t]
F_t =Fuel consumption (sector total) [t]
F_p =Fuel consumption (known point sources within sector) [t]

<u>Emission factors (other than small scale wood combustion)</u>

POP compounds
PAH-4 emissions are calculated using expert estimates based on information in the EMEP EEA Emission Inventory Guidebook (EEA, 2002). For oil combustion the emission factors are based on information from the UBA (UBA, 1998). For peat combustion the emission factors are domestic estimates (KTM, 1988). A comparison to the EFs from the latest version of the Guidebook will be made in a specific project related to the review of emission factors. The project will be finalized in spring 2024.

The emission factors used for calculating POP emissions are presented in Table 2.29. PCP emission factor (0.0219 µg/MJ) is the same as for the public electricity and heat production and combustion in the manufacturing industries and may underestimate PCP emissions from 1A4 sector. Fuel consumption data obtained from the energy statistics is used as activity data.

Table 2.29 EFs for POP compounds in small combustion sources (other than wood combustion).

Fuel	PCDD/F mg I-Teq/TJ	PAH-4 g/TJ	PCB	PCP µg/MJ
	Reference			
	UNEP 1999* USEPA 1997** Ruuskanen 2000***	Expert estimation based on EEA, 2002* UBA, 1998 ** KTM, 1988 ***	EEA, 2005	US EPA (AP-42)
Coal	0.004*	0.012 *	4.5	
Heavy fuel oil	0.0004*	2.8 **	3.6	
Light fuel oil	0.0005*	2.8 **	3.6	
Peat	0.0175***	1 ***	0.9	
Natural gas	0.0005*	0 *		
HCB emission factors for NFR 1A4 subcategories for combustion of wood and coal				
1A4ai	0.01	Reference Joas A., 2006		
1A4bi	0.5			
1A4ci	0.5			

Heavy metals
Heavy metal emissions from 1A4ci (agriculture and forestry) vary annually depending on the use of fuels.

Ammonia
Ammonia emissions from NFRs 1A4ai, 1A4bi and 1A4ci are presented below under Chapter 2.4.8 Small combustion sources.

Particles
Particle emissions (TSP, PM_{10}, $PM_{2.5}$, PM1 and BC) from NFRs 1A4ai, 1A4bi and 1A4ci are presented below under Chapter 2.4.8 Small combustion sources.

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

2018
- Recalculation of the time series

Source-specific planned improvements

2024
- Verification of EFs by comparing national information and latest version of the Guidebook.

1 A 4 b i Residential combustion of wood

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Source category description

This chapter covers emissions from small scale combustion of wood in households, agricultural, commercial and institutional spaces (Table 2.30).

Table 2.30 Activities and emissions reported under NFR 1A4bi

NFR	Source	SNAP	Emissions
1A4bi	Residential combustion - Stationary plants	020201, 020202a, 020202b, 020203, 020204 and 020205	NO_X, NMVOC, SO_X, NH_3, TSP, PM_{10}, $PM_{2.5}$, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB

Small scale combustion in Finland

General Note on Wood combustion in Finland

Many of the commonly used residential wood combustion appliances and specifically the burning habits in Finland differ from those in Europe and even in the other Nordic countries, due to the characteristic principle of the devices to achieve high combustion rate within a short operating time (Tissari et al, 2008). Thus the combustion efficiency is higher and consequently the cleanliness of burning better than in devices generally used in Europe. The placing of the combustion appliance and the chimney in the room space is central, thus allowing maximum utilization of the heat radiation. In the latest decades the building regulations have further tightened and there are minimum values for the insulation structures and coefficients of heat transfer.

User impact

The user dependent impact on small scale wood combustion of emissions is considerable and is taken into account in the calculation of emissions as explained below. Wood combustion skills have traditionally been common knowledge due to the cold climate and need for efficient heating. In the latest decades urbanization (movement to district heating equipped houses) has brought up the need to provide guidance for good combustion practices to those less skilled in manual wood combustion.

Among the best practices in wood combustion are
(a) Low moisture content of the wood, which is impacted by the correct storage conditions (moisture content preferably < 20%)
(b) Combustion according to the equipment specifications regarding the batch lay-out, adding and sizes of batches, ignition, adjustment of air intake and shutdown
(c) Maintenance of the equipment and the chimney
(d) Waste combustion has been forbidden for a long period
(e) While combustion conditions are automatically controlled in the automated equipment, part of the issues listed above remain user influenced.

In recent years several research and development projects have been carried out in order to improve the efficiency of combustion equipment. In the connection of these projects there have been measurement programmes to quantify emissions in the different types of domestic equipment taking also into account those variations to emissions caused by different user practices and other conditions. CE labels have been introduced to industrial appliances and there have been voluntary inspections for the construction of equipment and flue gas properties.

Factors that impact the different air pollutant emissions are presented in Table 2.31.

Table 2.31. Factors that impact emissions.

COMPOUND	FUEL QUALITY	APPLIANCE	USE	MAINTENANCE
Particles	X	X	X	X
SOx	X			
NMVOC, CO		X	X	
NOx	X	*		
NMVOC		X		
NH_3				
Heavy metals	X			
PAHs		X	X	
PCDD/F	X			
Heat yield	*X*	*X*	*X*	*X*

Wood quality/species: barked logs and pellets lowest emissions
New biofuels impact SOx and NOx emissions;
HMs, PCDD/F from contaminated wood (e.g. plastic, waste, boards, treated wood
*Increased use of automatic appliances may reduce NOx emissions

Energy Consumption in NFR 1A4 Sectors

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Shares of energy sources falling under NFR category 1A4, i.e. commercial/institutional buildings (NFR 1A4ai), residential buildings (NFR 1A4bi) and buildings in agriculture and forestry (1A4ci) in 1970-2017 are presented in Figure 2.17. In these sectors energy consumption has increased by 22% during the last 50 years and since 1990 by 50%, while the population increased by 20% and 10%, respectively. The building area has multiplied during the period.

District heating, electricity, ambient energy and wood use are all increasing while the use of oil and coal are in sharp decrease. Out of the new energy forms geothermal heat pumps have compensated part of LFO use and air source heat pumps are increasingly interconnected with electricity use. Other renewable energy sources, e.g. solar and wind energy, are currently not realistic under NFR 1A4 sectors in Finland.

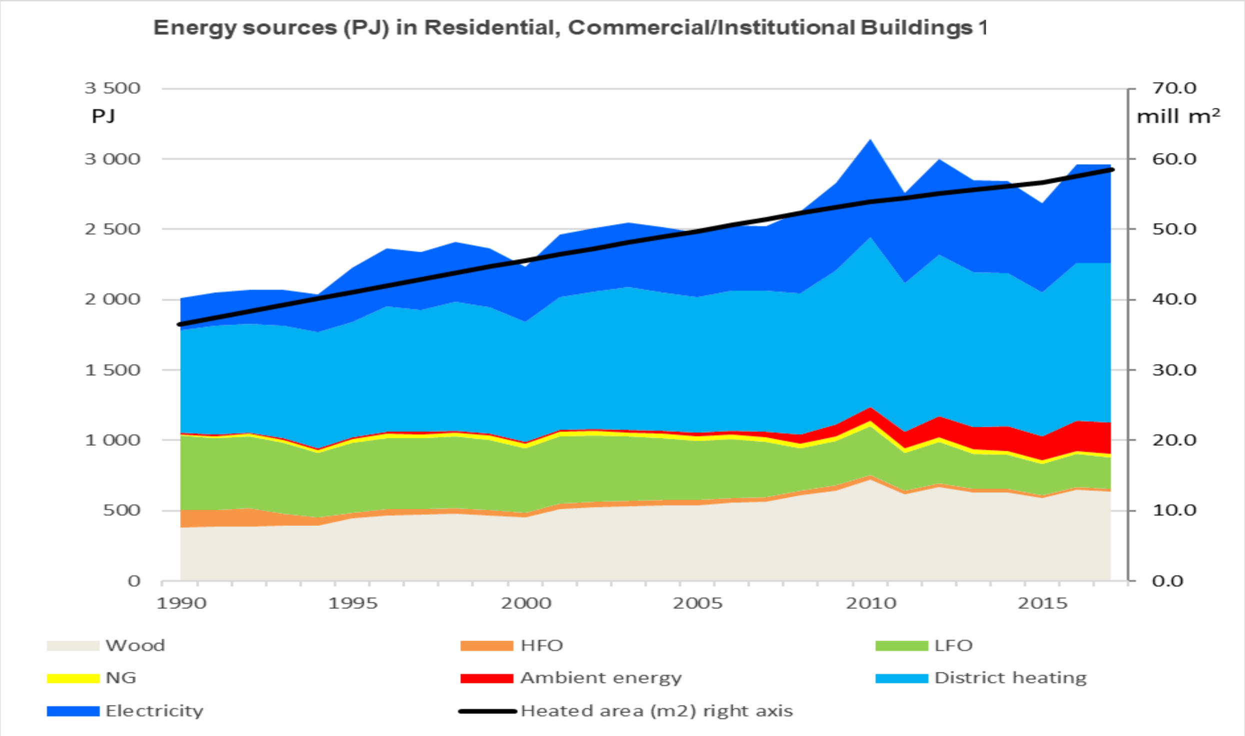

Figure 2.17 Energy sources of heating of residential, commercial/public and agriculture/forestry buildings and heated building area in 1990-2017.

Wood use

Wood is the primary energy source in 25% of residential detached buildings as well as in most recreational buildings, while it is a supplementary heating energy source in most detached residential houses and the main method in recreational buildings.

Energy consumption follows closely the number of heating degree days (HDD) that vary from year to year (Figure 2.18), locally and throughout the year (Figure 2.19). The higher ambient temperature the lower are the HDD values and thus also energy consumption.

