LITHUANIA‘S INFORMATIVE INVENTORY REPORT 2023

Air Pollutant Emissions 1990-2021

under the UNECE CLRTAP and the EU NECD

Part 3 – ENERGY

Lithuanian Environmental Protection Agency

Contents

List of abbreviations

CHP – Combined Heat and Power Plants

ELV – Emission limit value

GB2019 - EMEP/EEA air pollutant emission inventory guidebook 2019

HM – Heavy metals

HP – Heating plants

LCP – Large combustion plant

LCPD- Large combustion plant directive

LPG – Liquified Petroleum Gases

MCP – Medium combustion plant

MCPD - Medium combustion plant directive

POP – Persistent Organic Pollutants

1. STATIONARY FUEL COMBUSTION (NFR 1.A.1-2-4)

This group comprises the following NFR sectors: 1.A.1.a “Public electricity and heat production”, 1.A.1.b “Petroleum refining”, 1.A.1.c “Manufacture of solid fuels and other energy industries”, 1.A.2.a “Stationary combustion in manufacturing industries and construction: Iron and steel”, 1.A.2.b “Stationary combustion in manufacturing industries and construction: Non-ferrous metals”, 1.A.2.c “Stationary combustion in manufacturing industries and construction: Chemicals”, 1.A.2.d “Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print”, 1.A.2.e “Stationary combustion in manufacturing industries and construction: Food processing, beverages and tobacco”, 1.A.2.f “Stationary combustion in manufacturing industries and construction: Non-metallic minerals”, 1.A.2.g.viii “Stationary combustion in manufacturing industries and construction: Other”.

The Statistics Lithuania fuel balance was used as the activity data for calculation of the historical emissions (1990-2021). The projected emissions (2022, 2025, 2030, 2035, 2040, 2045,2050) were prepared on the basis of the fuel combustion scenarios WEM and WAM compiled by Lithuanian Energy Agency (LEA). The WEM scenario includes measures that were foreseen in the National Air Pollution Control Programme (August 2022) and in the National energy and climate plan (December 2019). The WAM scenario comprises measures that are included in the above mentioned plans and additional measures foreseen in the renewal of the National energy and climate plan which is currently being prepared.

General methodological issues for stationary non-residential fuel combustion in Medium Combustion Plants

NOx and PM emission factors for “new” MCP. According to the Medium Combustion Plant Directive (MCPD), for combustion plants 1-50 MW which are installed after 20th December 2018, following ELV (Emission Limit Values, mg/m3) are set:

Pollutant	Solid biomass 1-5 MW	Solid biomass 5-50 MW	Natural gas 1-50 MW
NOx ELV (mg/m3)	500	300	100
NOx EF (g/GJ)	140	84	28

Figure 1. NOx ELV and corresponding EF for MCP installed after 20.12.2018

NOx emission factors were evaluated using the methods provided in Appendixes B and C of EMEP/EEA air pollutant emission inventory guidebook 2019, chapter 1A4. For old devices burning wood, Lithuanian national ELV (mg/m3) for NOx is 750; corresponding EF value was selected as 210 g/GJ (Table 3.45, GB2019, 1A4). For MCPD ELV equal 500, corresponding EF was derived by formula EF =210*(500/750), for MCPD ELV 300, by formula EF =210*(300/750). For natural gas, NOX EF was taken from Table C3.2 (GB2019, 1A4).

Pollutant	Solid biomass 1-5 MW	Solid biomass 5-20 MW	Solid biomass 20-50 MW
TSP ELV (mg/m3)	50	30	20
TSP EF (g/GJ)	12,3	7,4	4,9
PM10 EF (g/GJ)	11,1	6,6	4,4
PM2.5 EF (g/GJ)	9,5	5,7	3,8

Figure 2. PM ELV and corresponding EF for MCP installed after 20.12.2018

TSP emission factors were evaluated using the methods provided in Appendixes B and C of EMEP/EEA air pollutant emission inventory guidebook 2019, chapter 1A4. For old devices burning wood installed before 01.07.1998 with capacity 1-20 MW, Lithuanian national ELV (mg/m3) for TSP is 700; corresponding EF value was selected as 172 g/GJ (Table 3.13, GB2019, chapter 1A1). For MCPD ELV equal 50, corresponding EF was derived by formula EF =172*(50/700), for MCPD ELV 30, by formula EF =172*(30/700), for MCPD ELV 20 EF=172*(20/700). Proportion of PM10 and PM2.5 was taken from Table 3.13 (GB2019, chapter 1A1).

Proportion of fuel combustion in MCP installed after 20.12.2018.

This proportion was evaluated by the LEPA experts in cooperation with the experts of Environment Ministry. It was applied for wood and natural gas combustion.

