FINLAND's INFORMATIVE INVENTORY REPORT 2019

Air Pollutant Emissions 1980-2017

under the UNECE CLRTAP and the EU NECD

Part 2 – Energy

MARCH 2019

FINNISH ENVIRONMENT INSTITUTE
Centre for Sustainable Consumption and Production
Environmental Management in Industry – Air Emissions Team

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PART 2 ENERGY

ENERGY (NFR 1)

Overview of the sector

Energy industries (NFR 1A1) and Manufacturing Industries and Construction (NFR 1A2)

Commercial/Institutional and Residential Plants(NFR 1.A.4)
Household, Gardening Agriculture/Forestry/Fishing and Other Stationary sources

Fugitive Emissions from Solid Fuels (NFR 1.B.1)
- Coal mining and handling
- Solid fuel transformation
- Other fugitive emissions from solid fuels (Wood pellets, Peat)

Fugitive Emissions from oil and natural gas (NFR 1.B.2)
- Exploration, production, transport
- Refining/storage

Natural gas .

Venting and flaring

Other fugitive emissions from geothermal energy production, peat and other energy extraction not included in 1B2

Sub-chapters included under each NFR subcategory:
- *Source category description*
- *Emission trend*
- *Methodological issues*
- *Uncertainty and time series' consistency*
- *Source-specific QA/QC and verification*
- *Source-specific recalculations including changes in response to the review*
- *Source-specific planned improvements*

ENERGY (NFR 1)

Changes in chapter	
Update of text	May 2018 KS, TF, JM

Overview of the sector

Recalculation of 1990-2016 data to the 2018 submission

The time series 1990-2016 was recalculated for NFRs 1A1 and 1A2 for the first time to the 2018 submission with additional corrections and harmonization of allocations carried out to the 2019 submission. As expected, the recalculation resulted in minor changes to emission levels. The time series is now organized according to the NFR 2014-2 reporting codes in the IPTJ reporting tool, which enables a full review of the data.

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

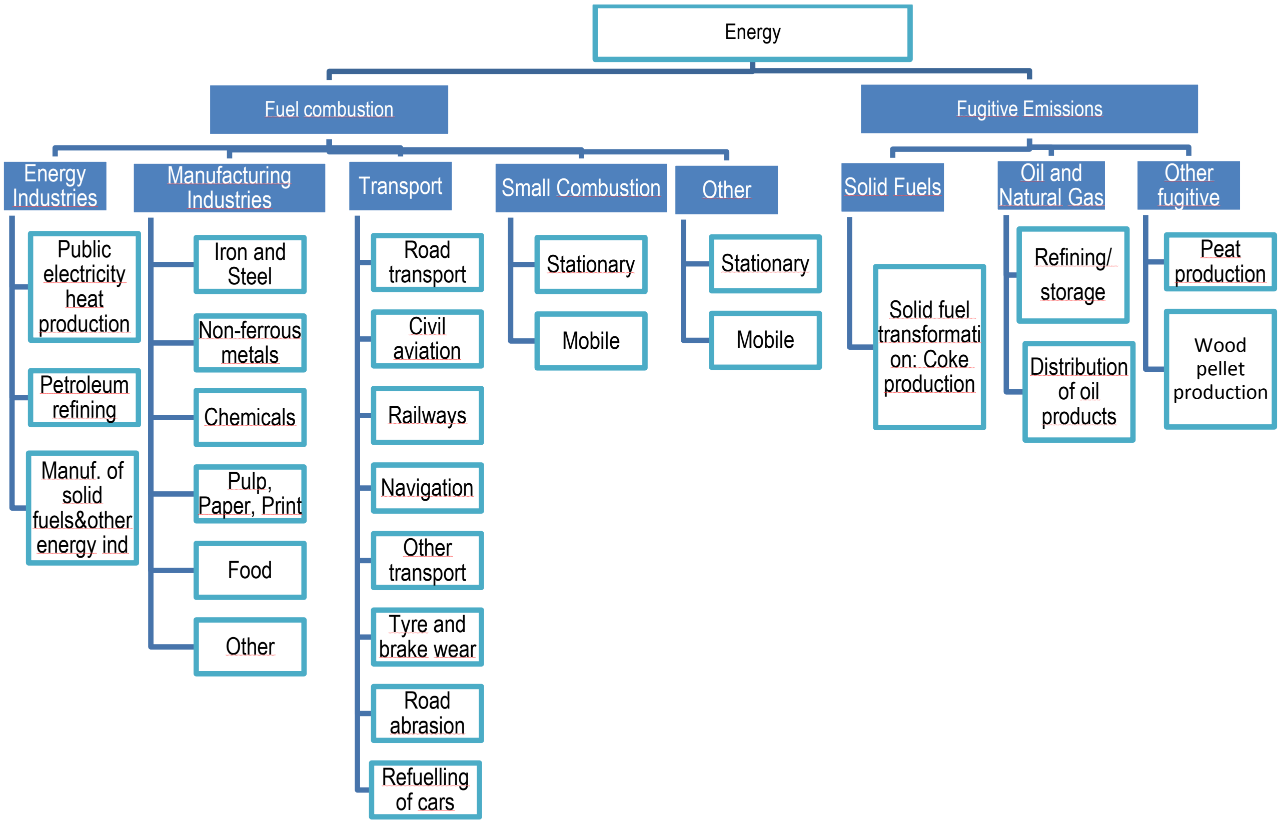


Figure 2.1. Emission sources included under the Energy Sector in the Finnish air pollutant inventory.

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.

Emissions from Energy Industries

Emissions reported are presented in Table 2.1.

Table 2.1 Emissions in 2017 reported under NFR 1A and 1B.

NFR 14	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**	
	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**	
	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, NOx, SOx, CO and particle emissions are reported under 1B2aiv)

Source category description

Changes in chapter	
May 2018	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 Emission Trading Registry and VAHTI database (Table 2.2)

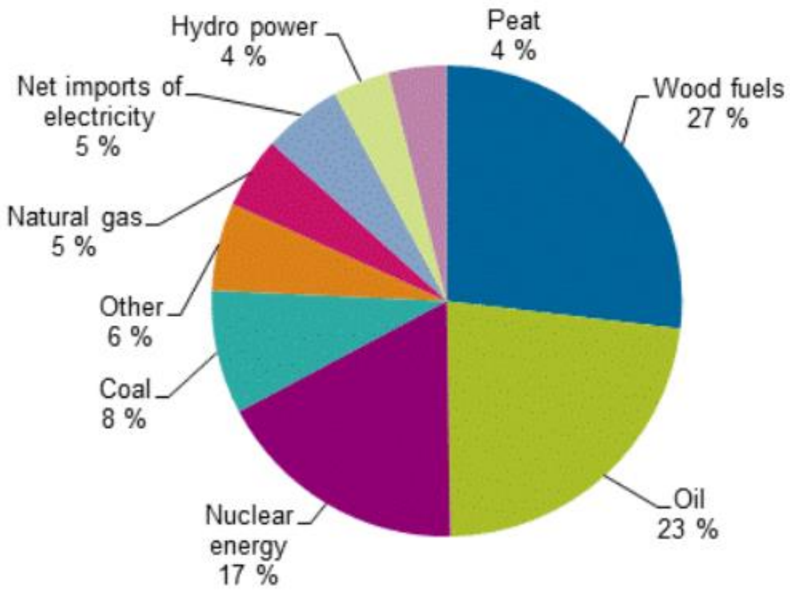
2. Aggregate sectoral (sub-sectoral) data for other sources, such as small combustion, partly energy industries, residential and others, covers approximately the rest 1/6 of the total fuel combustion. This data is based on the national Energy Statistics, data in the CRF energy tables[12] by fuels, and on the energy balance difference. Currently, the energy balance difference is allocated under NFR 1.A.5.a.

Energy consumption

Changes in chapter	
February 2019	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 2000's due to improved energy efficiency and decreased volume of heavy industries. In the period of 2000-2010 the share of industry of the total energy use decreased from 52% to 45%[1].



Source: Energy supply and consumption, Statistics Finland

Figure 2.2 Energy sources in 2017

[1] Finnish Environment Institute S YKE http://www.ymparisto.fi/fi-FI/Kartat_ja_tilastot/Ympariston_tilan_indikaattorit/Ilmastonmuutos_ja_energia/Energiankulutus_ei_enaa_kasva%2828547%29

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)[2]. The Finnish climate is the coldest in the EU and, consequently, a large share of the energy (22 %) 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 grew to 35% in 2015. The share of wood fuels in Finland's total energy consumption continued to grow and was 25%. EU targets for renewable energy are calculated relative to total final energy consumption; calculated in this manner, the share of renewable energy was over 39 per cent in Finland in 2015 based on preliminary data. Final data will be released on Eurostat's website in February/March 2017. Finland's target for the share of renewable energy is 38% of final energy consumption in 2020, which was reached for the first time in 2014 (Energy supply and consumption, Statistics Finland). Also in the transport sector there is increased use of biofuels, for instance in the road traffic the share of biofuels was over 13% in 2015.

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:

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

- In the 1990's, first the *economic depression* and later the recovery up to the early 2000's 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 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 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).

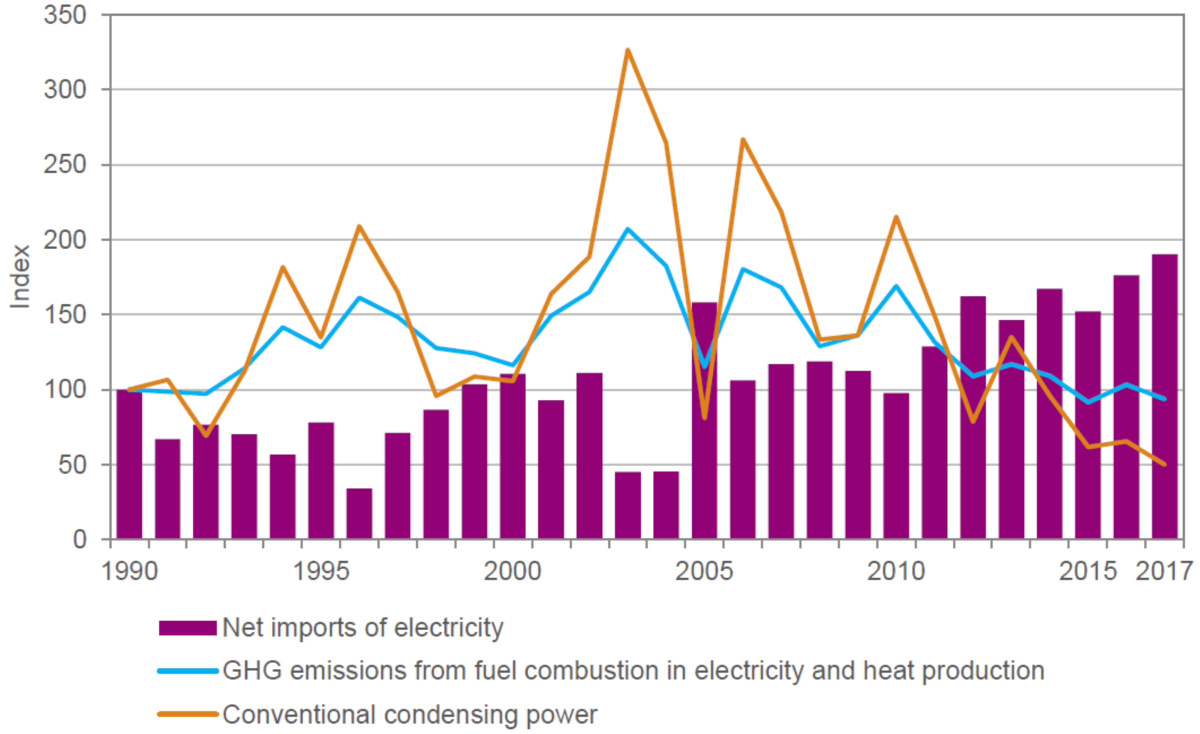


Figure 2.3. Net imports of electricity and conventional condensing power 1990-2017 (Finnish NIR 2019) (Index 1990=100)

Energy use of waste

Changes in chapter	
February	KS

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 allocated under NFR 1A1a or NFR 1A2gviii.

One waste incineration plant with no energy recovery was 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 reported by the plants to the supervising authorities.

Waste incineration with energy recovery

Energy use of waste is 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 are nine waste incineration plants in operation in Finland at the moment, and one is under consideration. Waste incineration capacity will increase from the current 1 million t/a to about 1.7 million t/a by the end of 2021. Waste incineration is increasing because of the costs of other fuels are believed to rise and tightening regulations and increase in costs for landfilling. (Finnish Energy)

Waste co-incineration with energy recovery

Waste is also co-incinerated in boilers using typically peat and/or biomass as primary fuel. The annual amount of waste co-incinerated about 300,000 – 400,000 t/a. There are eight co-incineration plants. 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, 2015)

As waste incineration/combustion plants are equipped with energy recovery, mostly combined heat and power production, no emissions from incineration have been reported under the Waste sector.

Energy and electricity trends

Consumption of fuels in 1970-2016 is presented in Figures 2.4, electricity supply in Figure 2.5 and of electricity consumption by sector in Figure 2.6. Energy statistics is available online at http://pxweb2.stat.fi/sahkoiset_julkaisut/energia2013/html/engl0000.htm.

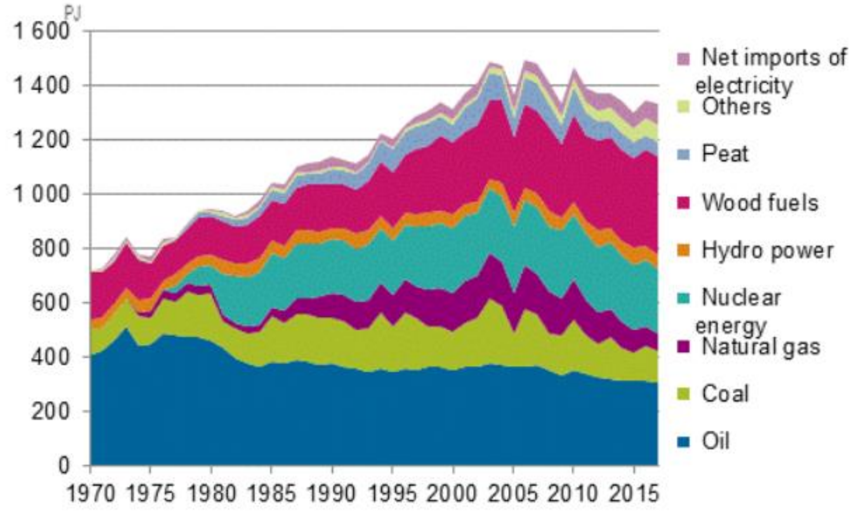


Figure 2.4a Total energy consumption 1970-2017 **(Yearbook of Energy Statistics 2018).**

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.

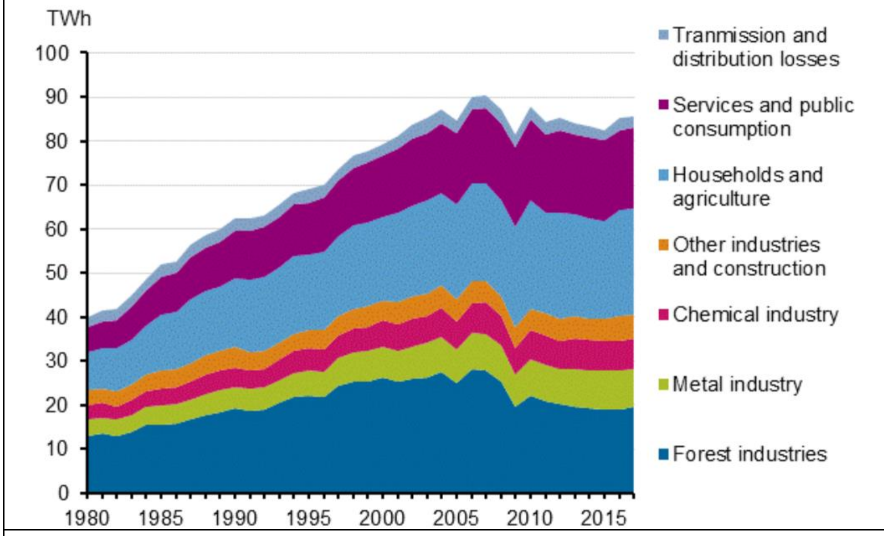


Figure 2.5a Electricity consumption by sector 1980-2017

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.