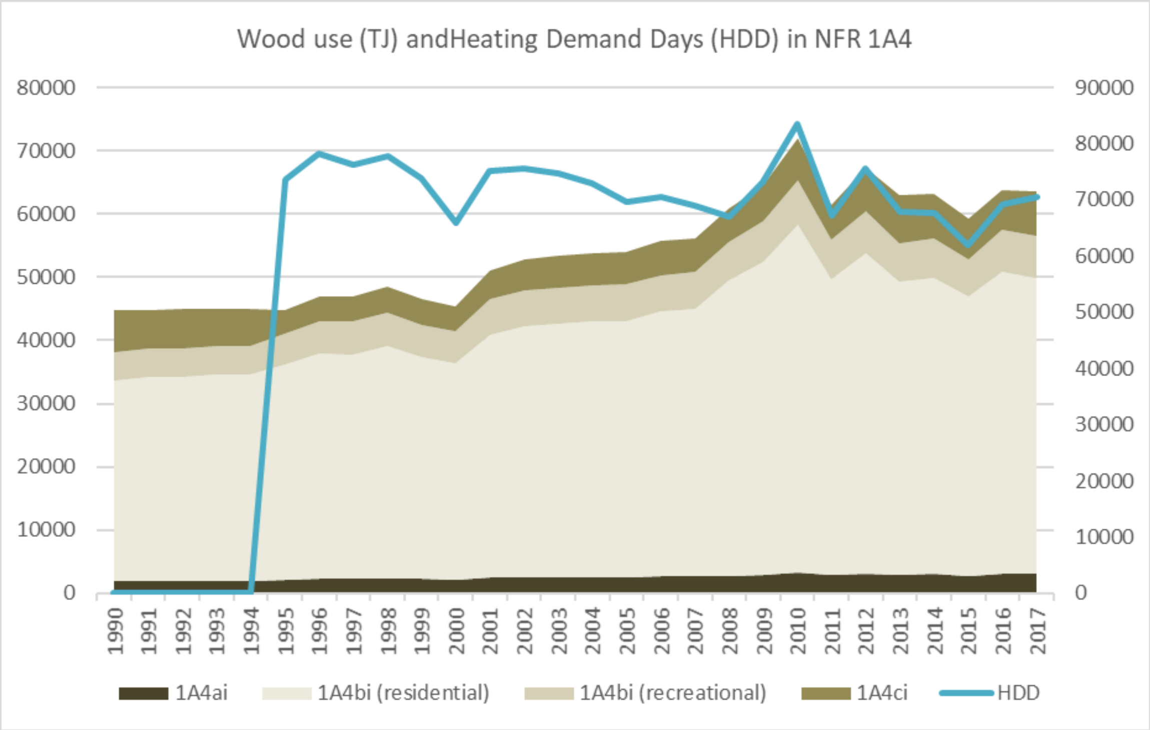

Figure 2.20. Wood use 1990-2017 in Finland in NFR 1A4: 1A4ai commercial/public, 1A4bi residential (presented separately for residential and recreational buildings) and 1A4ci agriculture/forestry buildings (TJ, left axis) and heating day demand (HDD, right axis).

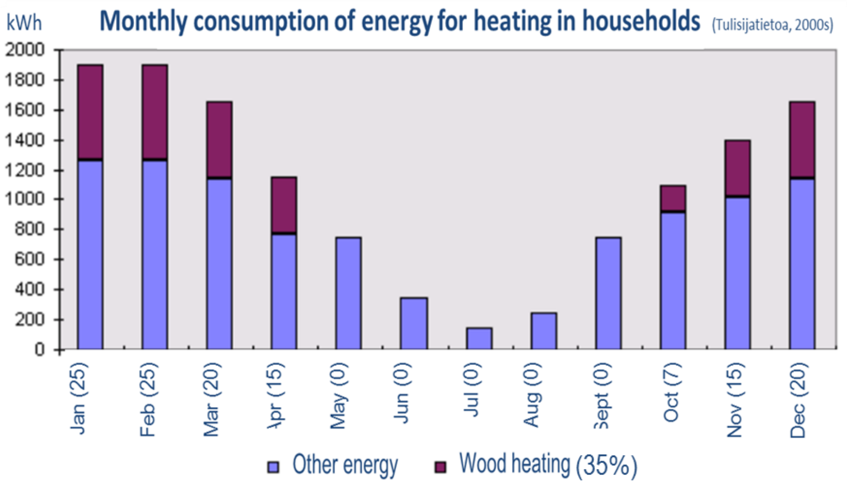

Figure 2.20. Mean monthly consumption of energy for heating purposes in households (Tulisijatietoa, 2000).

Emission trends in small combustion of wood

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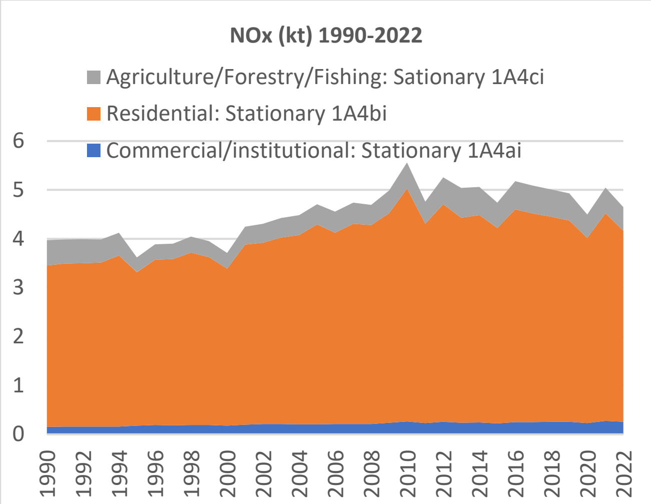
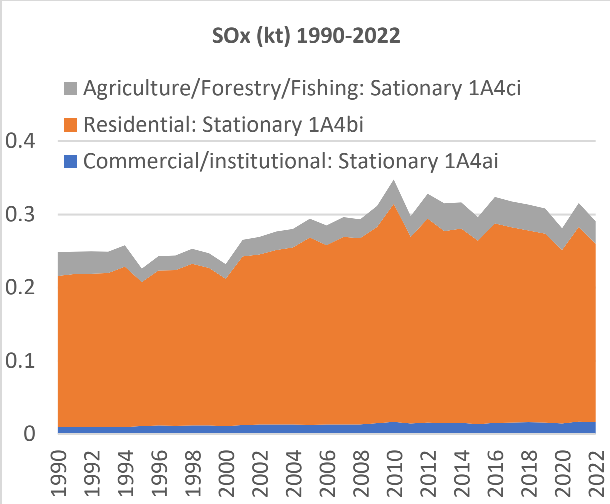
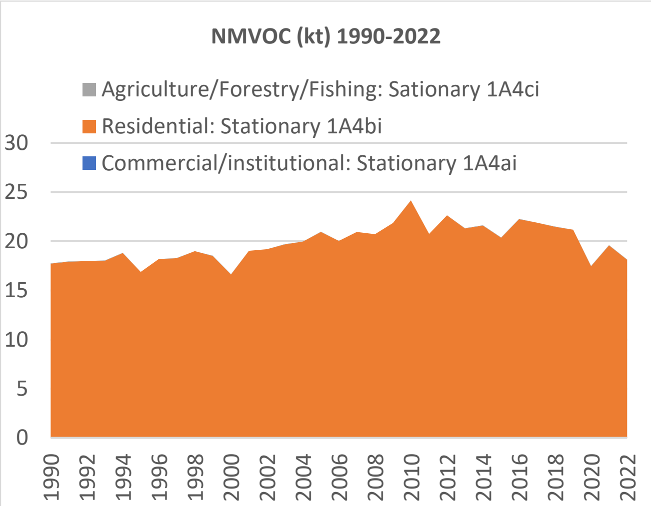
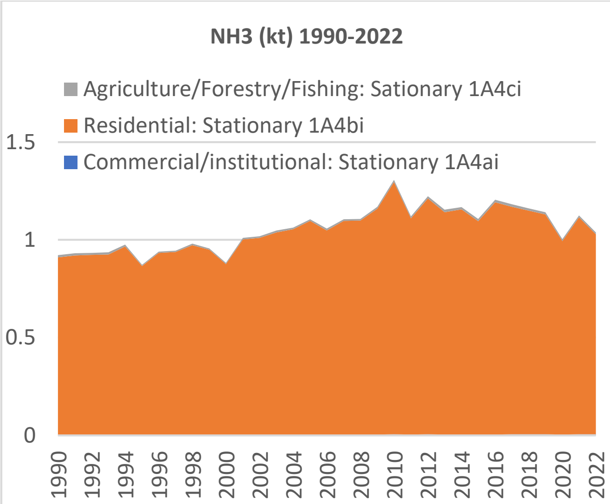
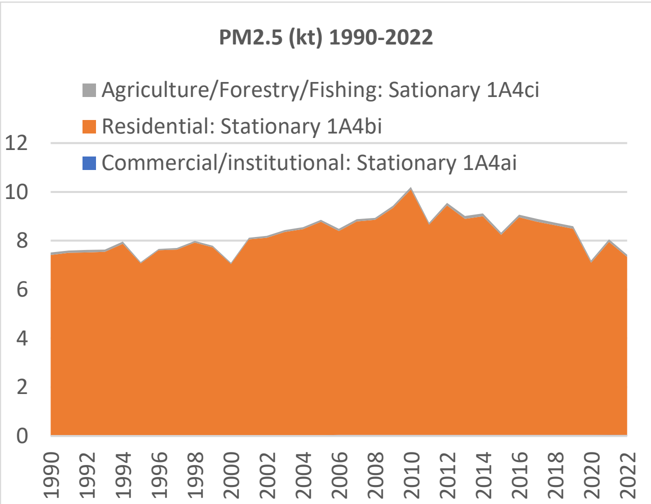
Emissions from small scale wood combustion are impacted by the volume of wood combusted and the share of wood combusted in the different technologies over time. There have been changes between the use of he different techniques since 1990, such as installation of modern sauna stoves, modern masonry heaters and modern iron stoves as can be seen in the method description below. (Figure 2.21)

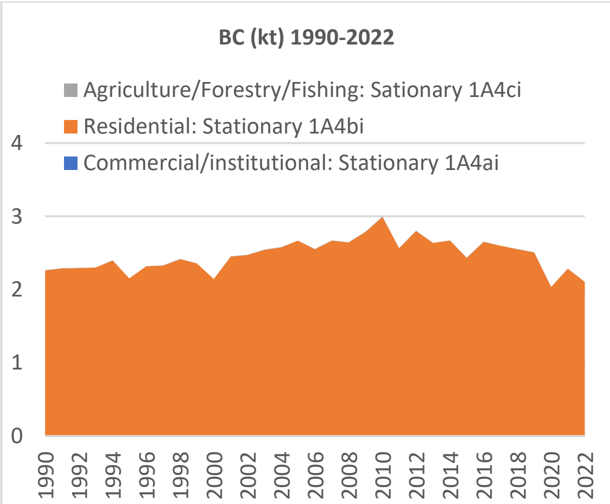

NOx (kt) 1990-2022
Agriculture/Forestry/Fishing: Sationary 1A4ci
Residential: Stationary 1A4bi
Commercial/institutional: Stationary 1A4ai
0 1 2 3 4 5 6
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022


SOx (kt) 1990-2022
Agriculture/Forestry/Fishing: Sationary 1A4ci
Residential: Stationary 1A4bi
Commercial/institutional: Stationary 1A4ai
0 0.1 0.2 0.3 0.4
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022


NMVOC (kt) 1990-2022
Agriculture/Forestry/Fishing: Sationary 1A4ci
Residential: Stationary 1A4bi
Commercial/institutional: Stationary 1A4ai
0 5 10 15 20 25 30
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022