Scenario:	Historical	Historical	Historical	WEM	WEM	WEM	WEM	WEM	WAM	WAM	WAM	WAM	WAM
Years:	2019	2020	2021	2025	2030	2035	2040	2050	2025	2030	2035	2040	2050
Proportion, %:	10	15	20	35	55	80	95	100	35	55	80	95	100

Figure 3.Proportion of fuel combustion in MCP installed after 20.12.2018

NOx and PM emission factors for "old" MCP.

Tables below provides ELV and EF for medium combustion plants that were installed before 20.12.2018 ("old" devices) and MCP directive is not implemented so far:

Pollutant	Solid biomass 1-50 MW	Natural gas 1-50 MW
NOx LT national ELV (mg/m3)	750	350
NOx EF (g/GJ)	210	89

Figure 4. NOx LT national ELV and corresponding EF for MCP installed before 20.12.2018 ("old" MCP)

Pollutant	Solid biomass 1-20 MW (installed before 01.07.1998)	Solid biomass 1-20 MW (installed after 01.07.1998)	Solid biomass 20-50 MW (installed before 01.07.1998)	Solid biomass 20-50 MW (installed after 01.07.1998)
TSP LT national ELV (mg/m3)	700	400	500	300
TSP EF (g/GJ)	172	98,3 (=172*(400/700))	122,9 (=172*(500/700)	73,7 (=172*(300/700))
PM10 EF (g/GJ)	155	88,6 (=155*(400/700))	110,7 (= =155*(500/700))	66,4 (=155*(300/700))
PM2.5 EF (g/GJ)	133	76 (=133*(400/700))	95 (=133*(500/700))	57 (= 133*(300/700))

Figure 5. PM LT national ELV and corresponding EF for MCP installed before 20.12.2018 ("old" MCP) when MCP directive is not implemented.

From 2019 for the above mentioned group of boilers, particulate matter emission factors were derived from the Lithuanian national EF research 2018-2019 results and are equal to particulate matter emission factors provided in the Table 3.49 (GB2019, chapter 1A4).

NOx and PM emission factors for "old" MCP from 01.01.2025 and 01.01.2030.

For boilers with capacity 5-50 MW those were installed before 20.12.2018, the following ELV (and corresponding EF) must be implemented from 01.01.2025:

Pollutant	Solid biomass 5-50 MW	Natural gas 5-50 MW
NOx ELV (mg/m3)	650	200
NOx EF (g/GJ)	182 (=210*(650/750))	51 (=89*(200/350))

Figure 6. NOx ELV and corresponding EF (from 01.01.2025) for MCP 5-50 MW installed before 20.12.2018

Pollutant	Solid biomass 5-20 MW	Solid biomass 20-50 MW
TSP ELV (mg/m3)	50	30
TSP EF (g/GJ)	12,3	7,4
PM10 EF (g/GJ)	11,1	6,6
PM2.5 EF (g/GJ)	9,5	5,7

Figure 7.PM ELV and corresponding EF (from 01.01.2025) for MCP 5-50 MW installed before 20.12.2018

For boilers with capacity 1-5 MW those were installed before 20.12.2018, the following ELV (and corresponding EF) must be implemented from 01.01.2030:

Pollutant	Solid biomass 1-5 MW	Natural gas 1-5 MW
NOx ELV (mg/m3)	650	250
NOx EF (g/GJ)	182 (=210*(650/750))	63,6 (=89*(250/350))

Figure 8. NOx ELV and corresponding EF (from 01.01.2030) for MCP 1-5 MW installed before 20.12.2018

Pollutant	Solid biomass 1-5 MW
TSP ELV (mg/m3)	50
TSP EF (g/GJ)	12,3
PM10 EF (g/GJ)	11,1
PM2.5 EF (g/GJ)	9,5

Figure 9. PM ELV and corresponding EF (from 01.01.2030) for MCP 1-5 MW installed before 20.12.2018

There is possibility for the enterprises in Lithuania to get funding for implementation of the MCP directive in advance.

HM and POPs emission factors for wood combustion in MCP

Wood combustion emissions of heavy metals and persistent organic pollutants are attached to the particulate matter emissions. Abatement of particulate matter emissions also reduces the HM and POPs. GB2019 provides HM and POPs emission factors for wood combustion in MCP in the Table 3.45, GB2019, chapter 1A4. This table lacks information what was particulate matter concentration in the combustion plants where HM and POPs measurements were performed. So it was problematic to evaluate the effect of PM abatement required in the Lithuanian standards and in the MCPD on the emissions of HM and POPs and emission factors for HM and POPs were used as they are in the Table 3.45 without any abatement.