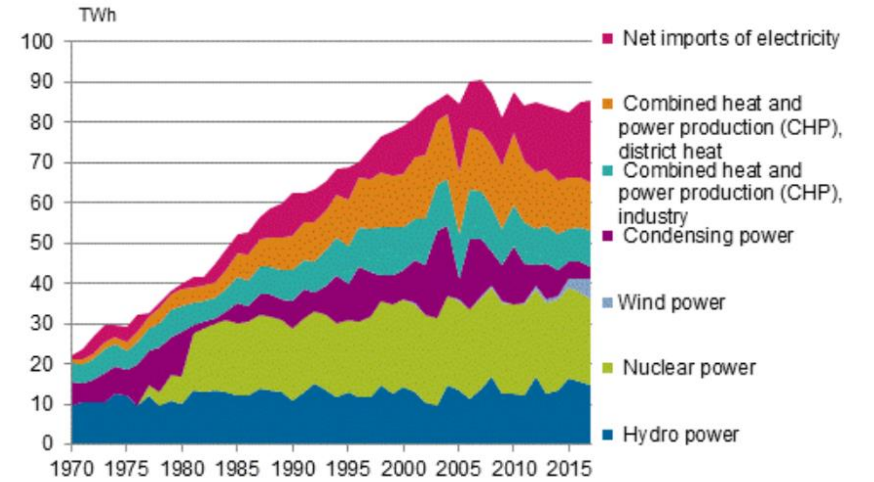


Figure 2.5b. Electricity supply 1970-2017 **(Yearbook of Energy Statistics 2018).**

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.

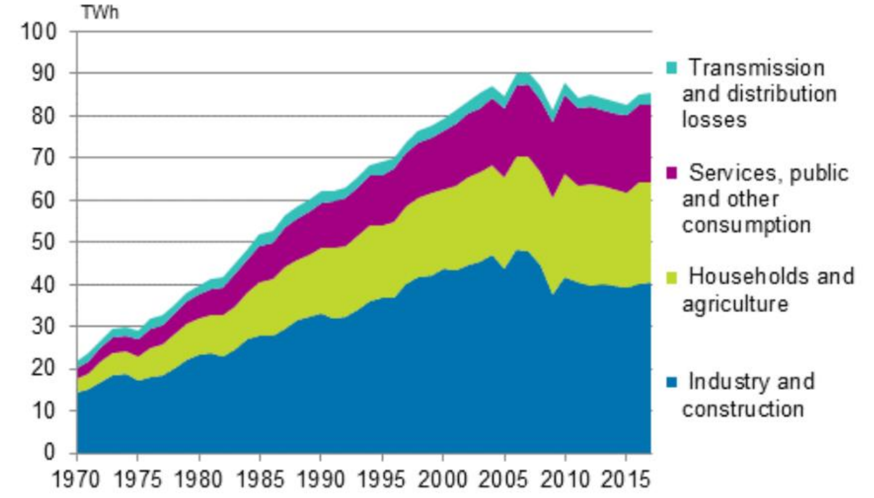


Figure 2.5c. Electricity consumption by sector 1970-2017 **(Yearbook of Energy Statistics 2018).**

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.

Changes in chapter	
February 2019	KS

Total consumption of energy

Total consumption of energy in Finland amounted to 1.35 million terajoules (TJ) in 2017, which was 1% less than in 2016 (Figure 2.6).

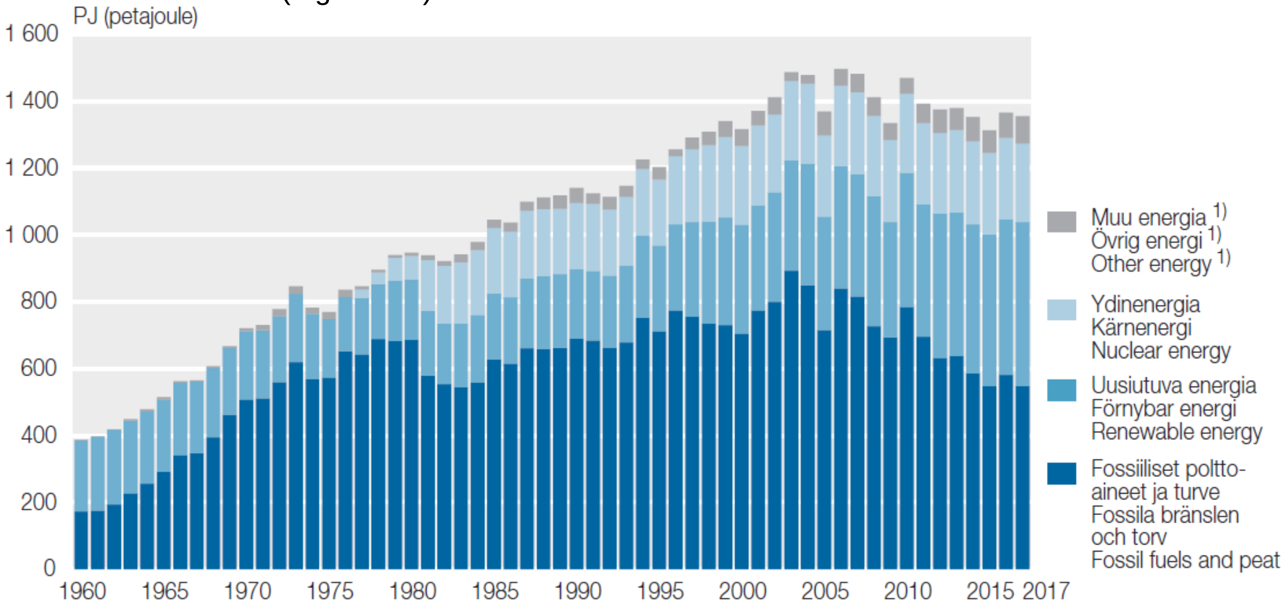


Figure 2.6 Total Energy Consumption 1960-2017 (Statistics Finland)

The use of renewable energy sources increased by 6% to a new record and was 37% of total consumption. The second most used energy source after wood was oil, 22% of total consumption and fell by 2%. Coal consumption fell by 8%, natural gas by 9% and energy peat by 5% from the previous year. Consumption of fossil fuels, including peat, decreased by 6% while the share of fossil fuels from total energy consumption was 40%.

Consumption by fuel types in 2017 is presented in Figure 2.7 (Energy supply and consumption, Statistics Finland).

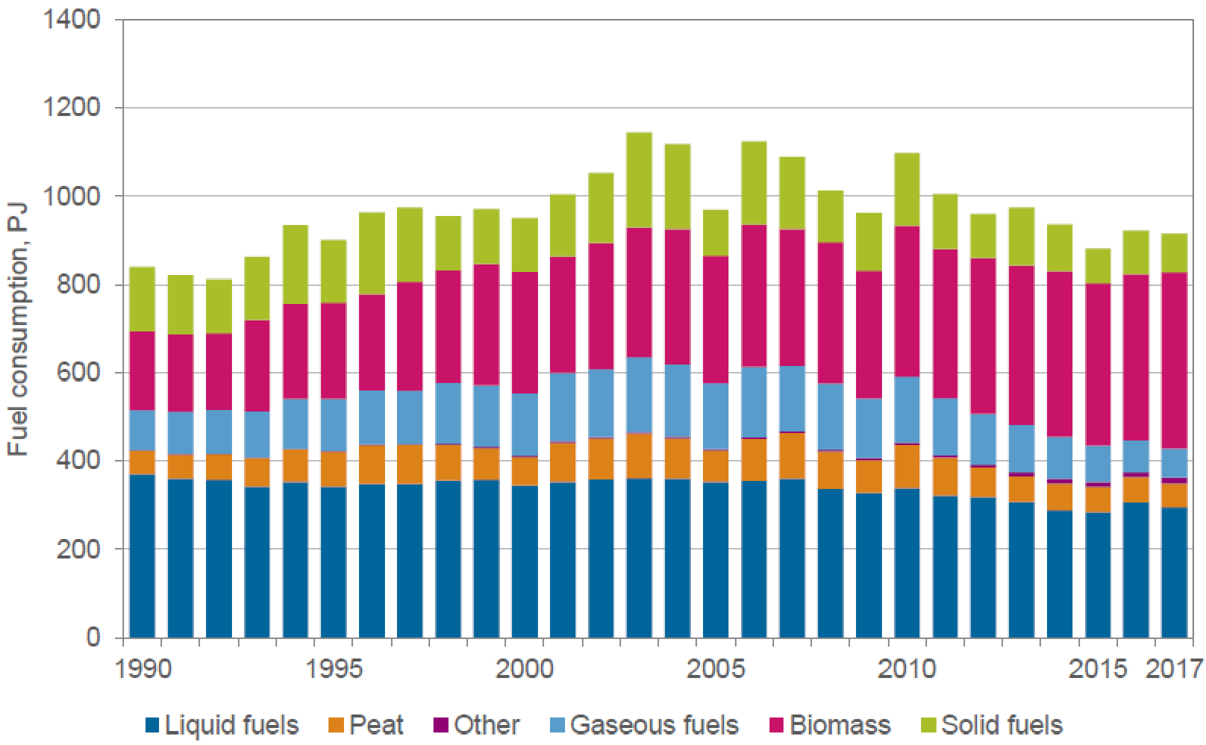


Figure 2.7 Energy consumption by fuel types (Statistics Finland)

Trends of renewable energy

The share of renewable energy in total energy consumption grew by 3% from the previous year to 37% in 2017 as shown in Figure 2.8.

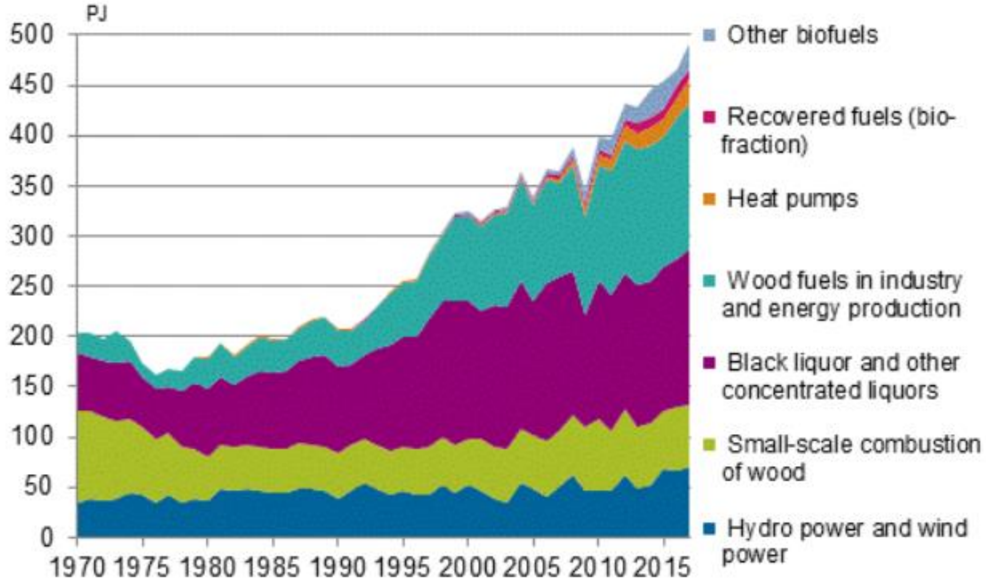


Figure 2.8. Development of renewable energy sources in 1970-2017 (Statistic Finland)

Wooden fuels remained the largest energy source in Finland with the share of 27%. 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 and wood residues of the forest industries, where the main by-products/wood residues are black liquor and bark. Also the consumption of Roundwood by the forest industry is higher that before, which leads to the availability of more by-products (Energy supply and consumption, Statistics Finland and Natural Resources Institute LUKE, 2018).

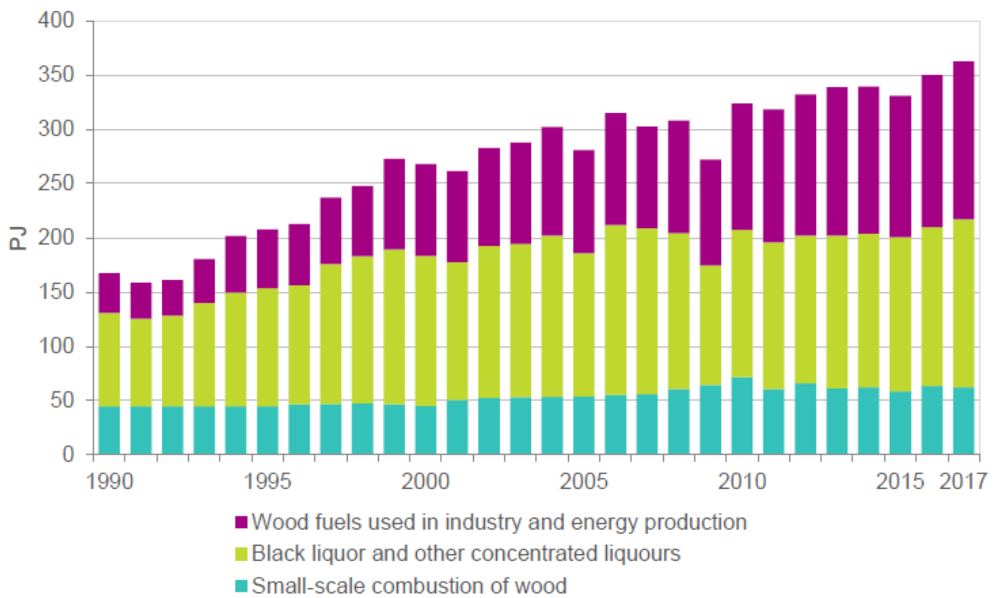


Figure 2.9 Energy consumption of wooden fuels and other biomass 1990-2017 (Energy Statistics, Statistics Finland 2018)

Consumption of biofuels in transport decreased by 64% from the record level in the two preceding years. 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. Although the consumption of renewable energy sources rose compared with the previous year, their share of total energy consumption and also of end consumption declined slightly. This is because the amount of other fuels simultaneously grew more than renewable energy sources.

29.6 TWh (45%) of electricity was produced with renewable energy sources (>50% with hydro power, 10% with wind power and the remainder with wood-based fuels). (Energy supply and consumption, Statistics Finland).