NH3 (kt) 1990-2022
Agriculture/Forestry/Fishing: Sationary 1A4ci
Residential: Stationary 1A4bi
Commercial/institutional: Stationary 1A4ai
0 0.5 1 1.5
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022


PM2.5 (kt) 1990-2022
Agriculture/Forestry/Fishing: Sationary 1A4ci
Residential: Stationary 1A4bi
Commercial/institutional: Stationary 1A4ai
0 2 4 6 8 10 12
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022


BC (kt) 1990-2022
Agriculture/Forestry/Fishing: Sationary 1A4ci
Residential: Stationary 1A4bi
Commercial/institutional: Stationary 1A4ai
0 1 2 3 4
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022

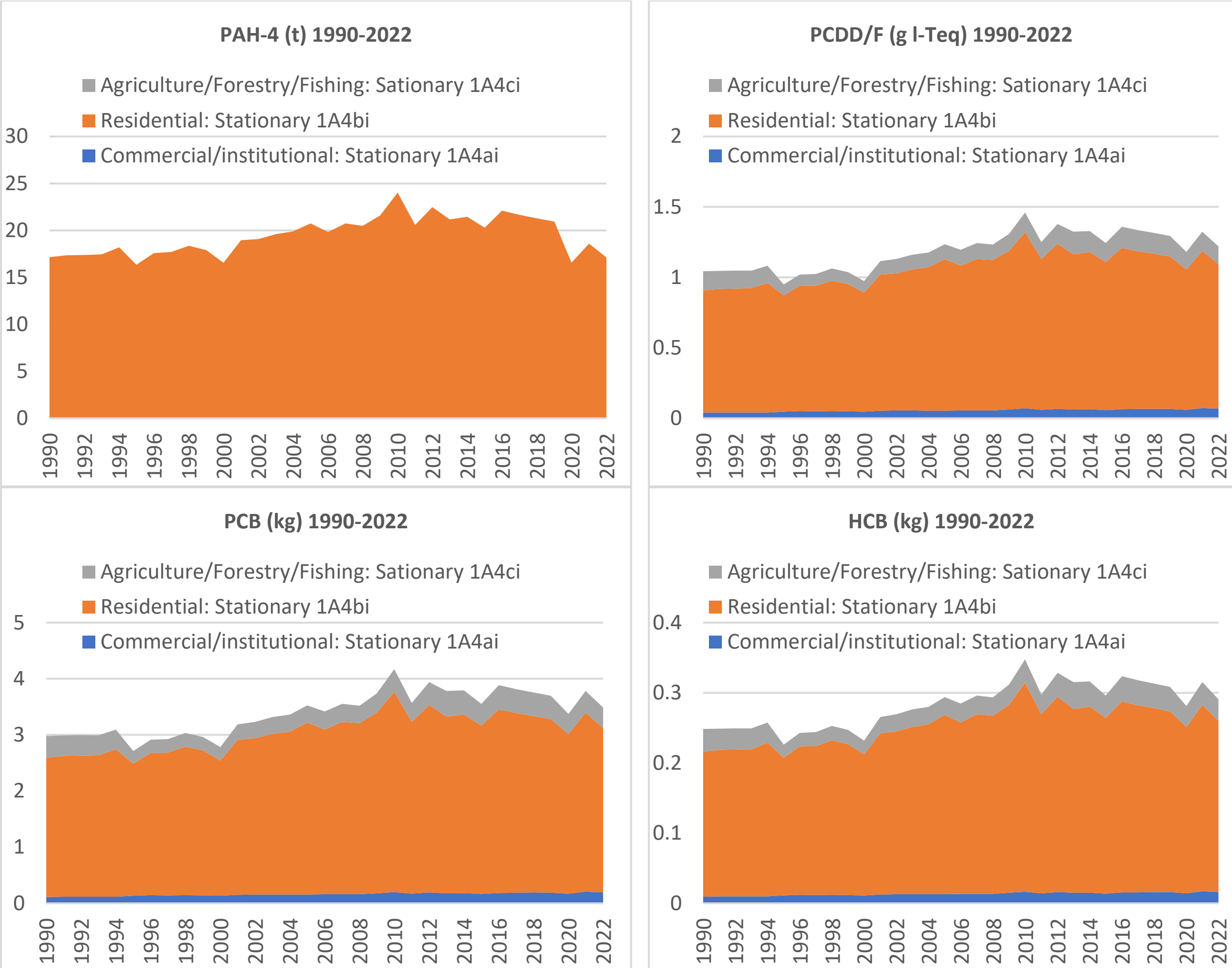


Figure 2.21 Emission trend graphs for small scale wood combustion (for PAH-4 see also Figure 2.28b)

Activity data 1/5 - Domestic combustion equipment

Changes in chapter	
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Wood combustion is the primary heating method in approximately a quarter of residential detached and most of recreational buildings, and the secondary method in almost all residential and recreational buildings. There are approximately 2.2 million small scale wood burning devices and, in addition, around 2 million sauna stoves in Finland (Tissari et al, 2008).

The largest share of wood is combusted in masonry ovens, log boilers and sauna stoves (Figure 2.22). Masonry heaters are energy efficient with high combustion rate, high heat storing capacity and low emissions, and are typically located centrally in the building to maximize the heat radiation. Log boilers and sauna stoves have lower energy efficiency and higher emissions.

Masonry heaters are typically massive (1000 - 6000 kg) heat storing structures with an upright rebox. The exhaust gas flows to an upper combustion chamber, then down through the ducts and then to the chimney (Figure 2.23). The large mass efficiently stores heat and releases it slowly (average rate of 1-3 kW) in a period ranging from 10 hours to two days. Most new detached houses in Finland are equipped with a masonry heater (Tissari 2008, Paunu 2012). The low emission rate is based on hot and closed surfaces of the firebox that support the completeness of combustion, and the good secondary combustion due to the secondary combustion chamber. The air intake is restricted and the operation temperature high, while particles emissions are composed of the vapourized ash elements of wood (Tissari et al 2008).

Figure 2.22. Air flow in a masonry oven (Alakangas et al 2008)

The firebox in a *sauna stove* is small and there is no secondary combustion as the use purpose is different from appliances that are designed to heat residential spaces: the heating need in a sauna room is temporarily high and therefore the combustion rate is high. *Water boilers* are common in sauna buildings have similar construction and are used to heat water to be used directly from the boiler (Tissari 2008).

Wood log boilers in Finland are typically updraught boilers, not always equipped with a heat storage tank, have often low thermal output and high emissions, and are mainly used in rural areas as the main heating device.

Other typical heating appliances include

- *wood chip boilers*, with a capacity range of 100-200 kW, used to heat large agricultural buildings and school spaces
- *multifuel boilers*, where oil, wood and pellets can be combusted and
- *masonry cooking stoves* where then structure includes both a wood burning oven and a masonry heater

The use of pellet burners or iron stoves is not common in Finland. (Tissari 2005).

The development of wood combustion in the different appliances over time is estimated based on questionnaires carried out by Natural Resources Institute (LUKE) and Statistics Finland with comparison to information from appliance sales.

Activity data 2/5 – Wood use statistics

Wood use statistics, compiled by Nature Resources Institute Finland (Luke) is based on Act on the Natural Resources Institute Finland (561/2014), Act on Statistics of Food and Natural Resources (562/2014) and Statistics Act (280/2004). The statistics covers data on fuel wood use in residential buildings by wood species as well as property, building and combustion equipment types and is publicly available since 1970. The data is part of national energy statistics, it is used in the preparation of national forest strategy, regional forest programs and in different accrual and outturn statistics as well as in follow-up of EU's renewable energy use targets and in reporting to Eurostat, FAO, IEA and UNECE.

Wood use in residential buildings covers all solid wood fuels, such logwood, smallwood and forest chips made of stemwood and waste wood from forests, wood residues from the sawmills, construction etc. and wood pellets.

Data collection (Luke and Statistics Finland, StatFi)

The statistics is based on surveys that have been carried out ten times since 1927. The methods used in the last four surveys (1992/1993, 2000/2001, 2007/2008 and 2016/2017) and in the calculation of results are consistent. The survey covers detached and semidetached houses, rowhouses, farmhouses and recreational buildings. Each of these forms a stratum that is used in the statistics. To minimize the total sampling error, sampling size for each stratum reflects its observed variance in earlier studies. The selection of survey subjects is based on Statistics Finland's building and apartment database and the frame covers the whole country. The sample size of the latest survey carried out in 2017 was 10 000 subjects representing all the strata.

Data processing, results and uncertainties (Luke and StatFi)

The calculation of annual wood use in years between the surveys is made at Statistics Finland using a specific wood consumption model. In the model the survey results are interpolated using the data for total heated area in detached and semidetached houses, rowhouses, farmhouses and recreational buildings. The model scales annual wood consumptions by applying annual mean temperatures and heat demand days (HDD) to equal the survey results. Finnish Meteorological Institute provides monthly HDD values for the different parts of the country. HDD values are lower, where outside temperatures are higher, thus equaling to lower energy consumption, and vice versa.

The surveys do not cover rental cottages or commercial and service buildings, where the use of wood is negligible compared to those covered by the survey. Uncertainty is related to the fact that some of the respondents had challenges in providing accurate information on the use of fuelwood. Information was considered most accurate in cases where the fuelwood was purchased on commercial basis or the amount procured from own forests was rather big.

Wood use statistics was corrected for accuracy to the official statistics, and, to the inventory for the 2022 submission as well.

Wood use is increasing due to:

1. Climate and energy policies and economical drivers

In the national energy and climate strategy up to 2030 wood is considered as a renewable carbon neutral energy source and its increased use is encouraged. Nationally the share of renewable fuels in total energy use is decided politically and the target in the 2020s is 50% out of final energy consumption with a 55% self-sufficiency degree. In the EU effort sharing regulation (and the regulations amending and implementing it), the 2030 target for the non-emissions-trading sector in Finland is to reduce greenhouse gas emissions with 50% from the 2005 level.

Wood and biogenic recycled fuels are the main renewable energy sources in Finland. Wood is easily accessible in Finland and a relatively cheap source of energy compared to electricity.

2. Increasing building stock

Despite the relatively young age and relatively energy efficient building stock, need for heating is increasing due to the increased volume of the stock. The heated space under NFR 1A4 categories has increased by 60% since 1990 while total energy consumption increased by 30% and use of wood by 40% at the same time.

80% of Finnish building stock has been constructed after 1946 and is thus rather young. In the latest decades the building regulations have further tightened regarding energy efficiency and minimum values for the insulation structures and coefficients of heat transfer have been determined in the National Building Code.