CO, NMVOC, SO2, NH3 emission factors for wood combustion in MCP

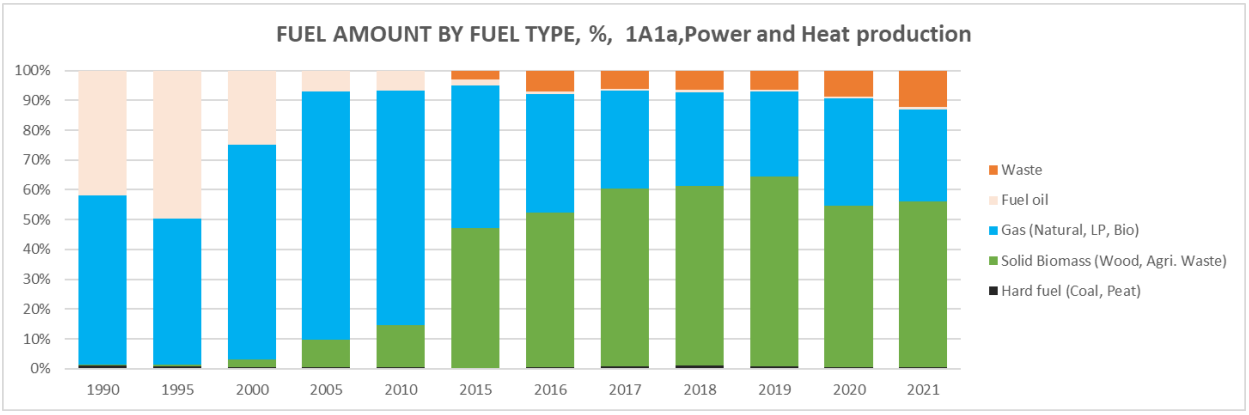
Emission factors from the Table 3.45, GB2019, chapter 1A4 were used. Emission factor (g/GJ) for NH3 is 8.2 and is taken from the IIASA TSAP 16 Underlying assumptions - GAINS details database .

1.1. Fuel combustion in the 1A1a (Public electricity and heat production)

1.1.1. Activity data

The following chapters of the fuel balance by Statistics Lithuania were used as the activity data for calculation of the historical emissions (1990-2021): Transformation in public CHP plants, Transformation in autoproducer CHP plants, Transformation in public heat plants, Transformation in autoproducer heat plants, Transformation in geothermal plants.

FUEL AMOUNT BY FUEL TYPE													
NFR:	1A1a, Power and Heat production												
Scenario:	Historical												
Fuel data source:	Fuel balance of Statistics Lithuania												
Amount unit:	TJ												
Years:			*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
All fuels			185649	84611	65206	68255,65	74311	52005	47046	46419	44433	41801	48983	57038
Hard fuel (Coal, Peat)			1940	558	369	397	260	156	184	412	436	289	198	242
Solid Biomass (Wood, Agri. Waste)			527	558	1640	6289	10509	24400	24409	27645	26770	26616	26522	31792
Fuel oil			78011	42015	16211	4840,65	5037	993	400	332	455	162	206	551
Gas (Natural, LP, Bio)			105171	41480	46986	56729	58505	24854	18807	15223	13950	11999	17736	17563
Waste			0	0	0	0	0	1602	3246	2807	2822	2735	4321	6890
Amount unit:%														
Hard fuel (Coal, Peat)			1,0%	0,7%	0,6%	0,6%	0,3%	0,3%	0,4%	0,9%	1,0%	0,7%	0,4%	0,4%
Solid Biomass (Wood, Agri. Waste)			0,3%	0,7%	2,5%	9,2%	14,1%	46,9%	51,9%	59,6%	60,2%	63,7%	54,1%	55,7%
Fuel oil			42,0%	49,7%	24,9%	7,1%	6,8%	1,9%	0,9%	0,7%	1,0%	0,4%	0,4%	1,0%
Gas (Natural, LP, Bio)			56,7%	49,0%	72,1%	83,1%	78,7%	47,8%	40,0%	32,8%	31,4%	28,7%	36,2%	30,8%
Waste			0,0%	0,0%	0,0%	0,0%	0,0%	3,1%	6,9%	6,0%	6,4%	6,5%	8,8%	12,1%