Electricity consumption and production in 2016

In 2016, the production of electricity in Finland amounted to 66.0 TWh and the total electricity consumption to 85.2 TWh, thus the difference of 19 TWh was net imports, which was more than ever before. 15 TWh of the imported electricity was imported from Sweden, 6 TWHs from Russia. Almost all export of electricity (3 TWh) was to Estonia. (Figure 2.10)

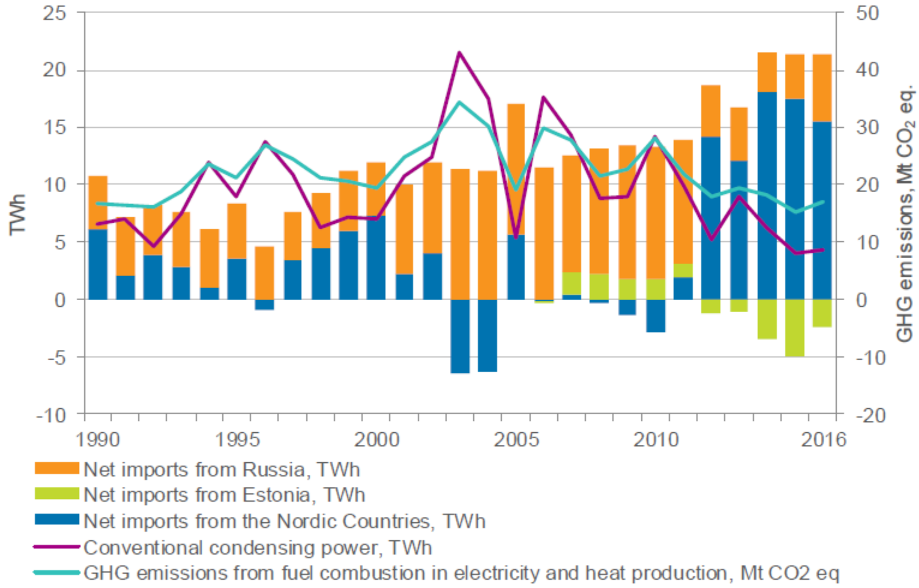


Figure 2.10 Net imports of electricity (Energy Statistics, Year book 2017)

45% of electricity was produced with renewable energy sources, 34% with nuclear power, 17% with fossil fuels and 4% with peat. (Production of electricity and heat, Statistics Finland).

District heating

The production of district heat totalled 38.5 TWh in 2016, half of it was produced by fossil fuels, wood and hard coal. The residential and commercial sectors have substituted direct oil heating with district heating and electricity after the 1990's.

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 production of industrial heat was 52.9 TWh in 2016. The production grew slightly from the year before. Over 70% 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. In the chemical 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 (Production of electricity and heat, Statistics Finland)

1.A.1 Energy industries

1.A.2 Manufacturing Industries and Construction

Changes in chapter	
March 2019	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)**
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 1A1a – 1A2f to total emissions, and the shares of emissions under these categories that are reported by the plants, in the year 2017 inventory are presented in Tables 2.2 – 2.8.

Regarding category 1A1c Manufacturing of solid fuels, which was earlier reported as “NO”, the notation keys for pollutants originating from coke production have been changed into “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.

Table 2.2 Contribution of NFR 1A1a in 2017 to total emissions, shares reported by the operators

Pollutant	Emissions in 2017	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	22.673	Gg	17.5	90.6
NMVOC	1.596	Gg	1.8	31.6
SOx (as SO2)	12.092	Gg	34.5	89.1
NH3	0.003	Gg	<0.1	100
PM2.5	0.370	Gg	2.1	0
PM10	1.159	Gg	4.0	0
TSP	2.572	Gg	5.9	71.8
BC	0.023	Gg	0.6	0
CO	13.449	Gg	3.7	17.6
Pb	2.024	Mg	13.0	15.9
Cd	0.148	Mg	15.4	18.2
Hg	0.146	Mg	25.3	58.5
As	0.690	Mg	28.3	16.0
Cr	1.613	Mg	9.8	17.1
Cu	2.435	Mg	6.7	12.2
Ni	2.123	Mg	14.4	20.0
Zn	19.661	Mg	16.6	13.4

PCDD/ PCDF	3.391	g I-Teq	25.3	15.6
PAHs	0.540	Mg	5.3	35.1
HCB	0.416	kg	1.2	0
PCB	0.291	kg	1.1	0

Table 2.3 Contribution of NFR 1A1b in 2017 to total emissions, shares reported by the operators

Pollutant	Emissions in 2017	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	2.102	Gg	1.6	98.2
NMVOC	0.062	Gg	<0.1	32.5
SOx (as SO2)	5.936	Gg	16.9	99.9
PM2.5	0.025	Gg	0.1	0
PM10	0.077	Gg	0.3	0
TSP	0.223	Gg	0.5	100
BC	0.002	Gg	<0.1	0
CO	1.017	Gg	0.3	13.6
Pb	3.255	Mg	20.9	0
Cd	0.074	Mg	7.8	0
Hg	0.015	Mg	2.6	0
As	0.534	Mg	21.9	0
Cr	4.092	Mg	24.9	0
Cu	1.434	Mg	3.9	0
Ni	1.654	Mg	11.2	68.7
Zn	6.151	Mg	5.2	0
PCDD/ PCDF	0.036	g I-Teq	0.3	0
PAHs	0.013	Mg	0.1	0

Table 2.4 Contribution of NFR 1A2a in 2017 to total emissions, shares reported by the operators

Pollutant	Emissions in 2017	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	3.191	Gg	2.5	99.8
NMVOC	0.019	Gg	<0.1	0
SOx (as SO2)	0.577	Gg	1.6	99.8
PM2.5	0.006	Gg	<0.1	0
PM10	0.014	Gg	<0.1	0
TSP	0.023	Gg	<0.1	100
BC	<0.001	Gg	<0.1	0
CO	1.083	Gg	0.3	9.2
Pb	0.007	Mg	<0.1	59.9
Cd	<0.001	Mg	<0.1	62.5
Hg	<0.001	Mg	<0.1	2
As	0.001	Mg	<0.1	27.5
Cr	0.003	Mg	<0.1	19.5
Cu	0.004	Mg	<0.1	13.4
Ni	0.062	Mg	0.4	96.2
Zn	0.014	Mg	<0.1	26
PCDD/ PCDF	0.008	g I-Teq	<0.1	0
PAHs	<0.001	Mg	<0.1	0
HCB	<0.001	kg	<0.1	0
PCB	0.094	kg	0.4	0

Table 2.5 Contribution of NFR 1A2b in 2017 to total emissions, shares reported by the operators

Pollutant	Emissions in 2017	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	0.184	Gg	0.1	90.8
NMVOC	0.001	Gg	<0.1	0
SOx (as SO2)	3.111	Gg	8.9	99.6
PM2.5	0.004	Gg	<0.1	0
PM10	0.006	Gg	<0.1	0
TSP	0.013	Gg	<0.1	100
BC	<0.001	Gg	<0.1	0
CO	0.051	Gg	<0.1	50.6
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	0.199	Mg	1.2	0
Cu	<0.001	Mg	<0.1	0
Ni	0.040	Mg	0.3	0

Zn	<0.001	Mg	<0.1	0
PCDD/ PCDF	0.001	g I-Teq	<0.1	0
PAHs	0.002	Mg	<0.1	0
HCB	<0.001	kg	<0.1	0
PCB	0.034	kg	0.1	0

Table 2.6 Contribution of NFR 1A2c in 2017 to total emissions, shares reported by the operators

Pollutant	Emissions in 2017	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	1.399	Gg	1.1	90.1
NMVOC	0.005	Gg	<0.1	0
SOx (as SO2)	0.755	Gg	2.2	95.0
PM2.5	0.037	Gg	0.2	0
PM10	0.058	Gg	0.2	0
TSP	0.067	Gg	0.2	100
BC	0.008	Gg	0.2	0
CO	0.274	Gg	<0.1	4.5
Pb	0.033	Mg	0.2	1
Cd	<0.001	Mg	<0.1	4.1
Hg	<0.001	Mg	<0.1	74.9
As	0.003	Mg	0.1	6.1
Cr	0.005	Mg	<0.1	5.1
Cu	0.005	Mg	<0.1	6.0
Ni	0.346	Mg	2.3	0.4
Zn	0.030	Mg	<0.1	6.9
PCDD/ PCDF	0.008	g I-Teq	<0.1	0
PAHs	0.005	Mg	<0.1	1.0
HCB	<0.001	kg	<0.1	0
PCB	0.026	kg	0.1	3.0

Table 2.7 Contribution of NFR 1A2d in 2017 to total emissions, shares reported by the operators

Pollutant	Emissions in 2017	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	18.586	Gg	14.3	98.9
NMVOC	0.323	Gg	0.4	4.9
SOx (as SO2)	2.423	Gg	6.9	92.8
PM2.5	1.410	Gg	7.9	0
PM10	1.948	Gg	6.7	0
TSP	2.259	Gg	5.2	100
BC	0.011	Gg	0.3	0
CO	19.783	Gg	5.5	11.9
Pb	4.021	Gg	25.8	4.2
Cd	0.309	Gg	32.3	2.4
Hg	0.125	Mg	21.5	18.8
As	0.163	Mg	6.7	8.6
Cr	0.146	Mg	0.9	27.4
Cu	0.400	Mg	1.1	63.6
Ni	0.519	Mg	3.5	53.8
Zn	2.437	Mg	2.1	27.3
PCDD/ PCDF	0.906	g I-Teq	6.8	14.9
PAHs	0.135	Mg	1.3	18.8
HCB	0.152	kg	0.5	0
PCB	0.037		0.1	0

Table 2.8 Contribution of NFR 1A2e in 2017 to total emissions, shares reported by the operators

Pollutant	Emissions in 2017	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	0.422	Gg	0.3	74.0
NMVOC	0.027	Gg	<0.1	0
SOx (as SO2)	0.696	Gg	2.0	50.4
PM2.5	0.015	Gg	<0.1	0
PM10	0.041	Gg	0.1	0
TSP	0.112	Gg	0.3	100
BC	0.003	Gg	<0.1	0
CO	0.174	Gg	<0.1	0.2
Pb	0.132	Mg	0.8	4.8
Cd	0.003	Mg	0.3	5.8
Hg	0.003	Mg	0.5	33.6
As	0.054	Mg	2.2	10.8

Cr	0.109	Mg	0.7	3.4
Cu	0.143	Mg	0.4	2.2
Ni	0.221	Mg	1.5	20.7
Zn	0.425	Mg	0.4	14.4
PCDD/ PCDF	0.022	g I-Teq	0.2	0
PAHs	0.003	Mg	<0.1	0
HCB	0.001	kg	<0.1	0
PCB	0.124	kg	0.5	0

Table 2.9 Contribution of NFR 1A2f in 2017 to total emissions, shares reported by the operators

Pollutant	Emissions in 2017	Unit	Share of total emissions %	% reported by the operators
NOx (as NO2)	2.053	Gg	1.6	93.2
NMVOC	0.010	Gg	<0.1	0
SOx (as SO2)	0.808	Gg	2.3	51.1
PM2.5	0.046	Gg	0.3	0
PM10	0.102	Gg	0.3	0
TSP	0.207	Gg	0.5	100
BC	0.005	Gg	0.1	0
CO	4.831	Gg	1.3	5.7
Pb	1.763	Mg	11.3	1.6
Cd	0.044	Mg	4.6	2.3
Hg	0.027	Mg	4.7	68.8
As	0.285	Mg	11.7	2.3
Cr	2.138	Mg	13	0.5
Cu	0.834	Mg	2.3	4.5
Ni	1.794	Mg	12.2	1.2
Zn	4.082	Mg	3.4	0
PCDD/ PCDF	0.071	g I-Teq	0.5	28.0
PAHs	0.006	Mg	<0.1	0
HCB	0.002	kg	<0.1	0
PCB	0.374	kg	1.4	0

Emission trends

Emission trends in NFR categories 1A1, 1A2, 1A4, 1A5 and 1B are presented in Figure 2.11.

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 1980’s 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 11 of this section of the IIR (i.e. IIR Energy and Transport Part 2).

For the years 1980-1989 the emissions are reported more or less aggregated 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.

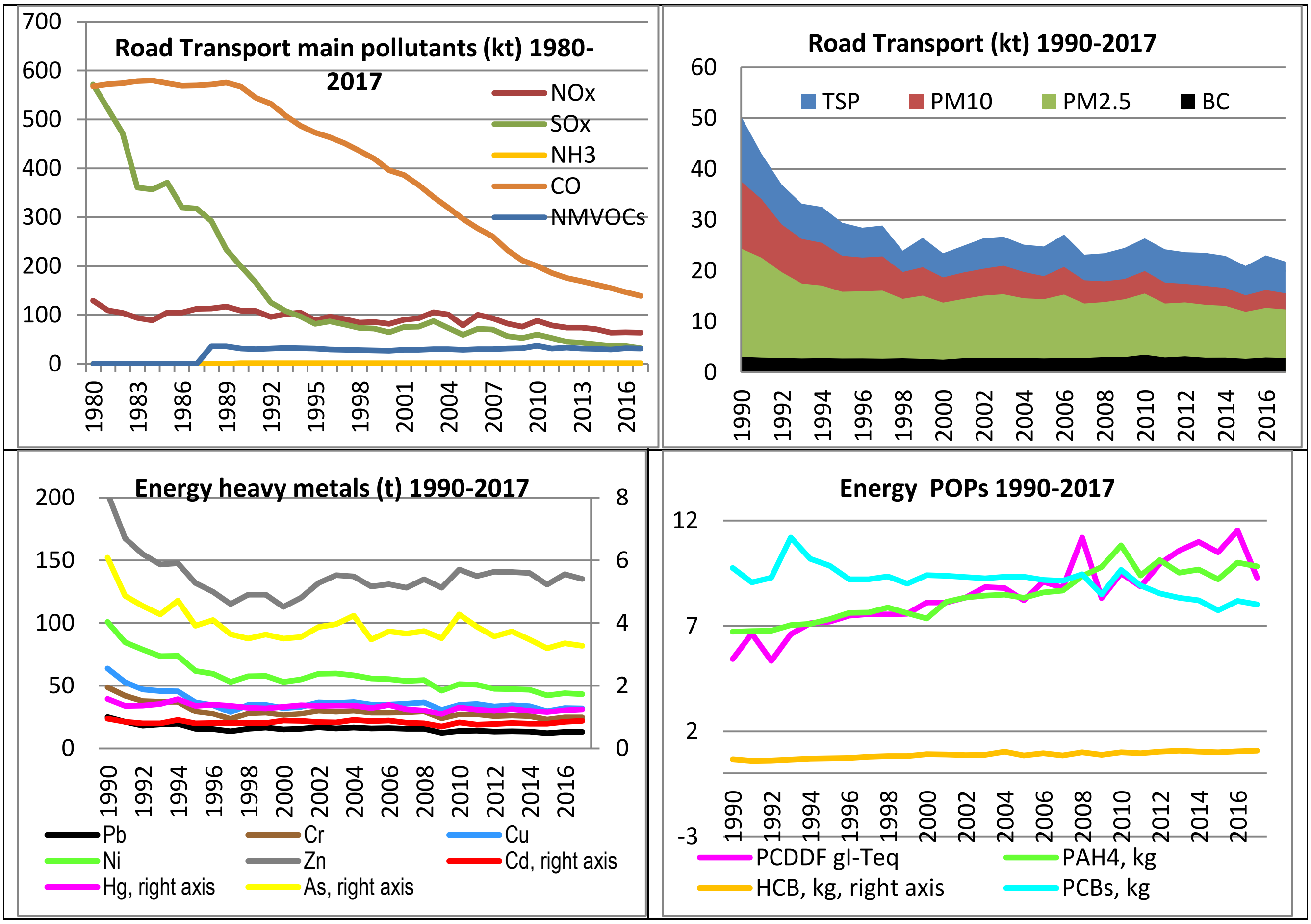


Figure 2.11. Air pollutant emission trends from Energy and Heat Production (NFRs 1A1, 1A2, 1A4, 1A5 and 1B)

Methodological issues

Changes in chapter	
February 2019	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 programmes 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 2016. 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 allows 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 2017 in the YLVA database is presented in Table 2.11. These point sources cover together two thirds of the total annual fuel combustion. 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 2.11 Number of boilers included in the year 2017 inventory in 2019.