3. Requirements for peak and reserve energy

In the cold climate, secondary heating systems are needed during cold periods to cut the electricity consumption peaks and as an emergency source of energy during power cuts and other exceptional situations. Good practice building practices include secondary heating systems in houses with direct electricity heating. Small scale wood combustion is a secondary heating system in most residential buildings. In rural areas, wood use in an increasing number of second (recreational) homes since the 1990s has compensated the due to urbanization declining wood use in abandoned residential buildings.

Activity data 3/5 – Combustion equipment

National energy statistics on wood use provides wood combustion volumes in residential and recreational buildings, single houses, row houses and block houses. The general shares as presented in Figure 2.24 are for residential combustion (NFR 1A4bi) three quarters of the annual wood use, with more than 70% used in detached houses and less than 1% in both block and row houses. For both recreational and agricultural buildings the annual wood use covers 10% of the total combustion volumes, and for both commercial and industrial buildings around 5%. For block houses, all wood is assumed to be combusted in fireplaces.

The development of the shares are presented in Figure 2.23.

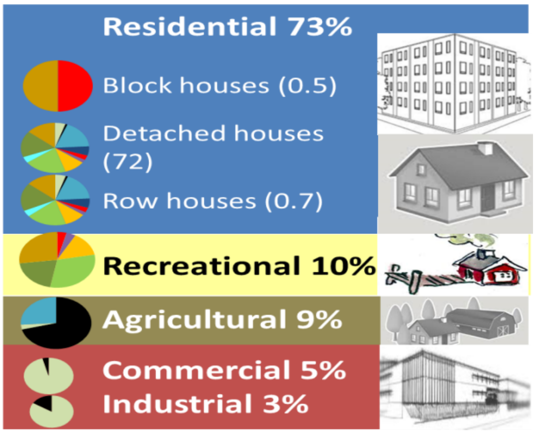

Figure 2.23. General shares of annual wood combustion in the different house types.

Technology specific methodology for small scale combustion of wood

Changes in chapter	
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The details included in the small combustion of wood inventory are presented below.

Combustion technologies in Finland

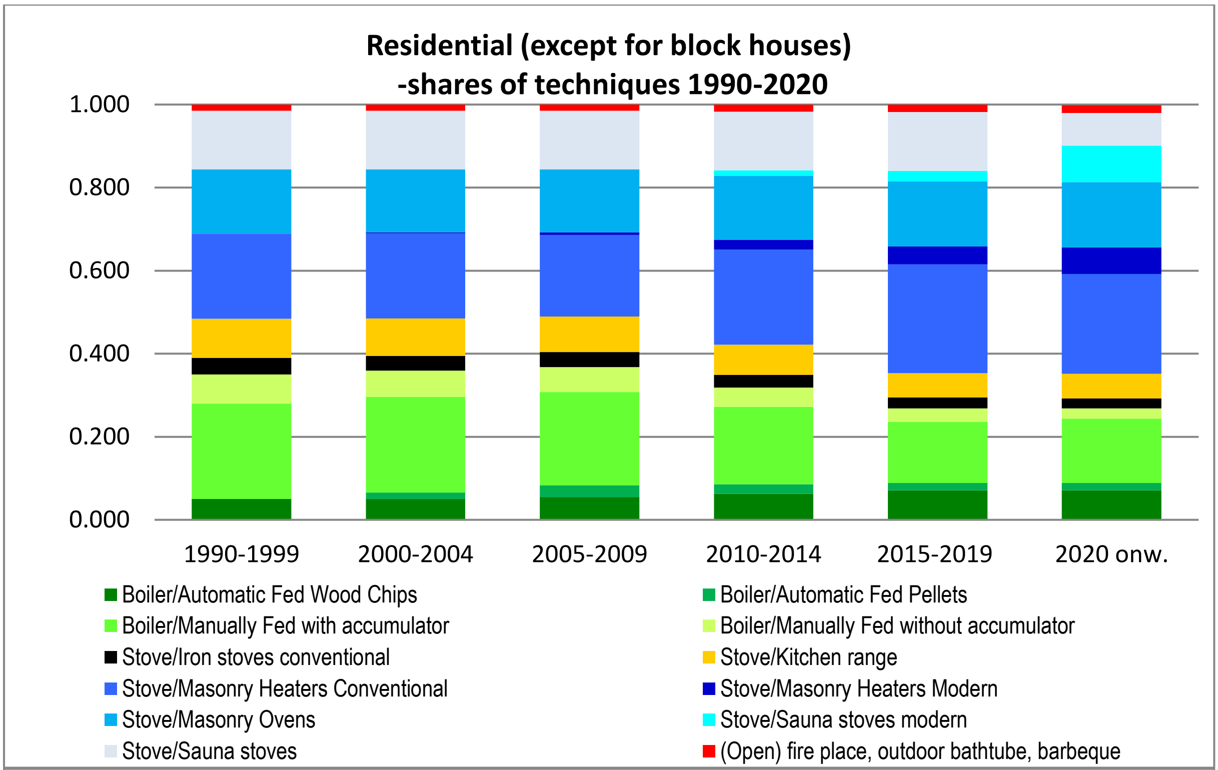
1 iron stoves conventional (firewood)
2 iron stoves modern (firewood)
3 automatic fed boilers (wood chips)
4 automatic fed boilers (pellets)
5 manually fed boilers with accumulator (firewood)
6 manually fed boilers without accumulator (firewood)
7 manually fed boiler, modern (firewood)
8 open fireplace and other stove (firewood)
9 kitchen range (firewood)
10 masonry heaters, conventional (firewood)
11 masonry heaters, modern (firewood)
12 masonry ovens (firewood)
13 sauna stoves (firewood)
14 modern sauna stoves

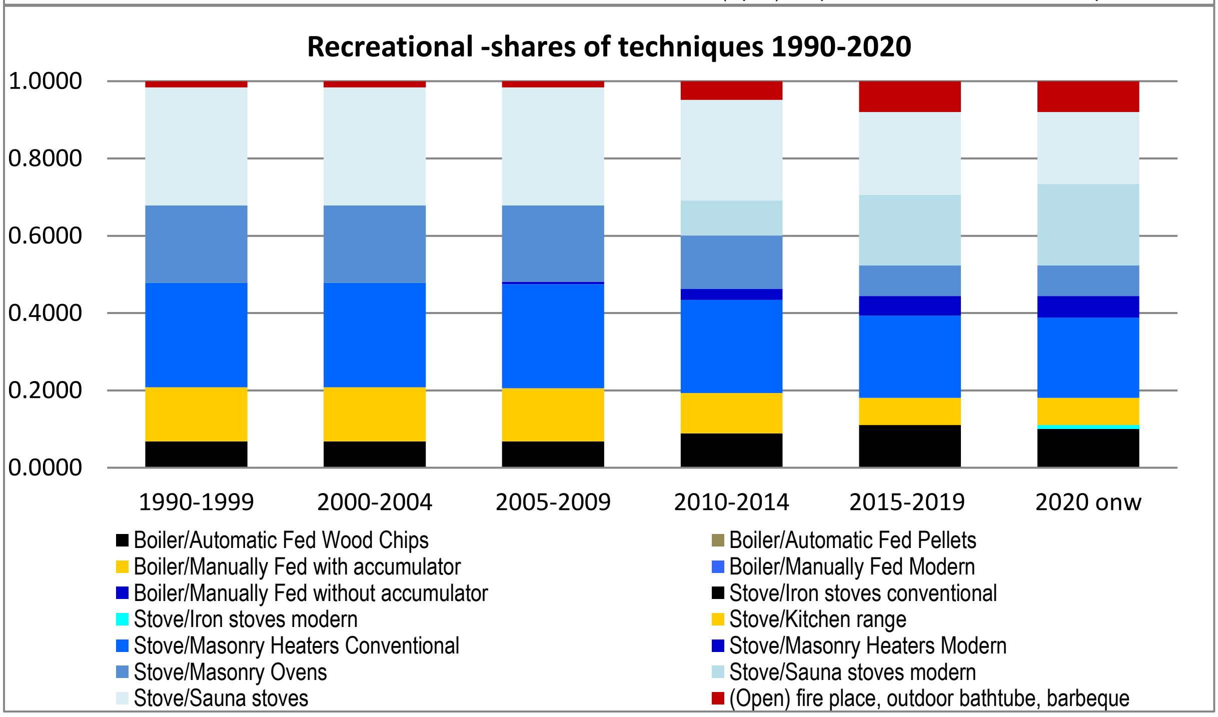
Activity data (4/5) – Wood use in the different equipment

Amounts of wood (firewood, wood chips and pellets) combusted in the different equipment (see above) in the four small combustion sectors (below) based on inquiries made for the national statistics (see above) and on expert knowledge as presented in Figure 2.24:

(1) Residential (Data is separately for single and row houses as well as block houses. For block houses after 1990 it is assumed that all wood is combusted in open fires.
(2) Recreational
(3) Commercial/industrial