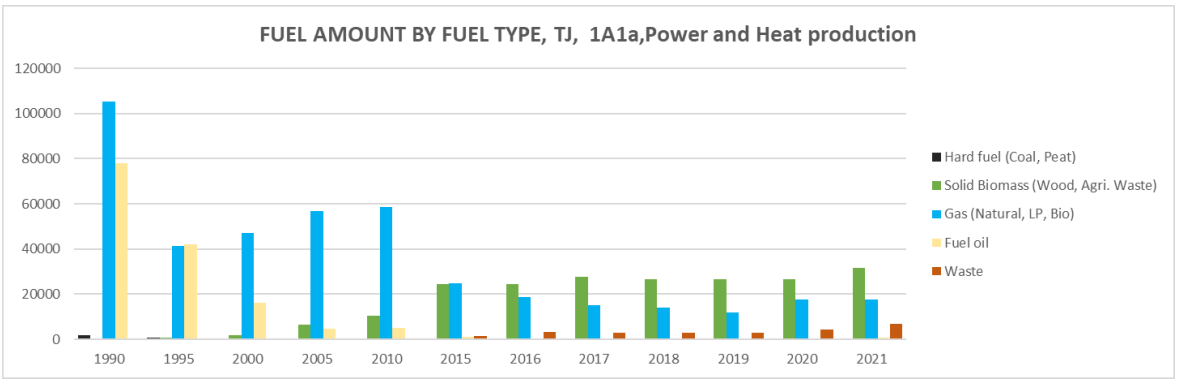


Figure 10. Fuel amount by fuel type, 1A1a

Total fuel consumption in the sector 1A1a in 2021 decreased by 20,5% as compared with 2005 (-69,3% versus 1990). But in the period 2013 – 2021, annual fuel consumption in 2021 was biggest: the increase by 3,5% versus 2013, by 36,5% versus 2019 and by 16,4% versus 2020.

1.1.2. Heavy fuel oil combustion and air pollutant emission factors

Categories of heavy fuel oil used in Lithuania in the 1A1a (1990-2021) are residual fuel oil (mazut), orimulsion and emulsified vacuum residue. Mazut was combusted in the Combined Heat and Power (CHP) Systems in the LCP (boilers > 50 MW) and in the Public Heating

Plants (MCP (boilers 1-50 MW)). Mazut that was combusted in the petroleum refinery power plant in 1990-2004 is included in the 1A1a, from 2005 it is included in the 1A1b sector. Orimulsion and emulsified vacuum residue was used in the Combined Heat and Power (CHP) Systems in the LCP (boilers > 50 MW).

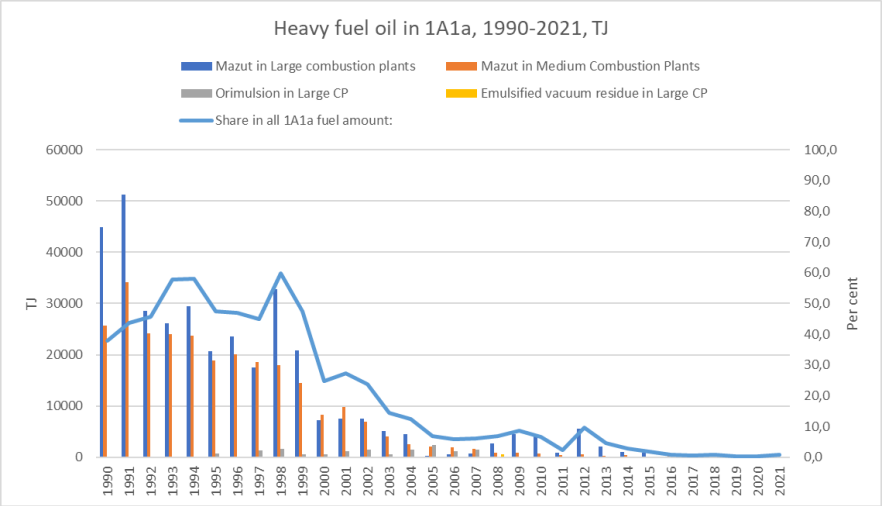


Figure 11. Usage of heavy fuel oil in 1A1a

The amount of mazut in 2021 was 444 TJ (-81% vs 2005, -99% vs 1990). Usage of other heavy fuel oil ceased in 2008.

SO2 emissions from heavy fuel oil combustion. Data on SO2 emissions were taken from the combustion plant operators air pollution reports.

NOx emission factors for heavy fuel combustion in period 1990-2021 for large combustion plants are adjusted according to the former Large combustion plant directive requirements. For years 1990-1998 emission factor (g/GJ) value 142 was taken from the Table 3-11 (GB2019, Chapter 1A1a). For later years the following values were applied: 1999-2003 120, 2004-2007 95, from 2008 80. NOx emission factors for mazut combustion in the medium combustion plants were taken from the Table 3-25 (GB2019, Chapter 1A4).

PM emission factors for heavy fuel combustion in period 1990-2021 are adjusted according to the former Large combustion plant directive requirements.

Pollutant	*1990-2007*	*2008-2018*	*from 2019*
TSP	35,4	14,2	8,9
PM10	25,2	10,1	6,3
PM2.5	19,3	7,7	4,8

Figure 12. PM emission factors (g/GJ) for heavy fuel combustion.

Heavy fuel combustion in LCP PM emission factors for period 1990-2007 were taken from the Table 3-11 (GB2019, Chapter 1A1a); for MCP PM emission factors were taken from the Table 3-25 (GB2019, Chapter 1A4).