Category	**Number of boilers in 1A1**	**Number of boilers in 1A2**
Combustion plants > = 300 MW (boilers)	18	5
Combustion plants > = 50 and < 300 MW (boilers)	85	53
Combustion plants > = 20 and < 50 MW (boilers)	76	94
Combustion plants < 20 MW (boilers)	755	343
Gas turbines	41	0
Stationary engines	22	12
Process ovens	5	157
Total	1002	664

A. Use of ETS data

The availability of EU ETS started from 2005, the second period from 2008 and the third period from 2013. 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 (and formerly VAHTI) 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 are less than +-1%. For the different wood fuels the differences in NCVs can be somewhat larger (generally +-2-10%), 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. The difference in the total amount of wood fuels in TJs was e.g. in 2015 about 0.6%.

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

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.stat.fi/static/media/uploads/tup/khkinv/khkaasut_polttoaineluokitus_maaritelmat_2018_en_2.pdf

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
All natural gas used in Finland is imported from Russia since 1974 and consists almost totally (>98%) of methane. Natural gas use in power plants became common since the end of the 1980's. The distribution network for natural gas covers Southern Finland. The range of NCV has been 35.8 to 36.5 MJ/m3n.

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 2.12. 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 2.12 Properties of fuels: heating values, density and sulphur contents

Fuel	Heating values		Heating values		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 wood)	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 2019	2019 TF KS

The Environmental authorities' database and the Emission Trading Registry contain records for 91 fuel types. An overview of the consumption of different fuels in 1990-2017 in NFRs 1A1 and 1A2 is presented in Table 2.13.

Table 2.13 Fuel consumption in NFR 1A1 (a) and 1A2 (b) in 1990-2017 (PJ) (Source: IPTJ Finnish Environment Institute 2019).

(a) Fuel consumption under NFR 1A1

		1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Liquid fuels	Heavy fuel oil	18,7	21,8	17,3	11,3	12,9	7,9	8,5	6,2	6,8	7,9	6,0	5,1
	Light fuel oil	1,3	1,1	0,8	0,7	0,5	0,5	0,9	0,4	0,5	0,4	0,9	1,0
	Other liquid fuels	0,4	0,1	0,3	5,8	6,0	6,9	4,1	1,0	1,0	1,1	1,5	3,3
Solid fuels	Hard coal	102,8	103,6	86,5	71,5	137,3	97,5	79,7	109,8	84,1	59,2	78,0	68,4
	Other solid fuels	2,6	3,7	3,9	4,4	4,4	4,8	4,3	4,8	4,7	3,9	4,3	4,1
Peat	Peat	42,7	64,0	45,6	54,2	80,9	69,8	52,1	44,8	47,3	44,3	43,7	41,5
Gaseous fuels	Natural gas	48,3	66,4	84,3	95,2	99,1	83,2	76,1	69,0	60,8	49,7	41,3	34,1
	Refinery gases	15,6	17,5	14,8	17,3	19,1	20,7	19,6	18,4	17,4	16,6	20,9	20,7
	Other gaseous fuels	0,1	0,9	0,4	1,5	6,5	6,2	6,5	6,0	4,9	5,4	8,8	9,6
Biomass	Woodfuels	7,0	13,0	27,2	46,7	66,5	69,8	72,5	78,9	79,4	78,9	79,6	83,1
	Other non-fossil fuels	0,2	0,9	1,8	3,1	3,6	3,3	5,6	7,4	9,4	10,6	12,8	11,9
Other fuels	Other fuels	NO	NO	NO	0,1	1,0	1,1	1,1	3,6	3,3	3,7	3,5	1,7

b) Fuel consumption under NFR 1A2

		1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Liquid fuels	Heavy fuel oil	29,4	25,3	23,3	18,9	11,3	10,8	9,7	8,3	7,7	7,6	8,0	7,2
	Light fuel oil	2,2	2,3	2,6	2,3	1,5	1,3	1,1	1,1	1,0	1,0	1,0	1,0
	Black liquor	88,7	108,7	139,9	133,5	135,9	134,1	136,5	140,5	142,1	142,1	145,7	153,0
	Other liquid fuels	13,6	14,2	16,6	21,9	24,8	22,5	23,7	22,5	21,7	20,1	18,9	22,4
Solid fuels	Hard coal	26,3	17,0	11,8	9,0	7,3	5,9	4,6	4,3	3,6	2,6	3,4	3,1
	Other solid fuels	2,5	5,4	6,2	6,8	5,5	6,3	2,6	3,0	2,6	2,8	2,9	2,7
Peat	Peat	11,4	14,4	16,4	14,4	14,3	13,8	11,9	10,6	11,5	11,3	10,2	9,8
Gaseous fuels	Natural gas	38,4	44,0	48,4	45,7	40,1	39,0	30,8	30,6	27,5	25,0	24,1	23,4
	Blast furnace gas, coke oven gas and refinery gases	18,4	24,7	29,1	32,2	29,1	30,1	26,7	27,8	28,6	28,5	27,6	25,3
	Other gaseous fuels	5,3	14,4	18,5	20,8	18,7	19,8	19,1	19,4	20,9	19,9	21,7	19,9
Biomass	Woodfuels	45,8	43,8	51,9	36,5	33,4	33,7	36,5	36,6	35,0	33,6	36,6	38,0
	Other non-fossil fuels	4,0	4,5	4,2	2,0	4,9	4,6	5,9	7,4	7,1	7,9	7,1	9,0
Other fuels	Other fuels	0,4	1,7	1,8	1,6	1,1	1,0	1,1	1,9	2,5	2,2	2,6	2,9

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 2.12

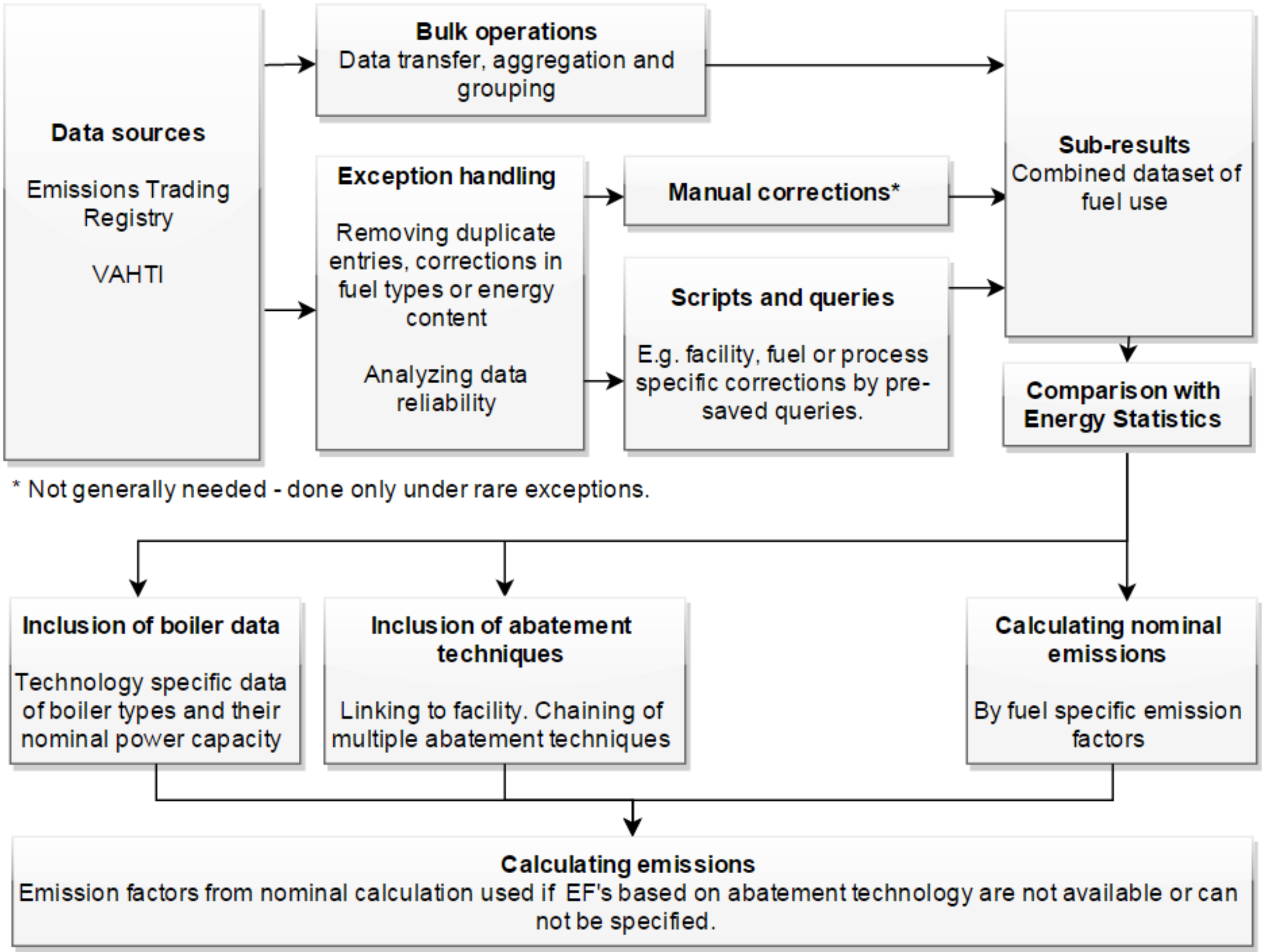


Figure 2.12. The process of calculating emissions from combustion plants

Phase 1 – Compiling data of fuel use

The main data sources in the energy sector emissions inventory are YLVA and Emissions Trading Registry out of which data are compiled into a single dataset. As mentioned above, the Emission Trading Registry was the primary data source for the first time for fuel consumption for point sources in 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 the volumetric errors of LPG precede from the reporting unit being changed from cubic metres to tons (of fuel). 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 corresponding 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 details. 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 are 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.

Emission factors

Changes in chapter	
March 2019	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 (e.g. 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 2 of Part 2 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 3 of Part 2 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 remainder of the calculated value subtracted from the reported value and 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 black carbon, which are calculated separately. Process based emissions of PM_{10} and $PM_{2.5}$ are calculated based on the TSP values using distribution factors presented under the IPPU sector.

Notes

Information on small and medium sized energy production units (1-MW) from a project in 2014 is not yet fully incorporated into the inventory.

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 2.13 and the shares according to size and hours of operation in Table 2.14.

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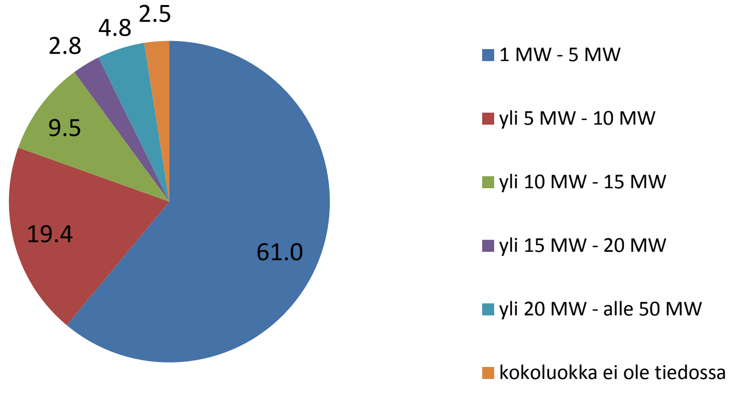


Figure 2.13. Number of small and medium sized energy production units by MWs
("yli" = above, "alle" = below; orange sector: capacity unknown)

Table 2.14. 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 2. In addition, national default EFs developed for E-PRTR reporting to be used when no measured data is available, are presented in Annex 3 Part 2 of the IIR.

Methodological issues

Changes in chapter	
March 2019	KS, TF

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 VAHTI 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 202 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 PM10 and PM2.5 fractions, the condensable part of PMs is not included.

Black carbon

Average emission factors used in the preliminary inventory are presented in Table 2.15.

Table 2.15 Average emission factors in the Finnish BC inventory (The EFs are from GB16 and have not been compared to GB16 due to resource restrictions in 2018. The comparison to GB16 EFs will be made to the 2019 submission as well as recalculations where needed)

Source	SNAP	EF	Unit	Reference
Boilers (solid)	010000-030000	3.3	% of PM2.5	GB16
Boiler (liquid)	010000-030000	72	% of PM2.5	Aasestad, 2013
Stationary engines (gas)	010000-030000	2.5-7	% of PM2.5	GB16,Aasestad ,2013
Stationary engines (Liquid)	010000-030000	33.5-78	% of PM2.5	GB16
Gas turbines (gas)	010000-030000	2.5	% of PM2.5	GB16
Gas turbines 20-200 MW (liquid fuel)	010000-030000	33.5	% of PM2.5	GB16
Grate furnace (liquid)	010000-030000	33.5, 81	% of PM2.5	Aasestad,2013 GB16
Grate furnace (solid)	010000-030000	3.3	% of PM2.5	GB16
Fluidized bed (LFO	010000-030000	33.5	% of PM2.5	GB16
Other (liquid)	010000-030000	33.5	% of PM2.5	GB16
Other (solid)	010000-030000	2.2, 5.6	% of PM2.5	GB16
Other (gas)	010000-030000	2.5	% of PM2.5	GB16
Coke oven	040201	0.05	% of PM2.5	GB16
BOF	040206	0.36	% of PM2.5	GB16
Electric furnace steel plant	040207	0.36	% of PM2.5	GB16
Rolling mills	040208	0.36	% of PM2.5	GB16
Sinter and pelletizing plant	040209	0.17	% of PM2.5	GB16
Other (foundries)	040210	0.36	% of PM2.5	GB16
Ferro alloys	040302	10	% of PM2.5	GB16
Other (copper production)	040309a	0.1	% of PM2.5	GB16
Sulphuric acid	040401	1.8	% of PM2.5	GB16
NPK fertilizers	040407	1.8	% of PM2.5	GB16
Titanium Oxide	040410	1.8	% of PM2.5	GB16

Other (paper coatings)	040416	1.8	% of PM2.5	GB16
Ethylene	040501	1.8	% of PM2.5	GB16
Other (cleaning agents)	040527	1.8	% of PM2.5	GB16
Paper pulp (kraft process)	040602	2.6	% of PM2.5	GB16
Road paving with asphalt	040611	5.7	% of PM2.5	GB16
Glass (decarbonizing)	040613	0.062	% of PM2.5	GB16
Lime (decarbonizing)	040614	0.46	% of PM2.5	GB16
Mineral wool enduction	060402	0.06	% of PM2.5	Aasestad, 2013
Fat, edible and non edible oil extraction	060404			
Other (tobacco)	060602	0.45	% of PM2.5	GB16, EMEP/EEA
Other (house fires)	060508	9	% of PM2.5	Aasestad, 2013
Tyre wear	070700	30	% of PM2.5	Aasestad, 2013
Brake wear	070700	1	% of TSP	Aasestad, 2013
Road surface wear	070700	0.83	% of TSP	Aasestad, 2013
Crematoria	090901	50	% of PM2.5	Aasestad, 2013
Field burning of agricultural waste	100300	13	% of PM2.5	Aasestad, 2013

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 Annexes 2 and 3).

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

NH3

Related to the NECD TERT recommendation on the issue, the Energy industries have considered the NH3 emission factors for biomass presented in the EMEP EEA Emission Inventory Guidebook 2016 to be unsuitable for the Finnish conditions and that those only could be relevant to ammonia slips from SCR/SNCR equipment, which are not common in Finland. The environmental permits falling under the IED are being completed by inclusion of the new BAT requirement in the Directive to include ammonia measurement requirements starting from 2021. Thus this development is expected to verify the information on emission levels from both plants equipped with and not equipped with SCR/SNCR.

The inventory includes some NH3 emissions reported by the plants.

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 small and medium sized boilers 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.

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). For the submission in 2021 a comparison to GB16 will be made as well as recalculations where needed. Due to the complexity of the calculation system, revision of emission factors is challenging. Construction of a new energy sector calculation model is under way during 2019-2020 and revision of emission factors is scheduled for 2021.