(4) Agriculture





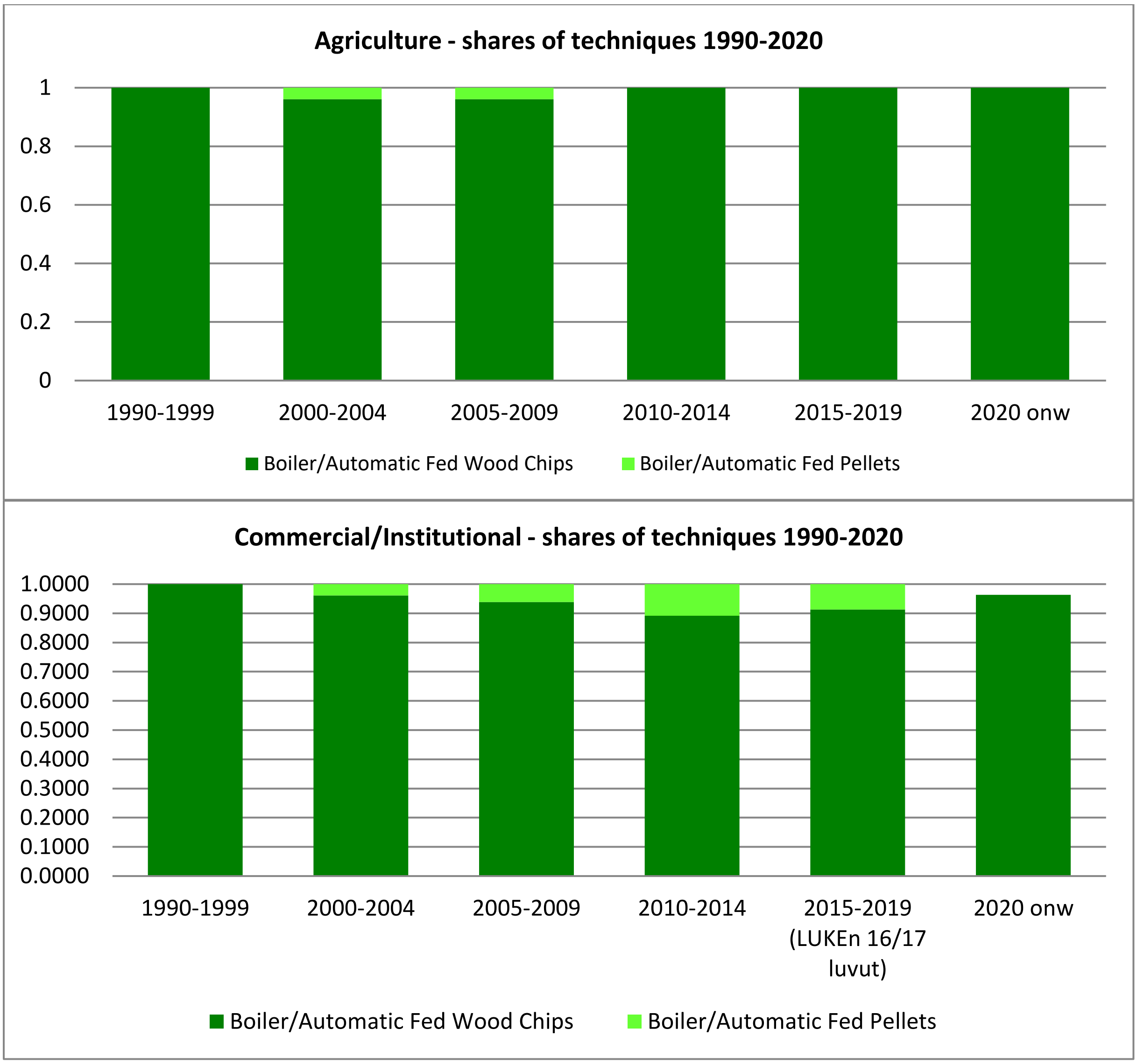


Figure 2.24 Wood use in different appliances in NFR 1A4 categories since 1990

Activity data (5/5) Normal and bad combustion

Shares of normal and bad combustion conditions in the different activity sectors and equipment are taken into account in the emission factors.

The emission factors are calculated as the sum of the EF for normal combustion conditions (between 90% … 100% of total combustion time, defined for each equipment) and the EF for bad combustion conditions (between 0% … 10% of total combustion time defined for each equipment).

The ratio bad combustion/normal combustion depends on the pollutant, being for instance for particulate matter between 1 … 3.3.

For small particles, the emission factors are calculated as shares from the TSP emission factors (10%).

Methodology for small combustion of wood

Changes in chapter	
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The emissions are calculated from the wood volumes combusted in each equipment category. Wood consumption is multiplied with the pollutant specific EF and the technique specific share of normal and bad combustion condition.

Technology specific EFs for residential combustion of wood-based fuels during normal operation conditions are presented in Table 2.32.

The EFs are based on domestic measurements, and the same measurement technique is used in all measurements. The operation (i.e. the way the appliances are used) varies according to the specifications of the appliance to be measured. The measurement results include the whole combustion period from ignition to glowing embers phase and normal combustion and are averaged over the combustion cycle. $PM_{2.5}$ samples of small particles are collected from diluted flue gas at room temperature and thus include the condensable component of particulate matter. The measurement and sampling technique are described in Tissari et al., 2019[4]. The method is not standardized but is used more than fifteen years successfully in several scientific projects at UEF (University of Eastern Finland, Fine Particle and Aerosol Technology Laboratory (FINE)).

The country specific emission factors are calculated as the weighted average of the EF for normal combustion conditions (between 90-100% of total combustion time, defined for each equipment) and the EF for bad combustion conditions (between 0-10%). The emission factors are recorded in large database (Starship), which includes results representing the whole combustion cycle (ignition, combustion phase under normal burning conditions, shut down of emission). The resuts cover different appliances under different loads and number of batches.

The share of bad combustion is estimated to be around 10.5% based on surveys to chimney sweepers, national studies and expert estimates.

The final EF is thus as follows:

Final EF = EF * (1-X) + EF * X * Y* EF.

Where EF = emission factor during normal combustion conditions
X = share of wood that is combusted under bad combustion conditions, 10.5%
Y = factor for how many times higher the emissions are during bad combustion conditions than during normal combustion conditions, depends on the equipment and the pollutant (e.g. 5)

Wood use in the different house types are divided into 14 equipment categories and into six 5-year periods to take into account the evolvement of the use of different equipment over time (Table 2.32): 1990-1999, 2000-2004, 3005-2009, 2010-2014, 2015-2019, and from 2020 onwards.

Table 2.32. Technology-specific EFs for residential combustion of wood based fuels during normal operation conditions (PUPO Database and Starship 2015)

MAIN POLLUTANTS	SO2	NOx	CO	NMVOC	NH3	TSP	PM10	PM2.5	PM1	BC
	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ
Iron stoves conventional	5	80	2315	3030	16.9	82	79	76	74	22
Iron stoves modern	5	80	1176	62	8.6	52	50	49	747	14
Autom. Fed Wood Chips	5	80	164	3	1.2	17	16	16	15	0.5
Automatic Fed Pellets	5	80	89	3	0.7	21	20	20	19	0.6
Manually Fed, accumulator	5	80	1951	49	14.2	146	140	135	131	24
Manually Fed without accumulator	5	80	1951	402	14.2	752	722	700	677	210
Manually Fed Modern	5	80	164	49	1.2	18	17	17	16	0.5
Open fire place, other stove	5	80	5939	308	43.4	621	596	578	559	35
Kitchen range	5	80	1517	70	11.1	51	49	48	46	32
Masonry Heaters Conventional	5	80	1875	159	13.7	100	96	93	90	38
Masonry Heaters Modern	5	80	869	106	6.3	36	34	33	32	15
Masonry Ovens	5	80	1312	70	9.6	47	45	43	42	14
Sauna stoves	5	80	3979	690	29.0	279	268	259	251	115
Modern sauna stoves	5	80	2795	345	20.4	134	129	125	121	51

[4] Available at https://doi.org/10.3390/atmos10120775

HEAVY METALS	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	V	Zn
	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ
Iron stoves conventional	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Iron stoves modern	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Autom. Fed Wood Chips	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Automatic Fed Pellets	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Manually Fed, accumulator	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Manually Fed without accumulator	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Manually Fed Modern	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Open fireplace and other stove	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Kitchen range	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Masonry Heaters Conventional	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Masonry Heaters Modern	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Masonry Ovens	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Sauna stoves	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7
Modern sauna stoves	0.001	0.003	0.035	0.006	0.0005	0.03	0.01	0.005	0.001	0.7

POP COMPOUNDS	PCDD/F	PAH-4	HCB	PCB	PCP
	mg ITEQ/MJ	mg/MJ	mg/MJ	mg/MJ	mg/MJ
Iron stoves conventional	0.000000021	0.3	0.000005	0.00006	0.0000219
Iron stoves modern	0.000000021	0.07	0.000005	0.00006	0.0000219
Autom. Fed Wood Chips	0.000000021	0.001	0.000005	0.00006	0.0000219
Automatic Fed Pellets	0.000000021	0.001	0.000005	0.00006	0.0000219
Manually Fed, accumulator	0.000000021	0.15	0.000005	0.00006	0.0000219
Manually Fed without accumulator	0.000000021	0.2	0.000005	0.00006	0.0000219
Manually Fed Modern	0.000000021	0.008	0.000005	0.00006	0.0000219
Open fireplace and other stove	0.000000100	0.1	0.000005	0.00006	0.0000219
Kitchen range	0.000000021	0.1	0.000005	0.00006	0.0000219
Masonry Heaters	0.000000021	0.2	0.000005	0.00006	0.0000219
Masonry Heaters Modern	0.000000021	0.005	0.000005	0.00006	0.0000219
Masonry Ovens	0.000000021	0.2	0.000005	0.00006	0.0000219
Sauna stoves	0.000000021	1.0	0.000005	0.00006	0.0000219
Modern sauna stoves	0.000000021	0.2	0.000005	0.00006	0.0000219

Pollutant and technique specific factors for bad combustion are based on information available in the PUPO database http://www.uef.fi/en/fine/pupo. To the 2019 submission CO and particle emission factors were revised in addition to PCDD/F EF for open fireplaces, due to new information from national research (Starship database, 2015).

PAH-4 emissions are divided into the 4 PAH indicator species by applying division factors developed in cooperation with University of Eastern Finland (Tissari et al., 2021[5]). The technique specific division factors are presented in Table 2.33.

[5] Tissari J, Lamberg H, Saarinen K, Savolahti M, Forsberg T (2021) Puun pienpolton PAH-4-päästökertoimien arviointi (PAH4), Loppuraportti. University of Eastern Finland, Kuopio. p. 65 (In Finnish) (English: Evaluation of PAH-4 emission factors for small scale wood combustion).

Table 2.33 Technology-specific division factors for dividing PAH-4 emissions for residential combustion of wood into the 4 PAH indicator species

TECHNIQUE	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd) pyrene	Reference
	fraction	fraction	fraction	fraction	
Iron stoves conventional	0.26	0.37	0.16	0.21	Expert estimate at UEF
Iron stoves modern	0.29	0.43	0.14	0.14	Expert estimate at UEF
Autom. Fed Wood Chips	0.3	0.6	0	0.1	Expert estimate at UEF
Automatic Fed Pellets	0.39	0.39	0.12	0.1	Expert estimate at UEF
Manually Fed, accumulator	0.51	0.33	0.03	0.13	Expert estimate at SYKE
Manually Fed without accumulator	0.28	0.33	0.16	0.23	Expert estimate at UEF
Manually Fed Modern	0.51	0.33	0.03	0.13	Expert estimate at UEF
Open fire place, other stove	0.34	0.31	0.17	0.18	Expert estimate at UEF
Kitchen range	0.26	0.37	0.16	0.21	Expert estimate at SYKE
Masonry Heaters Conventional	0.31	0.2	0.22	0.27	Expert estimate at UEF
Masonry Heaters Modern	0.25	0.44	0.16	0.15	Expert estimate at UEF
Masonry Ovens	0.31	0.2	0.22	0.27	Expert estimate at SYKE
Sauna stoves	0.31	0.25	0.22	0.22	Expert estimate at UEF
Modern sauna stoves	0.3	0.32	0.16	0.22	Expert estimate at UEF

Ammonia
Ammonia emission factors for small scale wood combustion are calculated as a share of carbon monoxide emissions for which extensive national measurements have been carried out for different combustion appliances and conditions (PUPO database http://www.uef.fi/en/fine/pupo). The specific emissions from different combustion appliances have in national measurements stayed at the level of 1.7-7.3 mg/MJ, which is just above the measurement threshold level. The ratio NH_3:CO of 0.0073 is based on a literature value for wildfires in order not to underestimate emissions. The resulting emission factors match well the national measurement results for ammonia emissions in the different conditions.