Emission factors of other pollutants for heavy fuel combustion in LCP were taken from the Table 3-11 (GB2019, Chapter 1A1a), for combustion in MCP - from the Table 3-25 (GB2019, Chapter 1A4) and applied without any abatement.

1.1.3. Light fuel oil combustion and air pollutant emission factors

Light fuel oil (diesel, gasoil, shale oil) mainly was used in 1990-1999. From 2000, usage is insignificant. Emission factors from the Table 3-24 (GB2019, Chapter 1A4) (SO2 - Table 4.1 , GB2019, chapter 1A4) were used to evaluate emissions from this source.

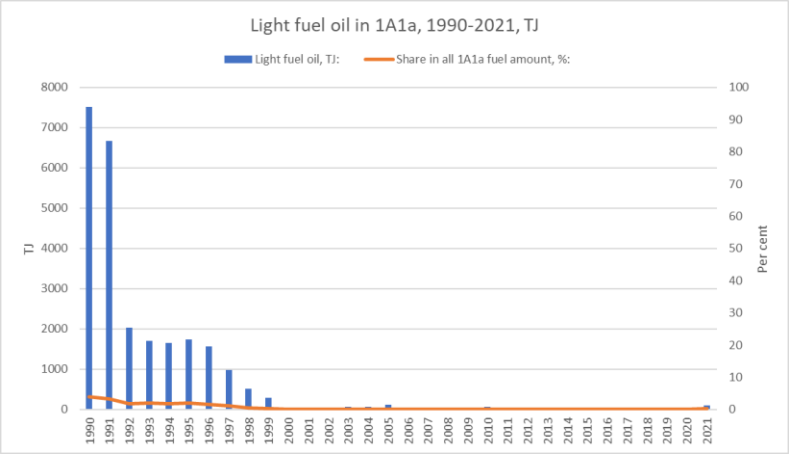


Figure 13. Light fuel oil usage in 1A1a

1.1.4 Coal and peat fuel combustion and air pollutant emission factors

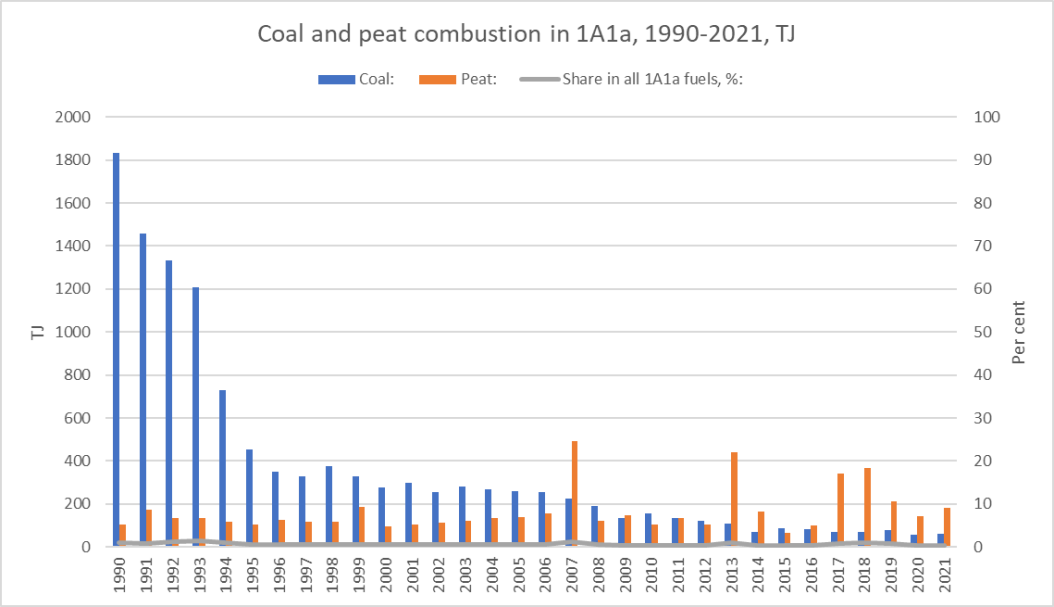


Figure 14. Coal and peat combustion in 1A1a

The amount of coal combusted in 2021 was 61 TJ (decreased by 77% vs 2005, by 97% vs 1990). Peat combustion in 2021 (181 TJ) increased by 32% compared to 2005, and by 71% compared to 1990. Emissions of pollutants (except SO2, NH3) for the period 1990-2017 were estimated using the emission factors from the Table 3.22 "Tier 2 emission factors for non-residential sources, manual boilers burning coal fuels" (GB2019, chapter 1A4). From 2018, the emission factors from the Table 3.23 "Tier 2 emission factors for non-residential sources, automatic boilers burning coal fuels" (GB2019, chapter 1A4) were used following the recommendations of the national emission factors research. Emission factor (g/GJ) for NH3 is 8 and is taken from the IIASA TSAP 16 Underlying assumptions - GAINS details database. SO2 emission factor for peat was 300 g/GJ (Lithuania's national EF), for coal were as follows:

Fuel:	*Bituminous coal*	
	1990-2002	from 2003
Sulfur,%	1,82	0,3
Calorific value, GJ/tonne	25	25
SO2 EF, g/GJ	1449	239
Fuel:	*Subbituminous coal*	
	1990-2002	from 2003
Sulfur,%	1,82	0,3
Calorific value, GJ/tonne	23	23
SO2 EF, g/GJ	1604	264

Figure 14a. SO2 emission factors for coal.