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). For the submission in 2021 a comparison to GB16 will be made as well as recalculations where needed. Due to the complexity of the calculation system, revision of emission factors is challenging. Construction of a new energy sector calculation model is under way during 2019-2020 and revision of emission factors is scheduled for 2021.

HCB and PCB

HCB and PCB emissions are calculated using fuel data from solid fuel and biomass combustion and Guidebook 2016 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 7 of the IIR.

Uncertainty in fuel combustion (NFR 1.A) in total was ±1% in Finland in 2015. The use of ETS data has been included in the revised uncertainty estimation since the submission in 2014.

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.

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 Regulation 525/2013 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, the boiler specific emission data was investigated for gaps or discontinuity events in the emission data of 1990-2015. A detailed description of the methodology is attached in Annex 6.

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 routine also marks the last known values before and ahead of the found gap. A gap can therefore consist of more than one year, and the duration of the gap is recorded. 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. As the inventory process is subject to annual changes in practically all of its parameters and is prone to technical and human errors, this analysis suggests extremely high level of consistency and accuracy in data management.

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

2018

The recalculation of the fuel consumption time series was finalized in April 2018. The recalculation covered

(1) an update of fuel combustion data based on new and corrected information in the data reported by the plants and in energy statistics.
(2) 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.

Source-specific planned improvements

2020

- Inclusion of national district heating statistics 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 provides more details)
- The need to update emission factors has been initiated with the energy industry and emission measurement communities. Thus far no need for updates has been identified.
- 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 2019	KS, TF

Overview of the Sector

The source category covers combustion activities which cannot be allocated under any of the other NFR 1A2 categories. A complete list of activities included is presented in Table 2.25 on page 92 of Part 1A General of the IIR.

The difference between the energy balance and point source fuel combustion is allocated under 1A5a.

The contribution of the sector to total emissions and shares reported by the operators are presented in Table 2.16

Table 2.16 Contribution of NFR 1A2gviii in 2017 to total emissions, shares reported by the operators

Pollutant	Emissions in 2017		Unit	Share of total emissions %	% reported by the operators
NOx (As NO2)	2.017		Gg	1.6	83.1
NMVOC	0.233		Gg	0.3	17.0
SOx (as SO2)	0.650		Gg	1.9	58.7
NH3	0.001		Gg	<0.1	100
PM2.5	0.094		Gg	0.5	0
PM10	0.239		Gg	0.8	0
TSP	0.538		Gg	1.2	100
BC	0.006		Gg	0.1	0
CO	3.201		Gg	0.9	9.5
Pb	0.206		Mg	1.3	2.9
Cd	0.020		Mg	2.1	1.2
Hg	0.014		Mg	2.4	68.5
As	0.018		Mg	0.8	9.2
Cr	0.155		Mg	0.9	3.8
Cu	0.231		Mg	0.6	1.9
Ni	0.266		Mg	1.8	13.0
Zn	3.300		Mg	2.8	0.1
PCDD/ PCDF	0.537		g I-Teq	4.0	1.2
PAHs	0.181		Mg	1.8	0
HCB	0.160		kg	0.5	0
PCBs	0.122		kg	0.5	0

Methodological issues

See the description above for NFRs 1A1, 1A2

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 7 of the IIR.

Uncertainty in fuel combustion (NFR 1.A) in total was ±1% in Finland in 2015. The use of ETS data has been included in the revised uncertainty estimation since the submission in 2014.

QA/QC and verification

Normal statistical quality checking related to assessment of magnitude and trends has been carried out. The data obtained from VAHTI is cross-checked against the summary data (by fuels and by CRF categories) reported to the UNFCCC as explained in Chapter 1.x.

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

Source-specific planned improvements

None.

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 2019	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 and 1A5b) are documented in Chapter 2.3. (Table 2.17).

Table 2.17 Activities and emissions reported under NFR 1A4 and 1A5a.

NFR	Source	Emissions	Chapter
1A4ai	Commercial/ Institutional combustion - stationary	NO_X, NMVOC, SO_X, 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, 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, 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 1A5b	Off-road, non-road, mobile sources (including military)	NOX, NMVOC, SOX, NH3, TSP, PM10, PM2.5, 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 2.14 and in Table 2.18

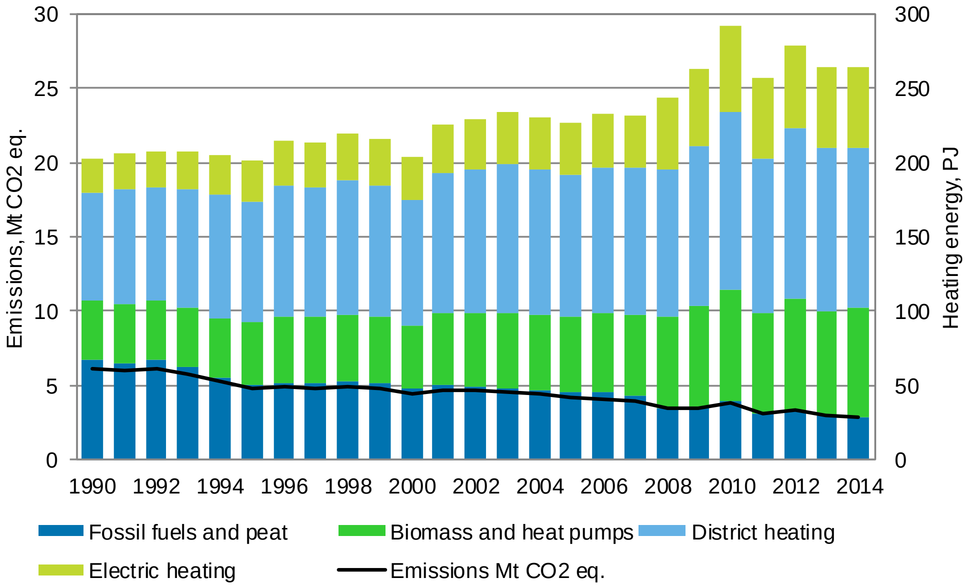


Figure 2.14. Energy consumption of heating in residential, commercial and public buildings and CO2 emissions of stationary combustion in CRF 1.A 4ai, 1.A 4bi and 1.A 4ci (Energy Statistics, Finnish NIR 2014)

Table 2.18 Fuel consumption 1990-2017 in NFRs 1A4 and 1A5 stationary sources (IPTJ Finnish Environment Institute 2019)

		1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017
Liquid fuels	Heavy fuel oil	21,2	9,1	7,9	7,8	6,6	4,9	4,9	4,3	4,0	3,5	3,6	3,4
	Light fuel oil	66,0	59,8	55,6	49,8	41,7	34,4	36,9	32,7	32,0	29,7	29,7	29,4
	Other liquid fuels	2,9	2,4	1,8	1,2	0,8	0,8	0,8	1,0	1,0	1,0	1,0	1,5
Solid fuels	Hard coal	0,6	0,4	0,3	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,1	0,1
Peat	Peat	1,3	1,0	1,3	1,6	2,6	2,1	2,3	2,1	2,0	1,8	2,1	2,2
Gaseous fuels	Natural gas	4,0	6,8	8,5	7,2	8,8	7,3	7,7	7,1	2,5	7,8	6,5	9,3
	Other gaseous fuels	3,0	3,5	4,2	3,9	4,0	4,5	4,1	4,2	4,2	4,3	3,9	5,8
Biomass	Woodfuels and other non-fossil fuels	45,1	44,8	46,7	62,3	82,0	73,2	80,2	74,2	76,0	71,6	79,2	78,7

Emission trends

The combined emission trends from NFRs 1A4 and 1A5 are presented in Figure 2.14.

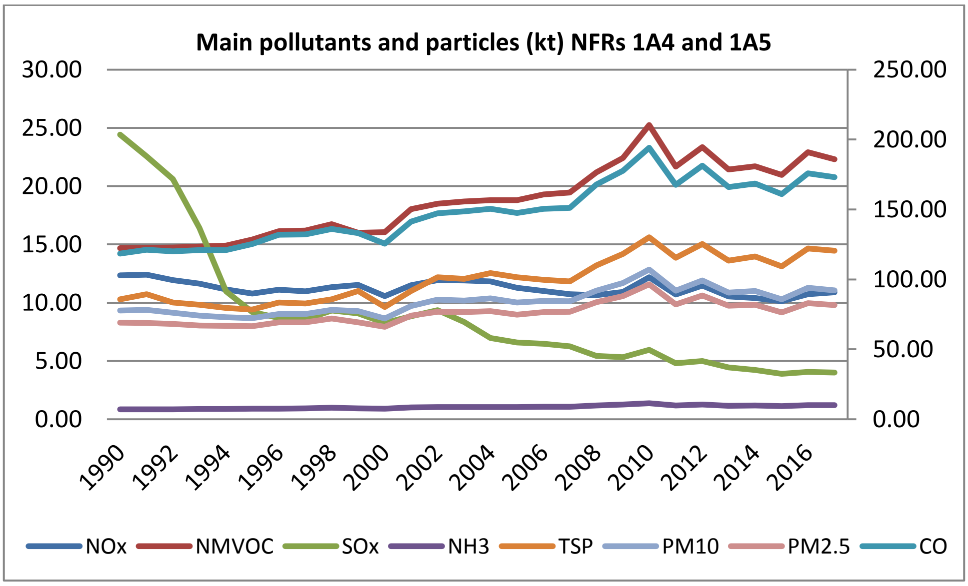


Figure 2.15 Emissions from stationary sources under NFRs 1A4 and 1A5

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 2.15 the SO2 emissions decreased considerably in the beginning of the 1990's. 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 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 2016.

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

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 energy statistics (Statistics Finland 2017). 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 2.18.

Procedure of calculation (other than small scale wood combustion)

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 VAHTI are presented in Table 2.21. 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 emissions 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 2.20. 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 2.20 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 VAHTI are presented in Table 2.21. Fuel consumption from the energy statistics is used when information on the fuel use at boiler level is not available.

The allocation of these point sources into NFR 1A4 needs to be revised, e.g. utilizing new information of district heating plants and allocating these under NFR 1A1. Also, part of the non-point source emissions, currently allocated under NFR 1A4, will then be removed under 1A1.

Table 2.21 The number of boilers active in 2017 (YLVA, 2019).

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)	24	0	0	0
Gas turbines	0	0	0	0
Stationary engines	0	0	0	0
Process ovens	0	0	0	0
Other equipment	4	0	0	0
Total	29	0	0	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]

Emission factors (other than small scale wood combustion)

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 Guidebook 2016 EFs will be made to the 2021 submission. Due to the complexícity of the energy sector calculations, are no simple options to change any EFs and this can be done first when the model is recoded, which is scheduled to 2019-2020.

The emission factors used for calculating POP emissions are presented in Table 2.22. 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 2.22 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, PM10, PM2.5, 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 7 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

2020

- Recoding of the energy sector calculation model

2021

- Verification of EFs by comparing national information and GB16.

Residential combustion of wood

1 A 4 b i Residential combustion of wood

Changes in chapter	
March 2019	KS, TF

Source category description

This chapter covers emissions from small scale combustion of wood in households, agricultural, commercial and institutional spaces (Table 2.23).

Table 2.23 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, TSP, PM_{10}, $PM_{2.5}$, CO, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, HCB, PCB

Heating need

Wood combustion is the primary heating method in 25% of residential detached houses and in most recreational buildings, while it is the secondary heating method in almost all residential and recreational buildings. There are around 2.2 million small scale wood burning devices in Finland, out of which 1.5 million are sauna stoves. The annual wood energy consumption is around 80 PJ.

Monthly wood combustion volumes in households vary depending on the heating need during the year. The heating need varies also across the country between the years depending on the local temperatures (Figure 2.17)

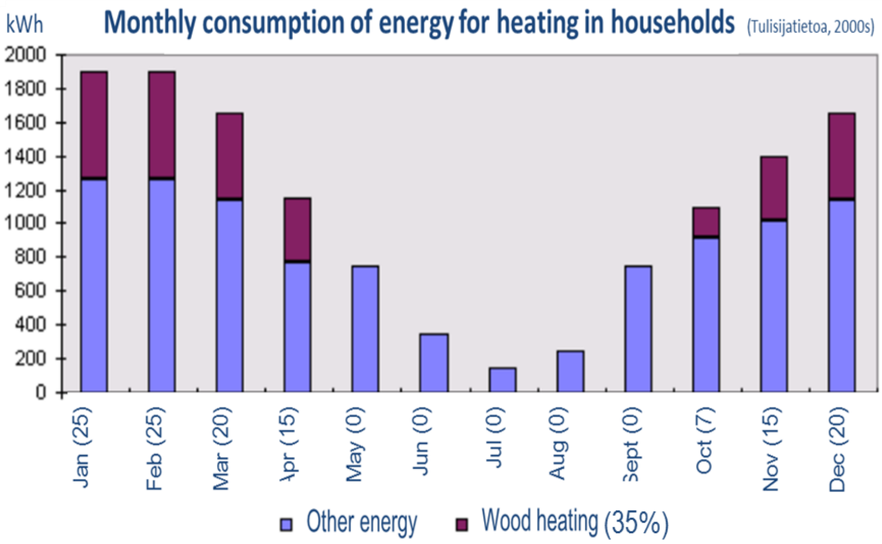


Figure 2.17 Monthly consumption of energy for heating purposes in households (Tulisijatietoa, 2000)

Domestic practices

Many of the commonly used residential wood combustion appliances and specifically the burning habits in Finland differ from those used in Europe and even in the other Nordic countries, due to the characteristic principle of the devices to achieve high combustion rate with short operating time (Tissari et al, 2008). The combustion efficiency is higher and thus the cleanliness of burning better than in devices generally used in Europe. Also the placing of the combustion appliance and the chimney in the room space is central, thus giving 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.

The user dependent impact on 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 where efficiency of heating has played a key role. 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 no more familiar to these skills.

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, as well as (c) maintenance of the equipment and the chimney. (d) Waste combustion has been forbidden for a long period. Combustion conditions are automatically controlled in the automated equipment but part of the issues listed above remain user influenced.

Factors that impact the different air pollutant emissions are presented in Table 2.24.