Particles and condensable part of the emissions
The particle emission factors are based on domestic measurements at the University of Eastern Finland (UEF), where the sampling and measurement method used collects also data for the condensable part of emissions (personal communication, Heikki Lamberg, 2018). PM2.5 samples are collected from diluted flue gas at room temperature and thus include the condensable component of particulate matter.

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. The data obtained from YLVA is cross-checked against the summary data (by fuels and by CRF categories) reported to the UNFCCC as explained in Chapter 1.4.4 (Part 1A General of the IIR).

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

2014-2016
- The inventory of small-scale combustion of wood was revised to better reflect the domestic combustion technologies and practices. Also, the allocation of wood fuels in the different NFR categories was checked.

2015
- BC and NH3 emissions were reported using the revised model for the whole time series.

2016
- All air pollutants were recalculated since 2016 using the revised model for the latest year.

2018
- All air pollutants were reported using the revised model for the whole time series following the time series recalculation of the energy sector.

2019
- Impacts of the recalculations are presented in Annex 9 (submitted 1 May 2019)
- The national wood use statistics was revised and thus wood use in the different techniques was updated
- All CO and particle EFs were updated and PCDD/F for open fires

2020
- 1A4ci/all pollutants for 2016: update according to energy statistics change on the amount of wood fuels in agricultural buildings, slight increase of emissions (max 16%)

2021
- PAH emissions were recalculated based on UEF 2020 study (reference: Tissari et al (2021) Puun pienpolton PAH-4 päästökertoimien arviointi (PAH4), Loppuraportti. (Evaluation of PAH-4 emission factors from small scale wood combustion, Final Report), University of Eastern Finland, Kuopio 65 p. (In Finnish)

2022
- All emissions previously reported under category 1A5b were reallocated under category 1A5a for the whole time series. These included emissions from military.
- The small combustion equipment stock shares of wood use were fine-tuned according to more accurate information.
- Corrections to official wood use statistics were incorporated into the inventory.

2024
- Corrections to official wood use statistics for agricultural buildings for 2020 were incorporated into the inventory.
- Corrections to fuel use data of several fuels for 2021 received from the energy statistics of Statistics Finland were incorporated into the inventory.

Source-specific planned improvements

None

4 Fugitive Emissions from Solid Fuels (NFR 1.B.1)

Changes in chapter	
February 2019	JMP, KS

1 B 1 a Fugitive emission from solid fuels: Coal mining and handling

There is no hard or brown coal mining in Finland.

Emissions from the use and handling of coal are included under NFR 2A5c Storage, handling and transport of mineral products and reported in the NFR as “IE”.

Source-specific recalculations and improvements

2018
- The notation key “NA” for $PM_{2.5}$ was changed to “IE” (included under 2A5c) as response to the recommendation from the NECD Review 2017.

1 B 1 b Fugitive emission from solid fuels: Solid fuel transformation

Changes in chapter	
February 2024	JMP, KS JM

Source category description

All emissions reported under the sector fugitive emissions from solid fuel (NFR 1B1) originate from coke production.

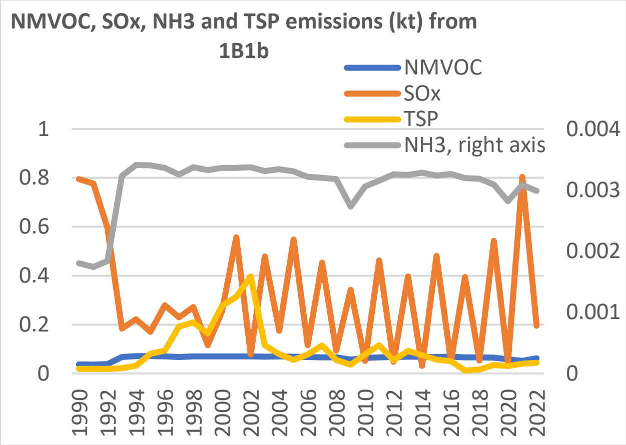
The contribution of emissions from coke production in 2021 to total emissions as well as the shares reported by the operators are presented in Table 2.34.

Table 2.34. Contribution of NFR 1B1b Fugitive emissions from solid fuels (NFR 1B1b), shares reported by operators, in 2022.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NMVOC	0.062	Gg	<0.1	0
SOx (as SO_2)	0.195	Gg	0.9	100
NH_3	0.003	Gg	<0.1	0
$PM_{2.5}$	0.008	Gg	<0.1	0
PM_{10}	0.018	Gg	<0.1	0
TSP	0.043	Gg	0.1	100
BC	0.004	Gg	0.1	0
Pb	0.013	Mg	0.1	100
Cd	<0.001	Mg	<0.1	100
Hg	<0.001	Mg	<0.1	0
As	0.001	Mg	<0.1	100
Cr	0.009	Mg	<0.1	100
Cu	0.010	Mg	<0.1	100
Ni	0.012	Mg	0.1	100
Zn	0.041	Mg	<0.1	100
PCDD/F	0.023	g I-Teq	0.2	100
PAH-4	<0.001	Mg	<0.1	0
PCB	2.909	kg	14.6	0

Emission trend

Emission trends in NFR category 1A1b are presented in Figure 2.25. In the case of SOx emissions, there is strong interannual fluctuation in the emissions. The higher SOx emissions are due to the maintenance shutdown of the desulphurization unit of the coking plant. The desulphurization unit includes also a claus process. When the claus process is out of use during the shutdown period, the deacifier is also out of use, which causes the increase in SOx emissions. The maintenance shutdown of the desulphurization unit occurs in average every other year. The duration of the maintenance shutdown is 4 to 5 weeks. The years with increased SOx emissions indicate the years with maintenance shutdowns in the desulphurization unit of the coking plant.



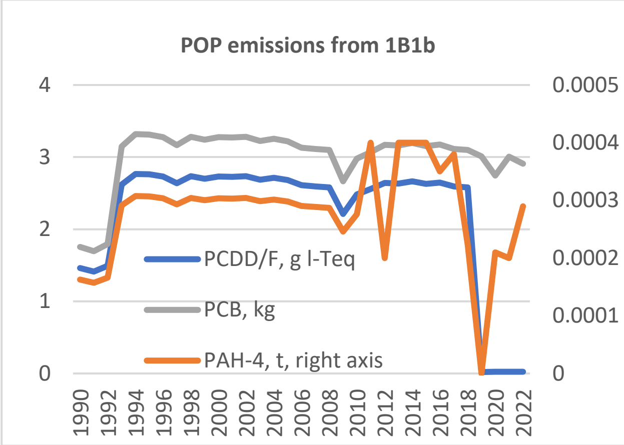


Figure 2.25. Emission trends from NFR 1B1b.

Methodological issues

SOx, PMs, HMs

SO_x, heavy metal and TSP emissions are reported by the operators according to monitoring requirements in their environmental permits. Fine particle fractions are calculated from TSP emission data reported by the plants using emission factors of 42% for PM_{10} and 18% of TSP for $PM_{2.5}$ (Guidebook 2023). BC emissions are calculated using a fraction of 49% of $PM_{2.5}$ (Guidebook 2023).

NH3, NMVOC, POPs

NH_3 and NMVOC emissions are calculated using coke production as activity data and emission factors from Guidebook 2023.

PCDD/F emissions are calculated using a plant specific emission factor $2.87E^{-8}$ g/t I-TEQ that is based on emission data reported by the plants. From 2019 onwards, the emissions are reported by the plants.

PAH emissions from 2011 onwards are reported by plants based on measurements, and for 2019 the measured values were below the detection limit (reported as NA). For calculation of PAH emissions in 1990-2010 the plant specific emissions factor of $3.336E^{-7}$ kg/t has been used.

For PCB emissions the emission factor of 3600 µg/t (BiPRO, 2006,1994) has been used. There is no PCB emission factor available in the 2023 Guidebook.

NOx and CO

NO_x emissions from coke production are currently allocated under NFR 1A2a. With reference to the NECD review question FI-1B1b-2018-0001, the emissions are reported by the plant are not split between energy and process-based emissions. Therefore, emissions under NFR 1B1b are reported as IE in the NFR table. In addition to NO_x emissions, also CO emissions are allocated under NFR 1A2a and thus reported as IE in the NFR table. In case the split would be done, process emissions for some years would become zero. The process emissions are small, this is due to the uncertainties in the energy-EF.

Activity data for coke production is taken from the YLVA database and it is based on information from the company. Production rates, calculated emissions and emission factors are presented in Table 2.35.

Table 2.35. Activity data and emissions for coke production.

Annual production of coke and the related emissions									
Year	Activity data (t)	NMVOC (t)	PCDD/F g I-TEQ	B(a)P (kg)	B(b)F (kg)	B(k)F (kg)	Ind (kg)	PCB (kg)	NH_3 (t)
1990	487 000	37.5	0.014	32.5	105.6	0.00	24.4	1.75	1.80
1991	471 000	36.3	0.013	31.4	102.2	0.00	23.6	1.70	1.74
1992	498 000	38.3	0.014	33.2	108.0	0.00	24.9	1.79	1.84
1993*	874 000	67.3	0.025	58.3	189.6	0.00	43.7	3.15	3.23
1994	922 000	71.0	0.026	61.5	200.0	0.00	46.1	3.32	3.41
1995	920 000	70.8	0.026	61.4	199.5	0.00	46.0	3.31	3.40
1996	910 000	70.1	0.026	60.7	197.4	0.00	45.5	3.28	3.37
1997	879 000	67.7	0.025	58.7	190.6	0.00	44.0	3.16	3.25
1998	912 000	70.2	0.026	60.9	197.8	0.00	45.6	3.28	3.37
1999	900 000	69.3	0.026	60.1	195.2	0.00	45.0	3.24	3.33
2000	910 000	70.1	0.026	60.7	197.4	0.00	45.5	3.28	3.37
2001	909 000	70.0	0.026	60.7	197.2	0.00	45.5	3.27	3.36
2002	912 000	70.2	0.026	60.9	197.8	0.00	45.6	3.28	3.37
2003	895 217	68.9	0.026	59.7	194.2	0.00	44.8	3.22	3.31
2004	903 723	69.6	0.026	60.3	196.0	0.00	45.2	3.25	3.34
2005	893 628	68.8	0.026	59.6	193.8	0.00	44.7	3.22	3.31
2006	869 937	67.0	0.025	58.1	188.7	0.00	43.5	3.13	3.22
2007	865 007	66.6	0.025	57.7	187.6	0.00	43.3	3.11	3.20
2008	860 428	66.3	0.025	57.4	186.6	0.00	43.1	3.10	3.18
2009	737 934	56.8	0.021	49.2	160.0	0.00	36.9	2.67	2.73
2010	826 800	63.7	0.024	55.2	179.3	0.00	41.4	2.98	3.06
2011	852 402	65.6	0.024	80.0	260.0	0.00	60.0	3.07	3.15
2012	880 551	67.8	0.025	40.0	130.0	0.00	30.0	3.17	3.26
2013	877 602	68.3	0.025	80.0	260.0	0.00	60.0	3.16	3.25
2014	887 784	68.4	0.025	80.0	260.0	0.00	60.0	3.20	3.28
2015	875 618	67.4	0.025	80.0	260.0	0.00	60.0	3.15	3.24
2016	882 270	67.9	0.025	70.0	227.5	0.00	52.5	3.18	3.26
2017	864 069	66.5	0.025	76.0	247.0	0.00	57.0	3.11	3.20
2018	860 711	66.3	0.025	44.6	145.0	0.00	33.5	3.10	3.19
2019	836 224	64.4	0.024	NA	NA	NA	NA	3.01	3.10
2020	761 778	58.7	0.023	42.0	136.5	0.00	31.5	2.74	2.82
2021	834 967	64.3	0.023	40.0	130.0	0.00	30.0	3.00	3.10
2022	808 033	62.2	0.023	60.0	190.0	0.00	40.0	2.91	2.99
*At the end of 1992 a new coking battery was started in the Raahe plant									