The method described in the GB2019, chapter 1A4, page 100, was used to evaluate the SO2 EF.

1.1.5 Biogas combustion and air pollutant emission factors

Biogas combustion in the 1A1a sector started in 2002. This fuel is used in the stationary internal combustion engines of the small-scale Combined Heat and power systems. Usage of biogas has grown rapidly from 2010.

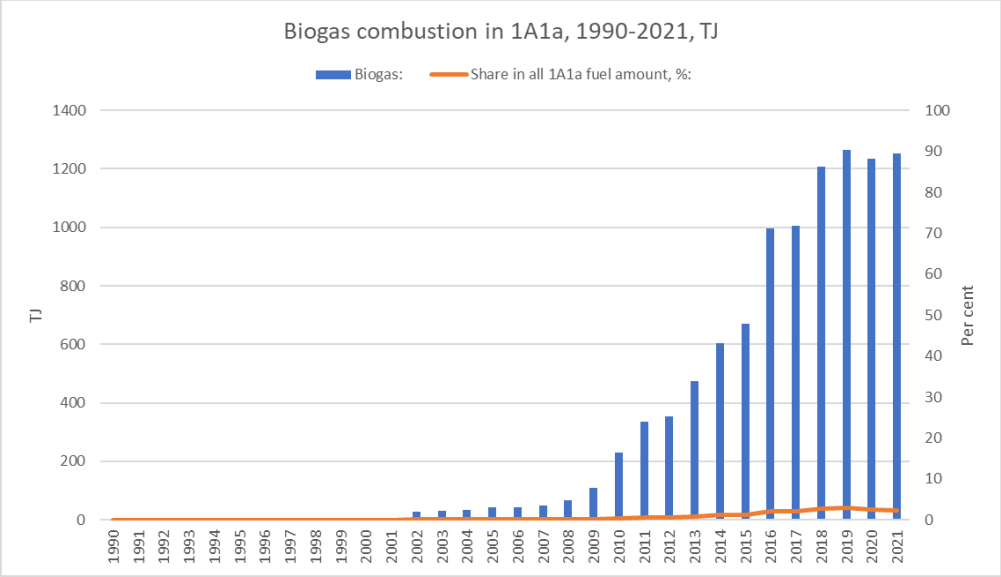


Figure 15. Biogas combustion in 1A1a, TJ

The emission factors from the Table 3.30 „Tier 2 emission factors for non-residential sources, reciprocating engines burning gas fuels“ (GB2019, chapter 1A4) were used for calculation of air pollutant emissions.