Table 2.24 Factors that impact emissions

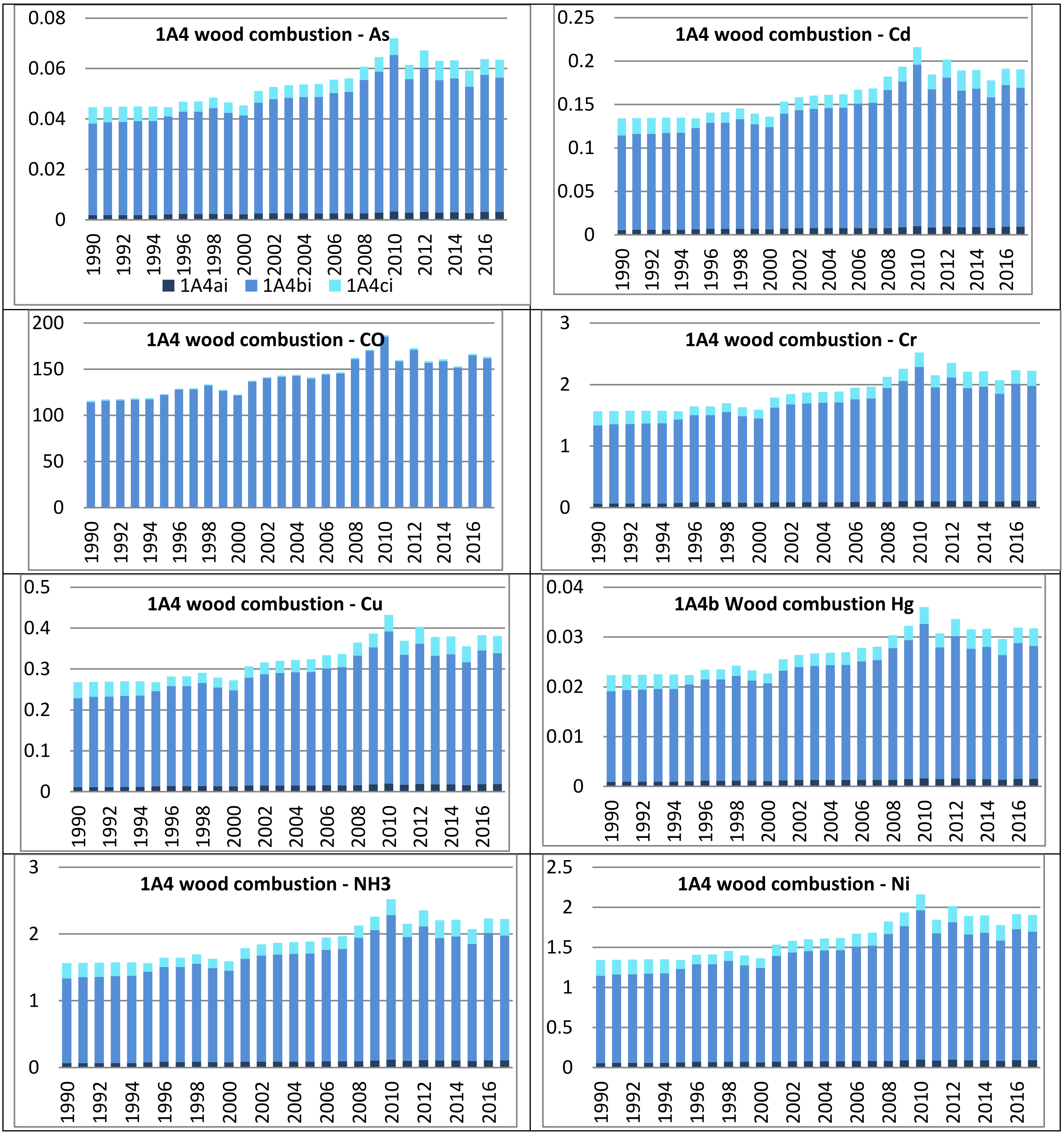
COMPOUND	FUEL QUALITY	APPLIANCE	USE	MAINTENANCE
Particles	X	X	X	X
SOx	X			
NMVOC, CO		X	X	
NOx	X	*		
NMVOC		X		
NH_3				
Heavy metals	X			
PAHs		X	X	
PCDD/F	X			
Heat yield	*X*	*X*	*X*	*X*

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

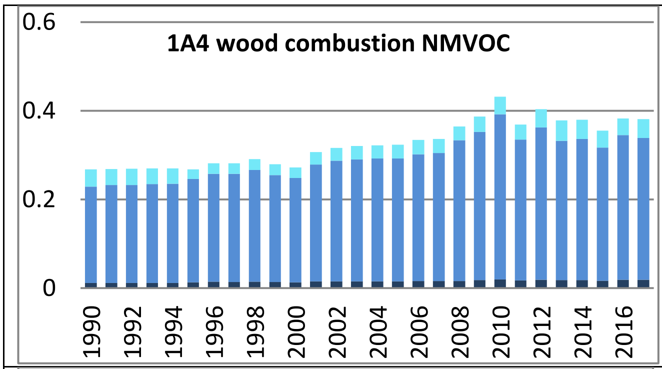
In the recent years several research and development projects have been carried out in order to improve the efficiency of combustion equipment. In the connection of these projects there have been measurement programmes to quantify emissions in the different types of domestic equipment taking also account those variations to emissions caused by different user practices and other conditions[3] . CE labels have been introduced to industrial appliances and there have been voluntary inxpections fort he constructions and flue gas properties.

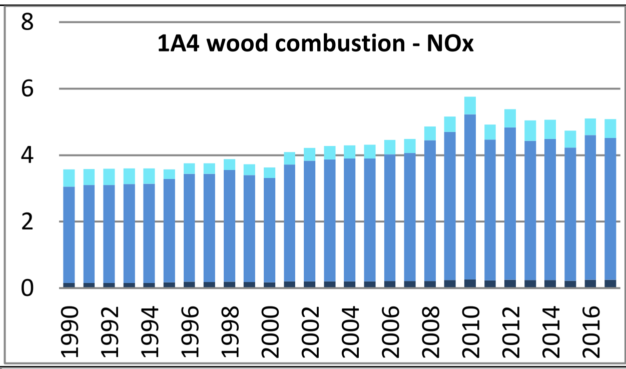
Emission trends

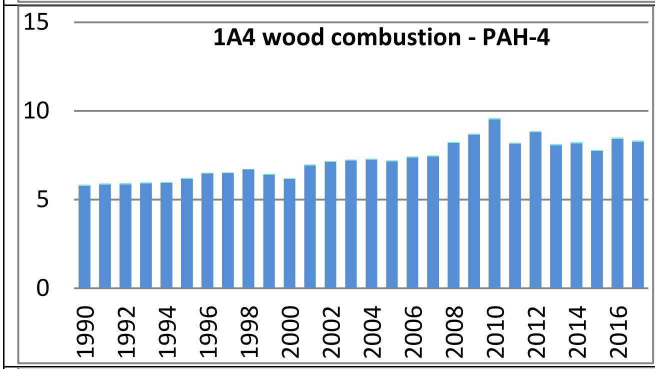
Emissions from small scale wood combustion are impacted by the volume of wood combusted and the share of wood combusted in the different technologies over time. There have been changes between the use of he different techniques since 1990, such as installation of modern sauna stoves, modern masonry heaters and modern iron stoves as can be seen in the method description below. (Figure 2.18)

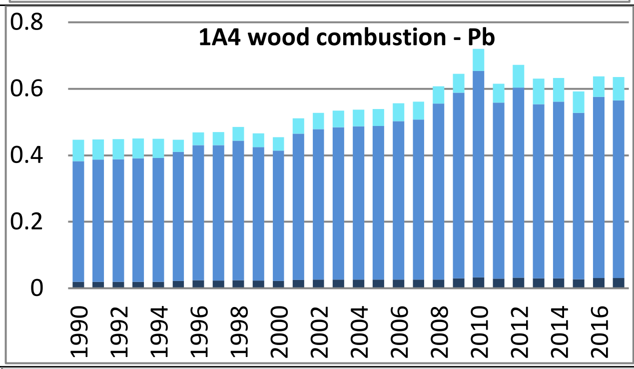


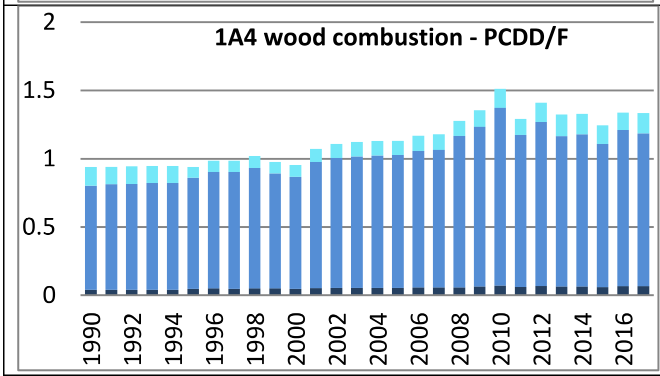
3 For instance the PUPO programme https://www.uef.fi/en/web/fine/pupo-database

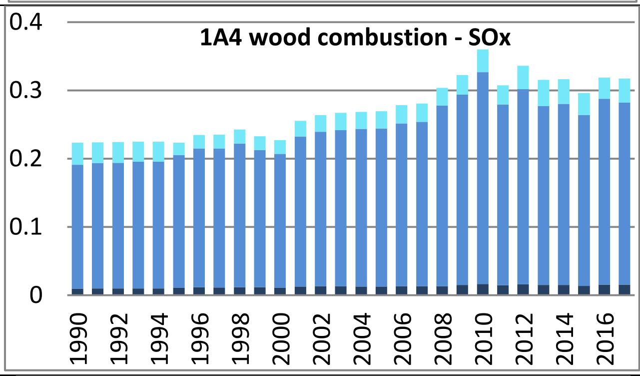

1A4 wood combustion NMVOC
0.6
0.4
0.2
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016

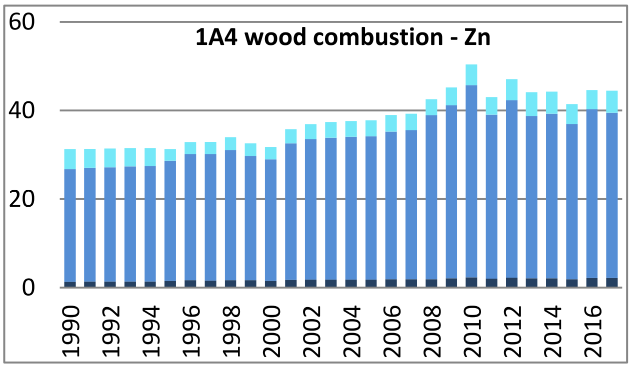

1A4 wood combustion - NOx
8
6
4
2
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016

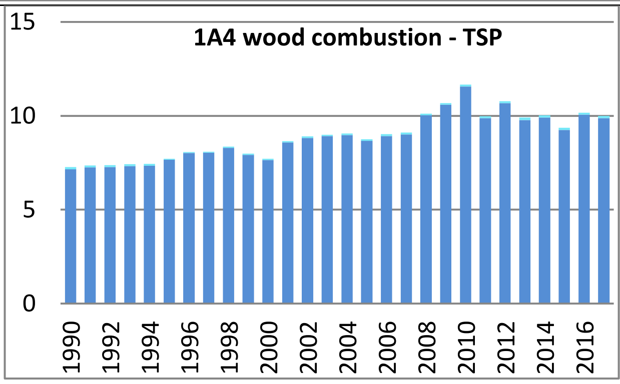

1A4 wood combustion - PAH-4
15
10
5
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016

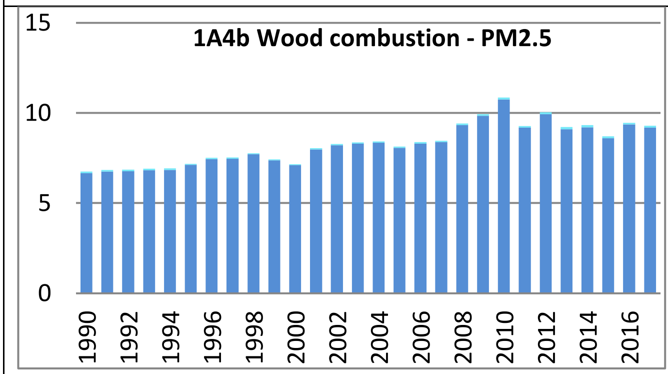

1A4 wood combustion - Pb
0.8
0.6
0.4
0.2
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016

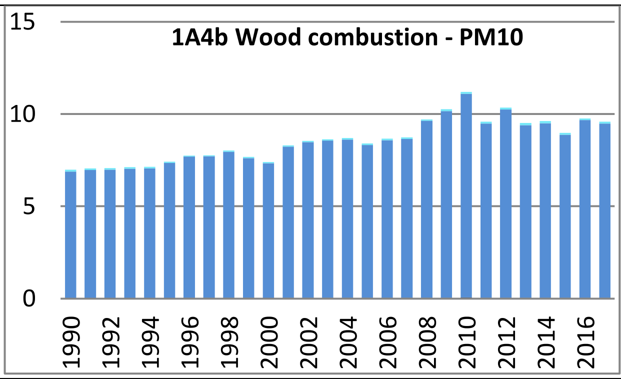

1A4 wood combustion - PCDD/F
2
1.5
1
0.5
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016

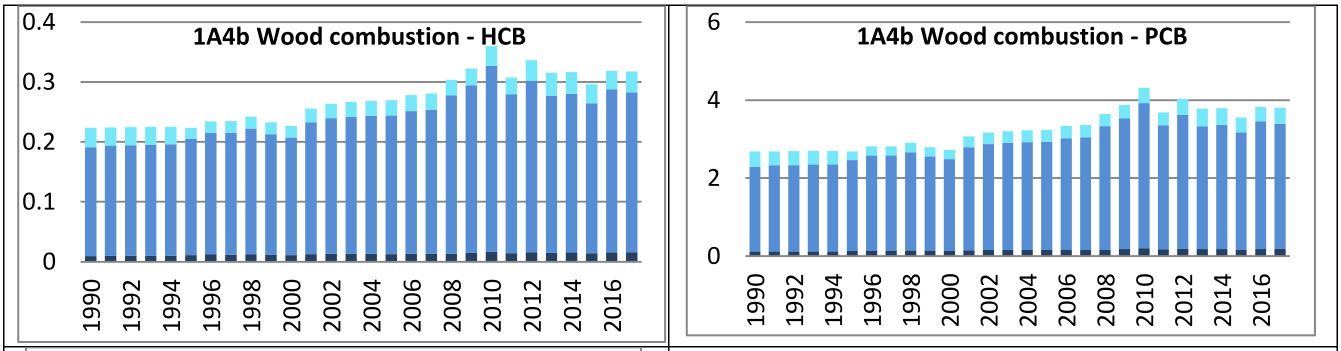

1A4 wood combustion - SOx
0.4
0.3
0.2
0.1
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016


1A4 wood combustion - Zn
60
40
20
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016


1A4 wood combustion - TSP
15
10
5
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016


1A4b Wood combustion - PM2.5
15
10
5
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016


1A4b Wood combustion - PM10
15
10
5
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016



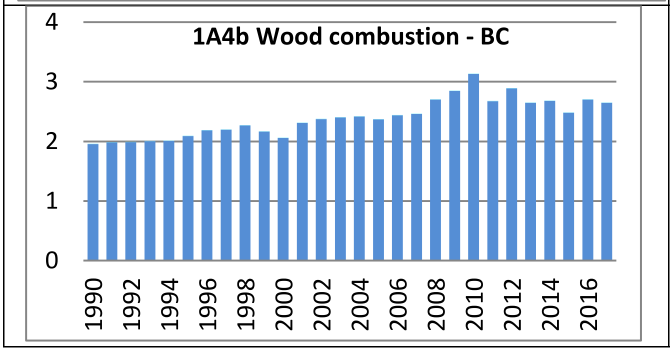


Figure 2.18 Emission trend graphs for small scale wood combustion

Domestic combustion equipment

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). Small scale combustion of wood has increased in the last decades to almost 80 PJ per year, and comprises about 35% of total primary heating energy in detached housing.

The largest share of wood is combusted in masonry ovens, log boilers and sauna stoves (Figure 2.19). 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.

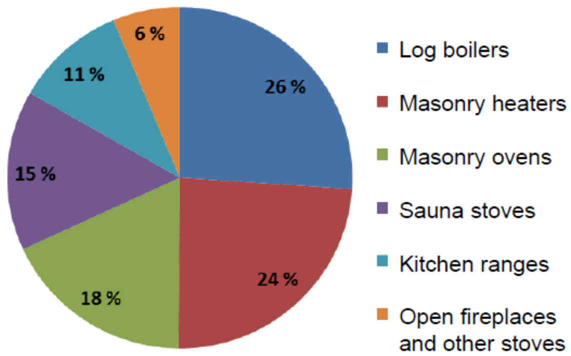


Figure 2.19. Residential wood use by combustion appliance type in Finland in 2010 (Paunu V. et al (2013)

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 2.20). 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 2.20. 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).

Wood use statistics

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 2.21 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%.