Source-specific QA/QC and verification

Normal statistical quality checking related to assessment of magnitude and trends has been carried out. The data obtained from YLVA is cross-checked against the summary data (by fuels and by CRF categories) reported to the UNFCCC as explained in Chapter 2.3.4.
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

2018
- The emission factor for PCDD/F was changed to correspond the updated emission factor in Guidebook 2016.

2023
- The time series of PAH-4 emissions was revised based on emissions data reported by the plants.

2024
- The time series of PCDD/PCDF emissions was revised due to update of emission factor used in the emission estimation. The new EF is based on data reported by the plants.
- The time series of BC emissions was revised due to update of emission factor used in the emission estimation. The new EF is taken from Guidebook 2023, whereas the previous EF was from Aasestad 2013. The previous EF was found to be incorrect.

Source-specific planned improvements

None.

1 B 1 c Other fugitive emissions from solid fuels

Changes in chapter	
February 2024	JMP, KS

Source category description

This category covers emissions from peat production. The contribution of Other fugitive emissions from solid fuels (NFR 1B1c) in 2021 to total emissions is presented in Table 2.36.

Table 2.36. Contribution of Other fugitive emissions from solid fuels (NFR 1B1c) in 2022 to total emissions.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
$PM_{2.5}$	0.204	Gg	1.5	0
PM_{10}	0.290	Gg	1.1	0
TSP	0.444	Gg	1.1	0

Emissions from the *production of wood pellets* are included under NFR 1A2gviii.

Peat production

One third of Finland’s land area is marshland. The peat production area is currently approximately 60 000 ha out of which 44 000 ha will be exhausted by 2020 and 120 000 ha of new production areas will be needed in 2020-2050 (Figure 2.25). Finland is the leading peat producer in the world.

Figure 2.26. Peat production area, transport and loading of peat (Ympäristöhallinto, 2012).

Peat is produced either as milled or sod peat. Milled peat is used fuel. The production includes peat extraction from marshland (peatland) and further treatment to be used as fuel in heat and electricity production, as garden peat or to be used in compost. After the extraction, peat is dried on peat lands. The process steps of peat production are presented in Figures 2.26 and 2.28.

In 2020 the government of Finland decided to target of halving the use of peat within in decade as a part of Finland’s climate strategy. In spring 2022 it seemed that peat production will be halved much faster than expected, so the volumes of produced peat (Table 2.38) are decreasing.

Peat harvesting is carried out using three different equipment:

(1) Haku method includes four phases: milling, turning, roughening, loading and stacking. The Haku method includes harvesting of several yields simultaneously utilizing dry weather and collecting 3-5 yields to harrowing/ridging.

(2) Suction wagon (Imu method): after milling and turning the suction wagon takes care of the rest.

(3) Mechanical collection wagon: after milling and turning the collection wagon takes care of the rest.

The Haku method was the most common in the earlier years, however, at the moment the Imu method using suction wagon has become the most common. The Imu method was earlier used for about 15 % of peat but now for around 10% of the harvested peat.

Peat production areas in Finland are mapped in Figure 2.27.

Emission trends

Peat production generates water and air emissions (specifically particles and greenhouse gases) and has impact on nature values such as biota and scenery.

Peat is produced either as milled or sod peat. The sod peat production is not estimated to cause particle emissions. The milled peat production, which is the main production method, causes relatively high emissions of fugitive soil dust.

Dust emissions are affected by the rate of decomposition of peat as well as by weather and terrain conditions and can be minimised by considering wind direction and speed during the work as well as by applying dust separators in the suction wagons. The annual production rates depend on the prevailing weather conditions: in a rainy summer the production rates are considerably lower than in a dry summer. Most of the working stages take place under dry conditions.

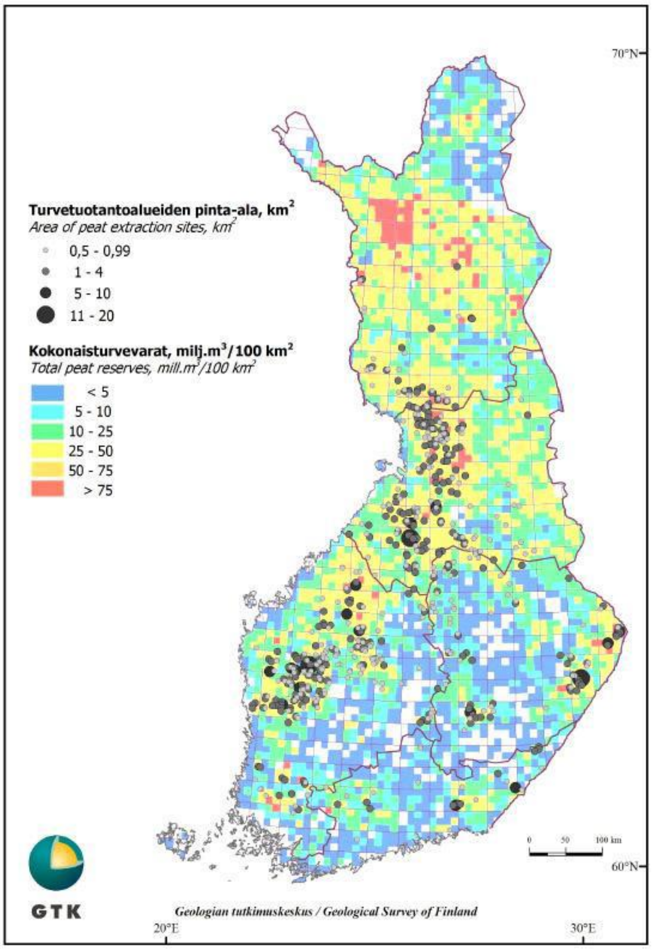
Sod peat
For sod peat production no dust emissions are anticipated. There are two harvesting periods at maximum during the year. In the sod peat method, peat is cut to 50 cm depth and moved as large peat carpets to dry. The sod pieces are turned twice during the drying period, then roughened and loaded for transportation. Sod peat is wet when lifted to dry and no dust is generated at this phase. The velocities used in the handling and turning phases are significantly slower than in the production of milled peat. While the working machines lift up peat dust during the operations, peat dust exits less in sod peat fields than in milled peat fields. The yield of sod peat is about 200 m^3/ha. (A. Erkkilä, 2016)

Milled peat
Milled peat is extracted by milling layers of 2-5 cm of the surface. The harvesting is carried out approximately 10 times annually. The yield of milled peat yield is around 40 m^3/ha. Milled peat production generates high dust emissions.

Methodological issues

In 1990-2000 45% of peat production was carried out using the “Haku” harvesting method, 15% using pneumatic harvesting and 40% using mechanical collector. From 2001 onwards 40 % of peat was collected using the “Haku” method, 10 % using pneumatic harvesting and 50 % using mechanical collector. These assumptions of used production methods are based on information from the experts in the industry (A., Erkkilä, VAPO Oy, 2015)

The emission factors are domestic and based on measurements carried out during summer 2007 (Table 2.37). Volumes of produced peat are obtained from Energy Statistics and are presented together with particle emissions in Table 2.38.



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Turvetuotantoalueiden pinta-ala: Corine Land Cover 2000 maankäyttö/maanpeite (25m): ©SYKE (osittain © MMM, MML, VRK);
Kokonaisturvevarat: GTK (Geological Survey of Finland).

Figure 2.27. Peat production areas in Finland.

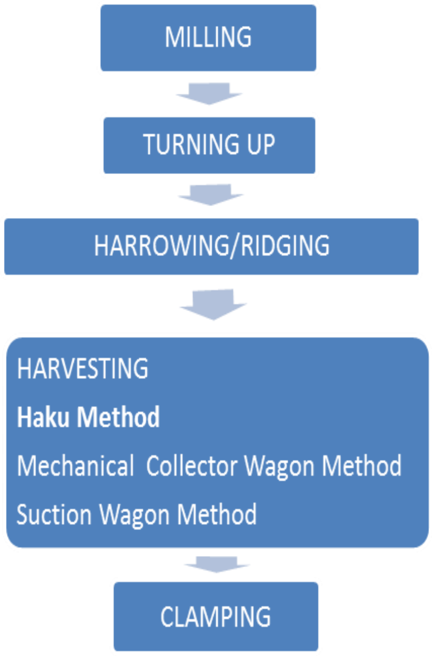

Figure 2.28. The process of peat harvesting and the three most common peat production processes.

Table 2.37. TSP, PM_{10} and $PM_{2.5}$ emission factors for milled peat production.

Source	Emission factors per produced peat cubic metre (kg/m³)			Reference
	TSP	PM_{10}	$PM_{2.5}$	
Haku method*	0.1377	0.09	0.0632	Nuutinen et al., 2007
Pneumatic harvester	0.2142	0.14	0.0983	Nuutinen et al., 2007
Mechanical collector	0.1836	0.12	0.08427	Nuutinen et al., 2007

*The EF for Haku harvesting covers 2 harvests, therefore activity data for Haku harvests needs to be halved.

Table 2.38. Particle emissions and activity data as volumes of produced peat in 1990-2022.