1.1.6. Solid biomass combustion and air pollutant emission factors

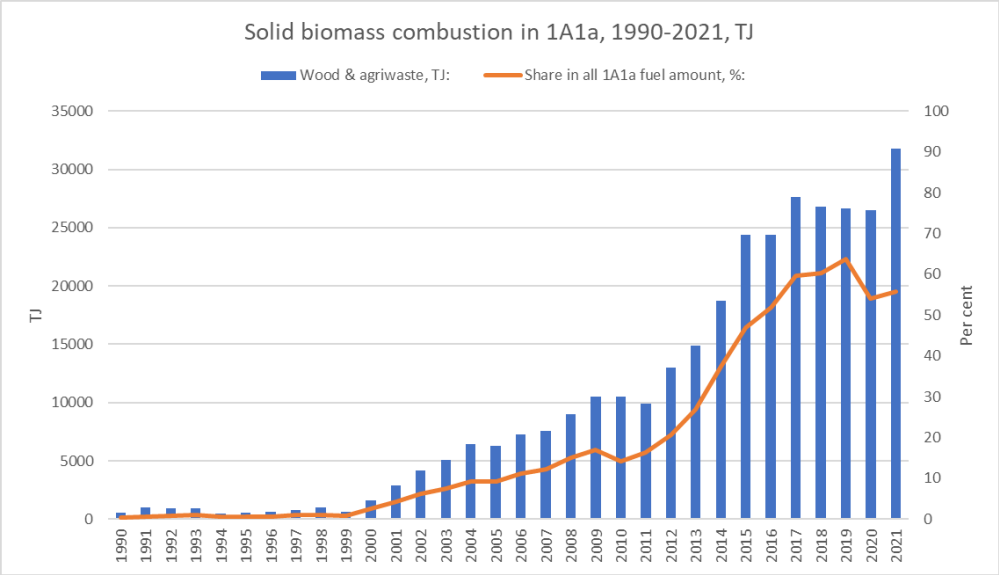


Figure 16. Solid biomass combustion in 1A1a, TJ

Scenario:		*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*
Years:		*1990*	*1995*	*1996*	*2000*	*2005*	*2010*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Sector:	1A1a													
Fuel:	Wood & Agriwaste													
Combustion devices:	All devices													
Amount, TJ:		527	558	648	1640	6289	10509	24400	24409	27645	26770	26616	26522	31792
Sector:	1A1a, CHP													
Fuel:	Wood & Agriwaste													
Combustion devices:	LCP (all devices are LCP)													
Amount, TJ:		0	0	0	0	191	2472	6365	5771	7009	7327	7268	7665	7881
Sector:	1A1a, HP													
Fuel:	Wood & Agriwaste													
Combustion devices:	All devices (Boilers 0,05-50 MW)													
Amount, TJ:		527	558	648	1640	6098	8037	18035	18638	20636	19443	19348	18857	23911

Figure 17. Solid biomass combustion in 1A1a by subsectors, TJ

Solid biomass combustion in Combines Heat and Power plants. All these plants were assumed to be large combustion plants. The former LCP directive regulates NOx and PM emission standards for this group of boilers. According to the Pollution Permits, NOx emission limit values till 2019 were 400 mg/m3 (corresponding EF was 108 g/GJ), from 2019 ELV are 300 mg/m3 (corresponding EF is 81 g/GJ); TSP emission limit values till 2019 were 50 mg/m3 (corresponding TSP EF was 6.88 g/GJ, PM10 EF was 6.2 g/GJ, PM2.5 EF was 5.32 g/GJ,), from 2019 ELV are 30 mg/m3 (corresponding TSP EF is 3.44 g/GJ, PM10 EF was 3.1 g/GJ, PM2.5 EF was 2.66 g/GJ). These NOx and PM emission factors were derived according to the methods provided in Annex D and Annex E (GB2019, chapter 1A1a). The emission factors of CO, NMVOC, SO2, POPs were taken from the Table 3-13 „Tier 2 emission factors for source category 1.A.1.a, dry bottom boilers using wood waste“ (GB2019, Chapter 1A1a) The emission factors of heavy metals provided in the above mentioned table were reduced according to particulate matter abatement efficiency.

Solid biomass combustion in Heating plants. The details on emission factors are provided in the paragraph "General methodological issues for stationary non-residential fuel combustion in Medium Combustion Plants". The emission factors for 0,05-1 MW boilers (except NOx) were taken from the Table 3.46, GB2019, chapter 1A4. NOx EF was taken from the Table 3.45, GB2019, chapter 1A4, because in Lithuania NOx ELV for 0,05-1 MW boilers is the same as for the 1-50 MW boilers.

Scenario:		*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*	*Historical*
Years:		***1990***	***1995***	***2000***	***2005***	***2010***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***	***2021***
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '0,05-1 MW												
Amount, TJ:		527	558	617	617	617	617	931,9	1031,8	972,15	967,4	942,85	1195,55
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '1-5 MW												
Amount, TJ:		0	0	1023	2250	2250	2250	1863,8	2063,6	1944,3	1934,8	1885,7	2391,1
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '1-5 MW												
Installation date:	after 20.12.2018												
Compliance to MCP dir.	Yes												
Amount, TJ:		0	0	0	0	0	0	0	0	0	193,48	282,855	478,22
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '1-5 MW												
Installation date:	01.07.1998-20.12.2018												
Compliance to MCP dir.	No												
Amount, TJ:		0	0	1023	2250	2250	2250	1863,8	2063,6	1944,3	1677,886	1539,411	1786,013
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '1-5 MW												
Installation date:	01.07.1998-20.12.2018												
Compliance to MCP dir.	Yes												
Amount, TJ:		0	0	0	0	0	0	0	0	0	63,43365	63,43365	126,8673
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '5-20 MW												
Amount, TJ:		0	0	0	2885,97	5555,92	8225,87	8759,86	9698,92	9138,21	9093,56	8862,79	11238,17
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '5-20 MW												
Installation date:	after 20.12.2018												
Compliance to MCP dir.	Yes												
Amount, TJ:		0	0	0	0	0	0	0	0	0	909,356	1329,419	2247,634
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '5-20 MW												
Installation date:	01.07.1998-20.12.2018												
Compliance to MCP dir.	No												
Amount, TJ:		0	0	0	2885,97	5555,92	8225,87	8759,86	9698,92	9138,21	7884,204	6754,796	7433,386
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '5-20 MW												
Installation date:	01.07.1998-20.12.2018												
Compliance to MCP dir.	Yes												
Amount, TJ:		0	0	0	0	0	0	0	0	0	300	778,575	1557,15
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '20-50 MW												
Amount, TJ:		0	0	0	1406,922	3986,703	6566,484	7082,44	7841,68	7388,34	7352,24	7165,66	9086,18
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '20-50 MW												
Installation date:	after 20.12.2018												
Compliance to MCP dir.	Yes												
Amount, TJ:		0	0	0	0	0	0	0	0	0	735,224	1074,849	1817,236
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '20-50 MW												
Installation date:	01.07.1998-20.12.2018												
Compliance to MCP dir.	No												
Amount, TJ:		0	0	0	1406,922	3986,703	6566,484	7082,44	7841,68	7388,34	6077,456	5011,692	5650,265
Sector:	1A1a, HP												
Fuel:	Wood & Agriwaste												
Combustion devices:	Boilers '20-50 MW												
Installation date:	01.07.1998-20.12.2018												
Compliance to MCP dir.	Yes												
Amount, TJ:		0	0	0	0	0	0	0	0	0	539,5596	1079,119	1618,679