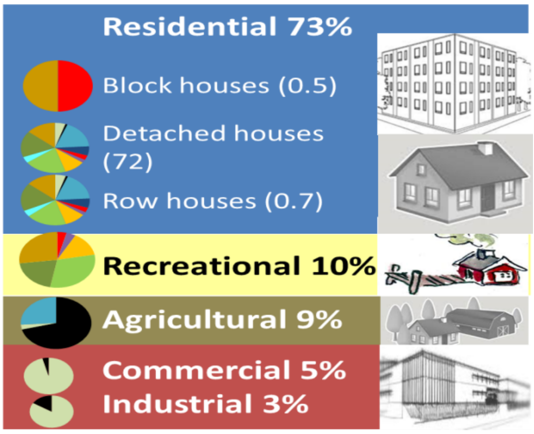


Figure 2.21 Shares of annual wood combustion in the different house types

Technology specific methodology for small scale combustion of wood

The emission inventory for small scale wood combustion is based on the use of 13 wood combustion techniques in residential, recreational, agricultural and commercial/industrial buildings (see Chapter x).

The technology specific method takes into account:

1 *Activity sector* where wood is combusted and where wood use is available per sector: (1) agriculture, (2) commercial/industry, (3) recreational and (4) residential sectors (data separately for single and row houses, block houses)
2 *Amount of wood* (firewood, wood chips and pellets) combusted in different equipment used in these activity sectors:

   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

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%).

3 *Wood use in the different combustion technologies over time* is as follows:

Residential single and row houses	1990-1999	2000-2004	2005-2009	2010-2014	2015 onwards
Boiler/Automatic Fed Wood Chips	0.0497	0.0477	0.0490	0.0490	0.0460
Boiler/Automatic Fed Pellets	0.0000	0.0221	0.0195	0.0160	0.0150
Boiler/Manually Fed with accumulator	0.2027	0.1947	0.1965	0.1980	0.1970
Boiler/Manually Fed Modern	0.0000	0.0000	0.0000	0.0000	0.0000
Boiler/Manually Fed without accumulator	0.0544	0.0522	0.0501	0.0530	0.0430
Stove/Iron stoves conventional	0.0247	0.0238	0.0239	0.0240	0.0250
Stove/Iron stoves modern	0.0000	0.0000	0.0000	0.0000	0.0000
Stove/Kitchen range	0.0962	0.0924	0.0940	0.0850	0.0570
Stove/Masonry Heaters Conventional	0.2100	0.2017	0.2000	0.2000	0.2540
Stove/Masonry Heaters Modern	0.0000	0.0175	0.0300	0.0420	0.0410
Stove/Masonry Ovens	0.1711	0.1643	0.1700	0.1820	0.1520
Stove/Sauna stoves modern	0.0000	0.0000	0.0000	0.0000	0.0230
Stove/Sauna stoves	0.1583	0.1520	0.1450	0.1340	0.1290
(Open) fire place, outdoor bathtube, barbeque	0.0329	0.0316	0.0220	0.0170	0.0180

Recreational	1990-1999	2000-2004	2005-2009	2010-2014	2015 onwards
Boiler/Automatic Fed Wood Chips	0.0000	0.0000	0.0000	0.0000	0.0000
Boiler/Automatic Fed Pellets	0.0000	0.0000	0.0000	0.0000	0.0000
Boiler/Manually Fed with accumulator	0.0000	0.0000	0.0000	0.0000	0.0000
Boiler/Manually Fed Modern	0.0000	0.0000	0.0000	0.0000	0.0000
Boiler/Manually Fed without accumulator	0.0000	0.0000	0.0000	0.0000	0.0000
Stove/Iron stoves conventional	0.0422	0.0800	0.1000	0.1310	0.1310
Stove/Iron stoves modern	0.0000	0.0000	0.0000	0.0000	0.0000
Stove/Kitchen range	0.1369	0.1200	0.1170	0.0850	0.0850
Stove/Masonry Heaters Conventional	0.2755	0.2750	0.2710	0.2710	0.2710
Stove/Masonry Heaters Modern	0.0000	0.0200	0.0440	0.0440	0.0440
Stove/Masonry Ovens	0.1975	0.1250	0.0950	0.0950	0.0950
Stove/Sauna stoves modern	0.0000	0.0000	0.0000	0.0100	0.0420
Stove/Sauna stoves	0.3057	0.3000	0.2780	0.2690	0.2370
(Open) fire place, outdoor bath tube, barbeque	0.0422	0.0800	0.0950	0.0950	0.0950
Block houses: since 1990 only wood use in fireplaces					
Commercial-Institutional					
Boiler/Automatic Fed Wood Chips	1.0000	0.9615	0.9391	0.8920	0.9130
Boiler/Automatic Fed Pellets	0.0000	0.0385	0.0609	0.1080	0.0870
Agriculture					
Boiler/Automatic Fed Wood Chips	1	1	1	1	1

Revision of wood use statistics

To the 2019 submission the results of the 2017 wood use survey by Natural Resources Institute LUKE and Statistics Finland was taken into account and the shares of wood combusted in the different techniques was revised and the shares of combusted were divided into 5 different periods instead of the earlier three, due to improved understanding of the use of the technologies.

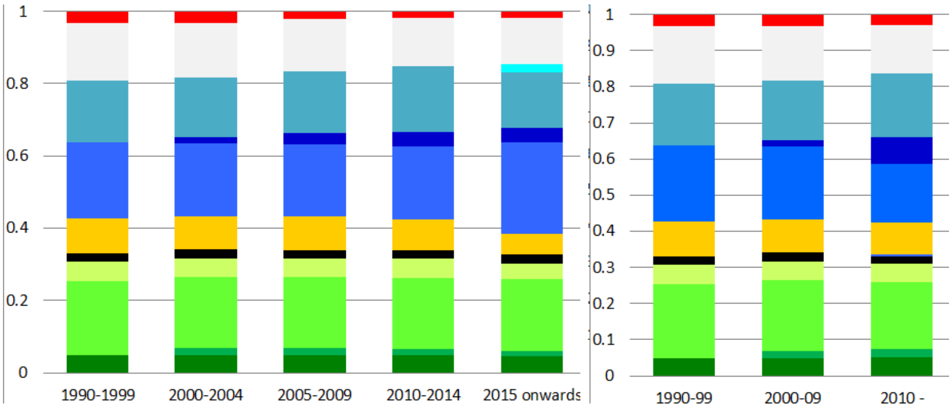
The main development in the residential sector is the increased use of masonry heaters, where also modern devices are being installed, installation of modern sauna stoves as well as decreased use of open fireplaces and kitchen ranges. For the recreational sector there is increased installation of modern sauna stoves, modern masonry heaters and especially modern iron stoves, while also the use of open fireplaces increased e.g. due to installation of outdoor bath tubes. For agricultural, commercial/institutional buildings no changes in the use of techniques were observed.

Legend to the pictures below:

(Open) fire place, outdoor bathtube, barbeque
Stove/Sauna stoves
Stove/Sauna stoves modern
Stove/Masonry Ovens
Stove/Masonry Heaters Modern
Stove/Masonry Heaters Conventional
Stove/Kitchen range
Stove/Iron stoves conventional
Boiler/Manually Fed without accumulator
Boiler/Manually Fed with accumulator
Boiler/Automatic Fed Pellets
Boiler/Automatic Fed Wood Chips

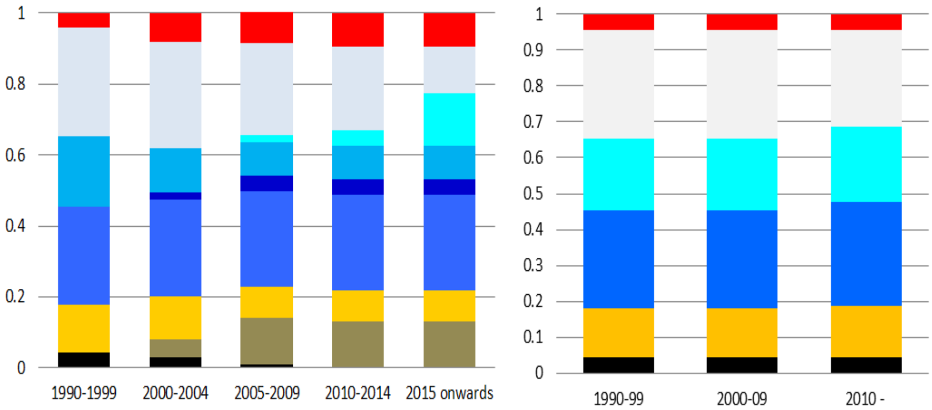
A. Residential buildings

Shares according to the 2017 survey Shares according to the old survey



B, Recreational buildings

Shares according to the 2017 survey Shares according to the old survey



Methodology

The emissions are calculated from the wood volumes combusted in each equipment category (Figure 2.22). 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 2.25.

The share of bad combustion is estimated to be 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)

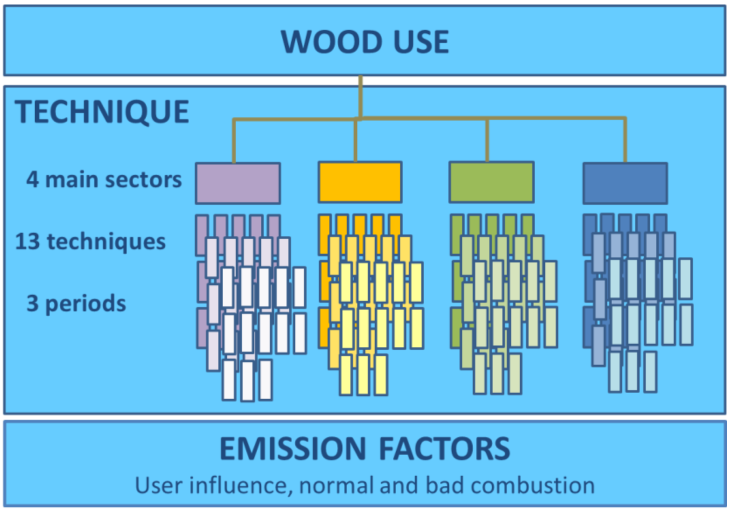


Figure 2.22 Wood use in the different main sectors (house types) are divided into 13 equipment categories and 3 time periods (before 2000, between 2000-2010, after 2010)

Table 2.25 Technology specific EFs for residential combustion of wood based fuels during normal operation conditions (The red EFs have been changed due to information from new studies (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	3288	3984.45	23.999	122	117	113	110	27.3
Iron stoves modern	5	80	1570	81.53	12.190	77	74	72	70	17.4
Autom. Fed Wood Chips	5	80	233	3	1.701	17	16	16	15	0.5
Automatic Fed Pellets	5	80	127	3	0.927	21	20	20	19	0.6
Manually Fed, accumulator	5	80	2770	49	20.221	146	140	135	131	24
Manually Fed without accumulator	5	80	2770	402	20.221	752	722	700	677	210
Manually Fed Modern	5	80	233	49	1.701	18	17	17	16	0.5
Open fire place, other	5	80	8434	405.02	61.566	686	659	638	618	35
Kitchen range	5	80	2154	92.05	15.723	56	54	53	51	33.7
Masonry Heaters	5	80	2662	209.085	19.433	148	142	138	133	47.2
Masonry Heaters Modern	5	80	1234	139.39	9.010	53	51	49	47	18.6
Masonry Ovens	5	80	1863	92.05	13.603	52	50	48	46	14.7
Sauna stoves	5	80	5651	907.35	41.250	337	324	314	304	121
Modern sauna stoves	5	80	3969	454	28.972	163	156	151	146	53.7
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 fire place 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		0.305		0.000005		0.00006		0.0000219	
Iron stoves modern	0.000000021		0.1525		0.000005		0.00006		0.0000219	
Autom. Fed Wood Chips	0.000000021		0.01		0.000005		0.00006		0.0000219	

Automatic Fed Pellets	0.000000021	0.005	0.000005	0.00006	0.0000219
Manually Fed, accumulator	0.000000021	0.05	0.000005	0.00006	0.0000219
Manually Fed without accumulator	0.000000021	0.1	0.000005	0.00006	0.0000219
Manually Fed Modern	0.000000021	0.005	0.000005	0.00006	0.0000219
Open fire place and other stove	0.000000100	0.305	0.000005	0.00006	0.0000219
Kitchen range	0.000000021	0.121	0.000005	0.00006	0.0000219
Masonry Heaters	0.000000021	0.1525	0.000005	0.00006	0.0000219
Masonry Heaters Modern	0.000000021	0.121	0.000005	0.00006	0.0000219
Masonry Ovens	0.000000021	0.1525	0.000005	0.00006	0.0000219
Sauna stoves	0.000000021	0.305	0.000005	0.00006	0.0000219
Modern sauna stoves	0.000000021	0.153	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 fire places, due to new information from national research (Starship database, 2015).

Ammonia

NH3 emissions for small combustion sources were calculated for the first time in 2015 due to the adjustment application for ammonia (see Appendixes 3-4) submitted by Finland and accepted by the Expert Review Team for Adjustments (Table 2.26, include both wood combustion and coal combustion, the volume of coal combusted is negligible but included in the calculation as presented in the file FI IIR 2016 Appendix 3B Documentation Small combustion 2018.xlsx)

Table 2.26 Adjusted NH3 emissions for 2010-2017 for small combustion sources

NFR	2010	2011	2012	2013	2014	2015	2016	2017
1A4ai	0.018	0.016	0.017	0.016	0.016	0.015	0.017	0.017
1A4bi	-0.916	-0.785	-0.842	-0.763	-0.776	-0.748	-0.821	-0.800
1A4ci	0.035	0.030	0.036	0.041	0.038	0.034	0.033	0.037
Sum	-0.862	-0.740	-0.789	-0.706	-0.722	-0.699	-0.772	-0.746

Ammonia emission factors for small scale wood combustion presented in Table 2.25 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 NH3:CO of 0.0073 is based on a literature value for wild fires 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).

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 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 VAHTI is cross-checked against the summary data (by fuels and by CRF categories) reported to the UNFCCC as explained in Chapter 3.3.4.

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

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 X (to be submitted by 1 May 2019)
The national wood use statistics was revised based and thus wood use in the different techniques was updated
All CO and particle EFs were updated and PCDD/F for open fires

Source-specific planned improvements

None

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

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

Changes in chapter	
	May 2018

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 PM2.5 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 2019	JMP, KS

Source category description

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

Emission trend

The contribution of emissions from coke production in 2016 to total emissions as well as the shares reported by the operators are presented in Table 2.27.

Table 2.27 Contribution of NFR 1B1b Fugitive emissions from solid fuels (NFR 1B1b), shares reported by operators, in 2016.

Year	Pollutant	Unit	% of National Total	Total Release	Shares% reported by the operators
SOx (as SO2)	0.05	Gg	0.1		100
NH3	0.003	Gg	<0.1		0
PM2.5	0.021	Gg	0.1		0
PM10	0.025	Gg	<0.1		0
TSP	0.05	Gg	0.1		100
BC	<0.001	Gg	<0.1		0
Pb	0.151	Mg	0.9		100
Cd	0.005	Mg	0.6		100
Hg	<0.001	Mg	<0.1		0
As	0.014	Mg	0.6		100
Cr	0.033	Mg	0.2		100
Cu	0.047	Mg	0.1		100
Ni	0.026	Mg	0.2		100
Zn	0.157	Mg	0.1		100
PCDD/ PCDF	2.647	g I-Teq	16.8		0

PAHs	0.468	Mg	4.6		0
PCBs	3.176	kg	8.6		0
SOx (as SO2)	0.05	Gg	0.1		100

Methodological issues

SO_x, heavy metal and TSP emissions are reported by the operators according to monitoring requirements in their environmental permits. Small particle fractions are calculated from TSP emission data reported by the plants using emission factors of 42% for PM10 and18% of TSP for PM2.5 from GB16.