Year	Produced peat (1000m³)	TSP (t)	$PM_{2.5}$ (t)	PM_{10} (t)
1990	8653	2363	1085	1545
1991	4212	1150	528	752
1992	9314	2544	1168	1663
1993	4834	1320	606	863
1994	11612	3171	1456	2073
1995	12139	3315	1522	2167
1996	12666	3459	1588	2261
1997	15548	4246	1949	2775
1998	2409	658	302	430
1999	12523	3420	1570	2235
2000	6131	1674	769	1094
2001	9595	2701	1240	1766

2002	12886	3628	1655	2371
2003	10836	3051	1400	1994
2004	4597	1294	594	846
2005	12732	3584	1645	2343
2006	19050	5363	2462	3505
2007	6527	1837	843	1201
2008	6975	1964	901	1284
2009	12500	3519	1615	2300
2010	10825	3048	1399	1992
2011	10065	2834	1301	1852
2012	6272	1766	801	1154
2013	10284	2895	1329	1892
2014	9428	2654	1218	1735
2015	5063	1425	654	932
2016	4416	1243	571	812
2017	4450	1253	575	819
2018	9157	2578	1183	1685
2019	5214	1468	674	959
2020	2859	805	369	526
2021	1069	310	197	138
2022	1576			

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

2016

- The shares of different harvesting methods for milled peat production have been updated for whole time series in 2016 submission, because the earlier method was found defective and overestimated the emissions. The calculation was revised in 2016 as the earlier method assumed that Imu and Collection wagon methods were used annually and Haku method was used every two years.

2018

- As response to the 2017 NECD review recommendations, an explanation was added on the allocation and method used to estimate emissions from wood pellets (i.e. under NFR 1A2gviii).

Source-specific planned improvements

Not scheduled

- The method for estimating particle emissions from sod peat will be further studied as the production of sod peat differs much from the production of milled peat.

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

Exploration, production, transport (1B2ai)

There is no exploration or production of oil and natural gas in Finland.

Emissions from transport of natural gas in pipelines are included under NFR 1A3ei.

Refining / storage (1B2aiv)

Changes in chapter	
March 2024	JMP, KS, TF

Source category description

The category covers storages at oil refineries, venting and flaring emissions and storage of fossil fuels in all storages in the country. Emissions reported under this sector include NMVOCs and particles. The contribution to total emissions and shares reported by the operators are presented in Table 2.39.

Table 2.39. Contribution of Refining/storage (NFR 1B2aiv) in 2022 to total emissions, shares reported by operators.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NMVOC	1.876	Gg	2.5	100
$PM_{2.5}$	<0.001	Gg	<0.1	0
PM_{10}	<0.001	Gg	<0.1	0
TSP	<0.001	Gg	<0.1	0

Emission trend

The NMVOC emission trend are presented in Figure 2.29.

There is a decreasing trend in NMVOC emissions due to improved abatement methods.

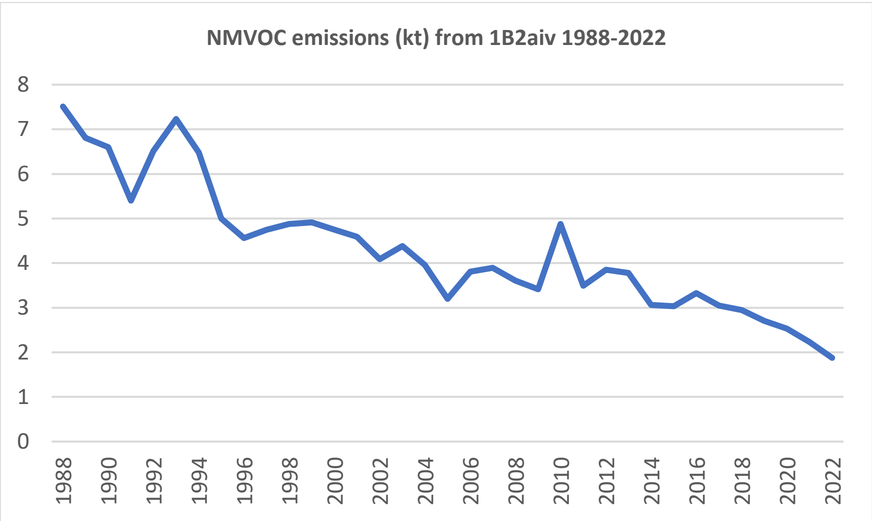

Figure 2.29. NMVOC emissions from refining/storage.

Fluctuation between the years occurs in particle emissions. The emissions are split between energy sector and process emissions. Most of the emissions are allocated in the energy sector. In 2010-2011 and in 2013-2016 all particle emissions are allocated to the energy sector.

Methodological issues

Petroleum industry reports their NMVOC emissions to the environmental authorities according to their monitoring programmes in the environmental permits since. Emissions of SO_x and NO_x are reported by the plants and are included in the energy sector. In the case of TSP, the emissions are also reported by the plants. In the case of some plants, the reported emission figures are the total emissions of the plant including both the fuel based and process-based emissions. These total emissions are split between energy sector and process emissions in the calculation system. In 2010-2011 and in 2013-2016 all particle emissions from 1B2aiv are allocated to the energy sector. Methodological details of the split between energy and process sectors are presented in chapters 1.A.1 and 1.A.2 of the Energy IIR. $PM_{2.5}$ and PM_{10} emissions from the process TSP emissions are calculated with the emission factors from the Guidebook 2023.

Emissions from venting and flaring should be reported under NFR 1B2c (Venting and flaring). However, it is not possible to separate these emissions from the emission data reported by the plants and therefore they are reported aggregated under NFR 1B2aiv.

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

2018
- As a result of the NECD Review 2018 PCB emissions from petroleum refining were removed. Finland was only Member State that reported these emissions. In the 2016 Guidebook there are no emission factors for PCB emissions (marked as 'NA'). The method used to quantify the emissions was from the BiPRO report (BiPRO 2006, 1994), where petrol refineries are regarded as sources of PCB emissions and the emission factor 1 mg/t of refined oil is provided (BiPRO 2006, 1994). Annual amounts of oil refined were available from the Energy Statistics (Statistics Finland, 2016).

2020
- NMVOC emissions for 2007-2012 and 2015-2017 were recalculated due to addition of facility reported emissions from the YLVA system previously missing from the inventory for two plants (minor increase in emissions)

2024
- Emissions of $PM_{2.5}$ and PM_{10} for the whole time series were recalculated due update of emission factors in the Guidebook 2023.

Source-specific planned improvements

None.

6 NATURAL GAS (1B2b)

Changes in chapter	
March 2023	JMP, KS, TF

Source category description

NOTE: Distribution of oil products (NFR 1B2av) is documented under the Transport sector chapters in Part 3 of the IIR.

There is no exploration or production of oil or natural gas in Finland.

NMVOC emissions from transmission and distribution of natural gas were included under NFR 1B2b since the 2018 submission according to the method presented in the EMEP/EEA Emission Inventory Guidebook 2019.

The contribution of the category to total emissions and the shares reported by the plants are presented in Table 2.40.

Table 2.40. Contribution of Distribution of oil products (NFR 1B2b) in 2021 to the total emissions, shares reported by the plants.

Pollutant	Emissions in 2022	Unit	Share of total emissions %	% reported by the operators
NMVOC	0.250	Gg	0.3	0

Emissions from compressor stations are reported under 1A3ei Pipeline Transport.

Emission trend

The emissions depend on the transmission rate of natural gas (Figure 2.30).

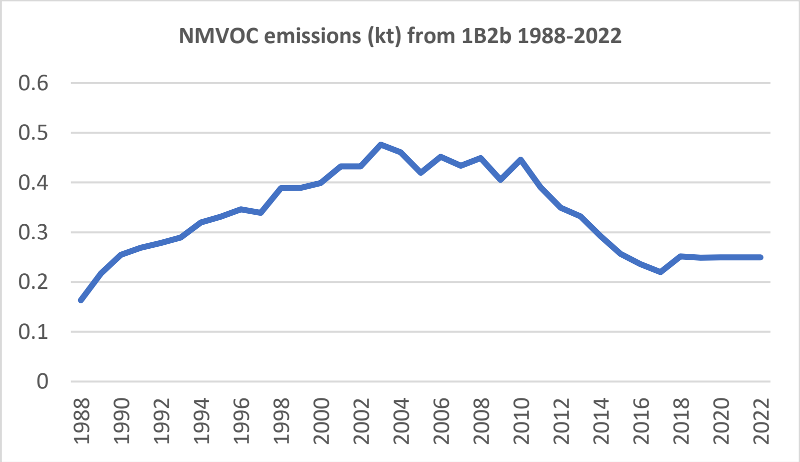

Figure 2.30. NMVOC emissions from NFR 1B2b.

Methodological issues

The emissions are calculated using emission factors from Guidebook 2019. Activity data used in the calculation is presented in Table 2.41.

Table 2.41. AD used in the calculation of NMVOC emissions from 1B2b (Statistics Finland, 2022).

Year	Volume of natural gas (milj m3)	Year	Volume of natural gas (milj m3)
1988	1634	2010	4463
1989	2171	2011	3908
1990	2545	2012	3495
1991	2690	2013	3323
1992	2788	2014	2923
1993	2895	2015	2566
1994	3201	2016	2362
1995	3311	2017	2197
1996	3460	2018	2517

1997	3389	2019	2488
1998	3889	2020	2494
1999	3892	2021	2496
2000	3990	2022	2496*
2001	4322		
2002	4295		
2003	4762		
2004	4606		
2005	4195		
2006	4519		
2007	4340		
2008	4492		
2009	4052		

*Due to lack of activity data, the volume of natural gas of 2021 is used for the year 2022.

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

2018
- NMVOC emissions were included due to the recommendation of the NECD review 2017.

2020
- NMVOC emissions for 2015-2017 were recalculated due to update of natural gas sales data in the calculation.

2021
- Activity data for year 2018 has been updated.

2022
- Activity data for year 2019 has been updated.

2023
- Activity data for year 2020 has been updated.

2024
- Activity data for year 2021 has been updated.

Source-specific planned improvements

For 2025 submission, the whole time series will be updated using emission factor presented in Guidebook 2023.

7 VENTING AND FLARING (1B2c)

Changes in chapter	
March 2018	KS

Source category description

SO_x, NO_x, CO, particles, NMVOC and heavy metal emissions from venting and flaring (NFR 1B2c) are currently reported under NFR 1B2aiv. It is not possible to separate these emissions from the emission data reported by the plants.

8 Other fugitive emissions from geothermal energy production, peat and other energy extraction not included in 1 B 2 (1B2d)

Changes in chapter	
March 2018	KS

Source category description

There are no activities in Finland that would fall under this category.

Particle emissions from mining of milled peat that were earlier reported under NFR 1B2 were reallocated to NFR 1B1c in 2008.