NH3, NMVOC, PCBs, PCDD/PCDF and PAH emissions are calculated using emission factors from EMEP EEA Guidebook 2016 (EEA, 2016).

Activity data for coke production is received from the Federation of Finnish Technology Industries. The production rates, calculated emissions and emission factors are presented in Table 2.28.

Table 2.28 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	benzo(a) pyrene (kg)	benzo(b) fluranthene (kg)	benzo(k) fluranthene (kg)	indeno(1,2,3-cd) pyrene (kg)	PCB (kg)	NH_3 (t)
1990	487 000	37.5	1.46	77.9	97.4	48.7	34.1	1.75	1.80
1991	471 000	36.3	1.41	75.4	94.2	47.1	33.0	1.70	1.74
1992	498 000	38.3	1.49	79.7	99.6	49.8	34.9	1.79	1.84
1993*	874 000	67.3	2.62	139.8	174.8	87.4	61.2	3.15	3.23
1994	922 000	71.0	2.77	147.5	184.4	92.2	64.5	3.32	3.41
1995	920 000	70.8	2.76	147.2	184.0	92.0	64.4	3.31	3.40
1996	910 000	70.1	2.73	145.6	182.0	91.0	63.7	3.28	3.37
1997	879 000	67.7	2.64	140.6	175.8	87.9	61.5	3.16	3.25
1998	912 000	70.2	2.74	145.9	182.4	91.2	63.8	3.28	3.37
1999	900 000	69.3	2.70	144.0	180.0	90.0	63.0	3.24	3.33
2000	910 000	70.1	2.73	145.6	182.0	91.0	63.7	3.28	3.37
2001	909 000	70.0	2.73	145.4	181.8	90.9	63.6	3.27	3.36
2002	912 000	70.2	2.74	145.9	182.4	91.2	63.8	3.28	3.37
2003	895 217	68.9	2.69	143.2	179.0	89.5	62.7	3.22	3.31
2004	903 723	69.6	2.71	144.6	180.7	90.4	63.3	3.25	3.34
2005	893 628	68.8	2.68	143.0	178.7	89.4	62.6	3.22	3.31
2006	869 937	67.0	2.61	139.2	174.0	87.0	60.9	3.13	3.22
2007	865 007	66.6	2.60	138.4	173.0	86.5	60.6	3.11	3.20
2008	860 428	66.3	2.58	137.7	172.1	86.0	60.2	3.10	3.18
2009	737 934	56.8	2.21	118.1	147.6	73.8	51.7	2.67	2.73
2010	826 800	63.7	2.48	132.3	165.4	82.7	57.9	2.98	3.06
2011	852 402	65.6	2.56	136.4	170.5	85.2	59.7	3.07	3.15
2012	880 551	67.8	2.64	140.9	176.1	88.1	61.6	3.17	3.26
2013	877 602	68.3	2.63	140.4	175.5	87.8	61.4	3.16	3.25
2014	887 784	68.4	2.66	142.0	177.6	88.8	62.1	3.20	3.28
2015	875 618	67.4	2.63	140.1	175.1	87.6	61.3	3.15	3.24
2016	882 270	67.9	2.65	141.2	176.5	88.2	61.8	3.18	3.26
2017	864 069	66.5	2.59	138.3	172.8	86.4	60.5	3.11	3.20
*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.

Corrections made to YLVA data are listed in Annex 4 of Part 2 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

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

Source-specific planned improvements

None.

1 B 1 c Other fugitive emissions from solid fuels

1 B 1 c Other fugitive emissions from solid fuels

Changes in chapter	
February 2019	

Source category description

This category covers emissions from peat production. The contribution of Other fugitive emissions from solid fuels (NFR 1B1c) in 2016 to total emissions is presented in Table 2.29.

Table 2.29 Contribution of Other fugitive emissions from solid fuels (NFR 1B1c) in 2016 to total emissions.

Pollutant	Emissions from Fugitive emissions from solid fuels in 2016	Total emissions in 2016	Unit	Share of total emissions %	% reported by the operators
PM2.5	0.571		Gg	2.9	0
PM10	0.812		Gg	2.5	0
TSP	1.243		Gg	2.6	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 2.23). Finland is the leading peat producer in the world.

Figure 2.23 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 Figure 2.24 a-b.

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.

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 m3/ha. (A. Erkkilä, 2016)

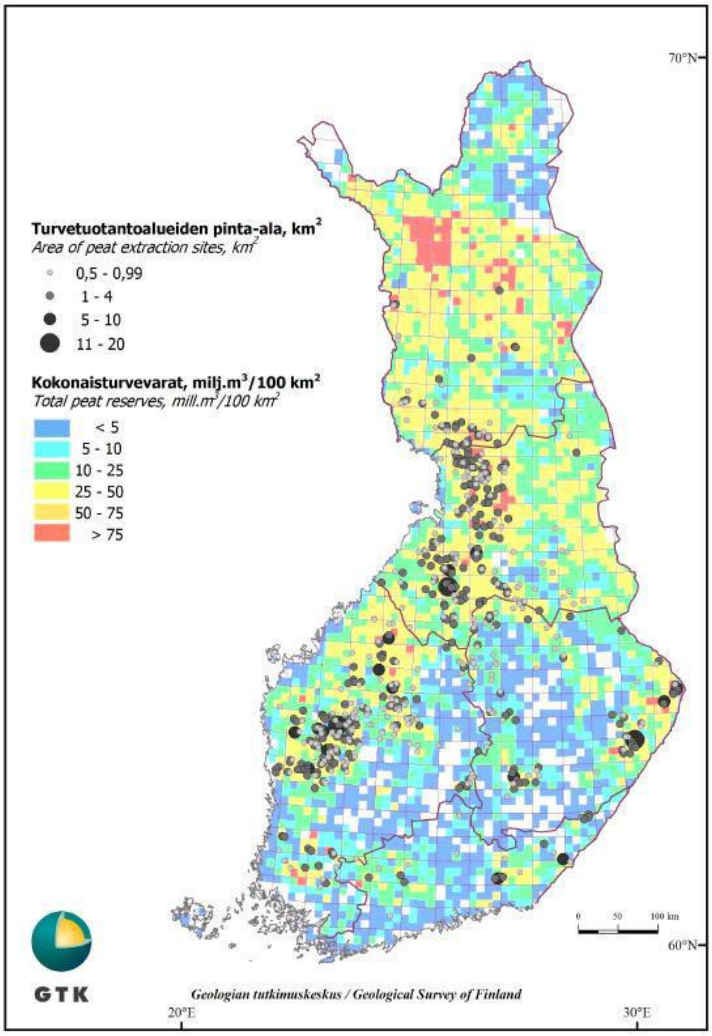
Milled peat

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 2.30). Volumes of produced peat are obtained from Energy Statistics and are presented together with particle emissions in Table 2.30.



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Kokonaisturvevarat: GTK (Geological Survey of Finland).

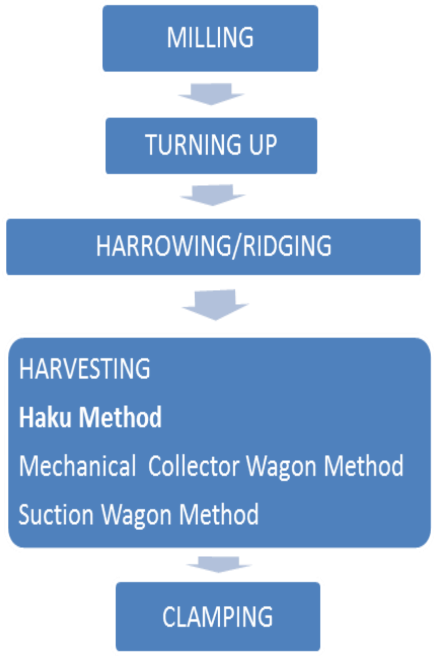

Figure 2.24b The process of peat harvesting and the three most common peat production processes

Figure 2.24a Peat production areas in Finland

Table 2.31 TSP, PM_{10} and $PM_{2.5}$ emission factors for milled peat production.

Source	Emission factors per produced peat cubic metre (kg/m^3)			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 acitivity data for Haku harvests needs to be halved

Table 2.32 Particle emissions and activity data as volumes of produced peat in 1990-2017.

Year	Produced peat ($1000m^3$)	TSP (t)	$PM_{2.5}$ (t)	PM_{10} (t)
1990	17 305	2363	1085	1545
1991	8 424	1150	528	752
1992	18 628	2544	1168	1663
1993	9 668	1320	606	863
1994	23 223	3171	1456	2073
1995	24 278	3315	1522	2167
1996	25 332	3459	1588	2261
1997	31 095	4246	1949	2775
1998	4 818	658	302	430
1999	25 046	3420	1570	2235
2000	12 261	1674	769	1094
2001	19 190	2701	1240	1766
2002	25 771	3628	1655	2371
2003	21 672	3051	1400	1994
2004	9 194	1294	594	846
2005	25 464	3584	1645	2343
2006	38 100	5363	2462	3505
2007	13 053	1837	843	1201
2008	13 950	1964	901	1284
2009	25 000	3519	1615	2300
2010	21 650	3048	1399	1992
2011	20 130	2834	1301	1852
2012	12 544	1766	801	1154
2013	20 567	2895	1329	1892
2014	18 855	2654	1218	1735
2015	10 125	1425	654	932
2016	8831	1243	571	812
2017	8900	1253	575	819

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 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

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 1A3e.

Refining / storage (1B2aiv)

Changes in chapter	
February 2019	JMP, KS

Source category description

The category covers oil refineries, venting and flaring emissions and storage of fossil fuels in all storages in the country. Emissions reported under this sector include only NMVOC's. The contribution to total emissions and shares reported by the operators are presented in Table 2.33.

Table 2.33 Contribution of Refining/storage (NFR 1B2aiv) in 2016 to total emissions, shares reported by operators

Pollutant	Emissions from Fugitive emissions from solid fuels in 2016	Total emissions in 2016	Unit	Share of total emissions %	% reported by the operators
NMVOC		3.309	Gg	3.7	100

Emission trend

The emission trends are presented in Figure 2.25.

NMVOC emissions are slightly decreasing due to improved abatement methods.

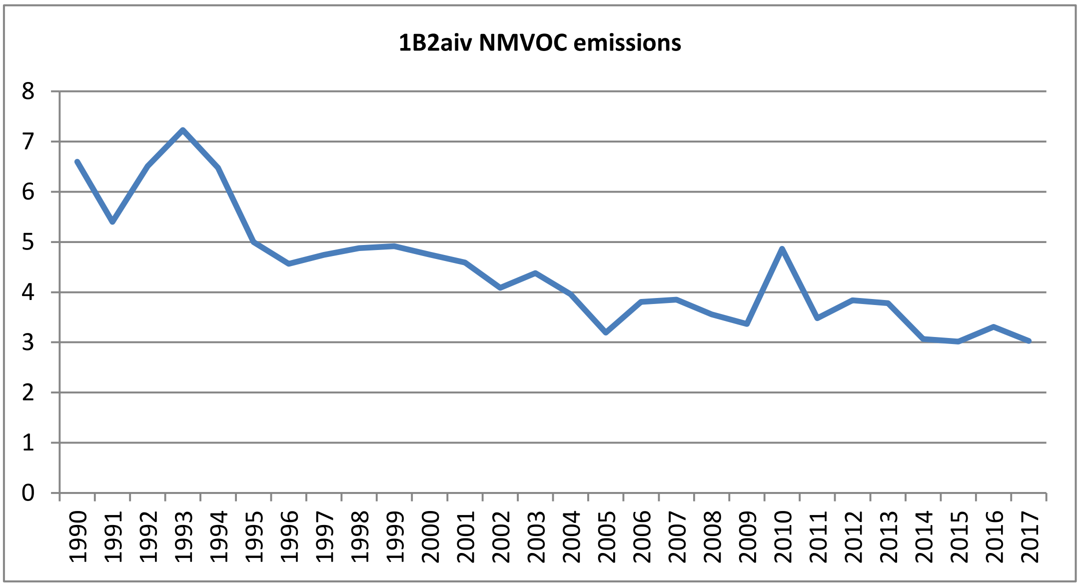

Figure 2.25 NMVOC emissions from refining/storage

Methodological issues

Petroleum industry reports their NMVOC emissions to the environmental authorities according to their monitoring programmes in the environmental permits since 1988. Emissions of SOx, NOx and particles are reported by the plants and are included in the energy sector.

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 7 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).

Source-specific planned improvements

None.

Natural gas (1B2b)

Changes in chapter	
February 2019	JMP KS

Source category description

NOTE: Distribution of oil products 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 2016.

The contribution of the category to total emissions and the shares reported by the plants are presented in Table 2.34.

Table 2.34 Contribution of Distribution of oli products (NFR 1B2b) in 2016 to the total emissions, shares reported by the plants.

Pollutant	Emissions from Fugitive emissions from solid fuels in 2016	Total emissions in 2016	Unit	Share of total emissions %	% reported by the operators
NMVOC	0.26		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 2.25)

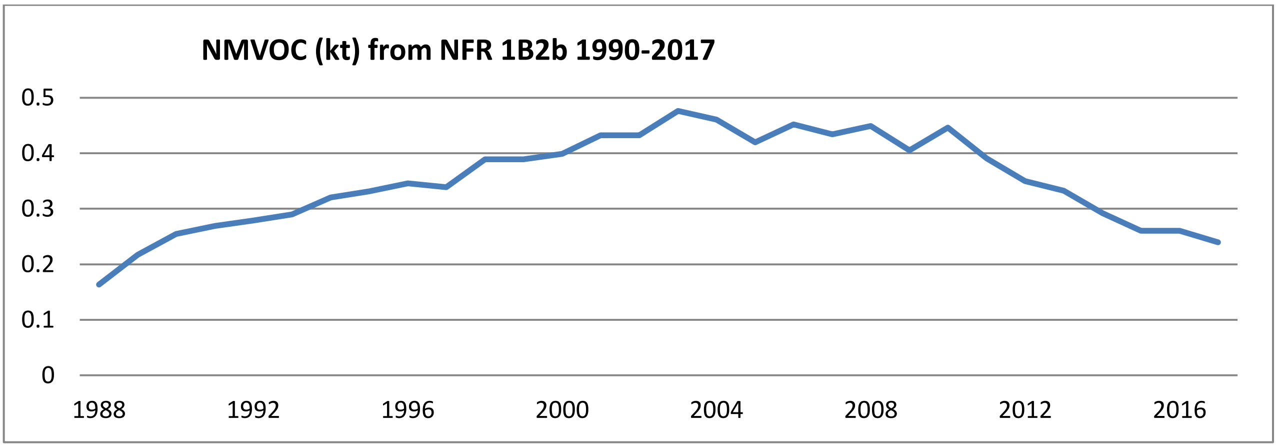

Figure 2.25. NMVOC emissions from NFR 1B2b

Methodological issues

The emissions are calculated using emission factors from Guidebook 2016. Activity data used in the calculation is presented in Table 2.35.

Table 2.35 AD used in the calculation of NMVOC emissions from 1B2b

Year	Volume of natural gas (milj m3)
1988	1634
1989	2171
1992	2788
1993	2895
1994	3201
1995	3311
1996	3460
1997	3389
1998	3889
1999	3892
2000	3990
2001	4322
2002	4295
2003	4762
2004	4606
2005	4195
2006	4519
2007	4340
2008	4492
2009	4052
2010	4463
2011	3908
2012	3495
2013	3323
2014	2923
2015	2601
2016	2395
2017	2395*

*due lack of activity data, the volume of natural gas of 2016 is used for the year 2017

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 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.

Source-specific planned improvements

None.

Venting and flaring (1B2c)

Changes in chapter	
March 2018	KS

Source category description

SOx, NOx, 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.

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.