Figure 18. Solid biomass combustion in 1A1a, Heating plants, by boiler capacity, installation date and compliance to MCP directive, TJ

LPG (Liquified Petroleum Gas) combustion and air pollutant emission factors

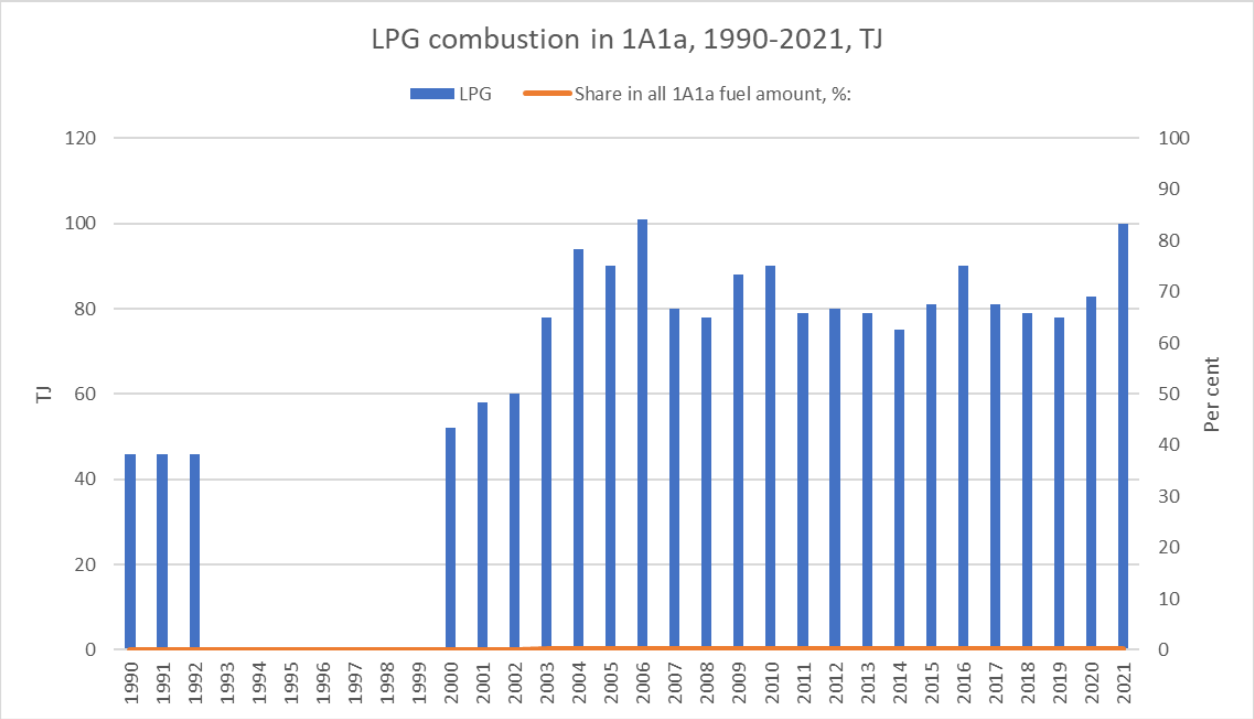


Figure 19. LPG (Liquified Petroleum Gas) combustion in 1A1a, TJ

Emission factors from the Table 3.26 “Tier 2 emission factors for non-residential sources, medium-sized (> 50 kWth to ≤ 1 MWth) boilers burning natural gas” (GB2019, chapter 1A4) were used.

Natural Gas combustion and air pollutant emission factors

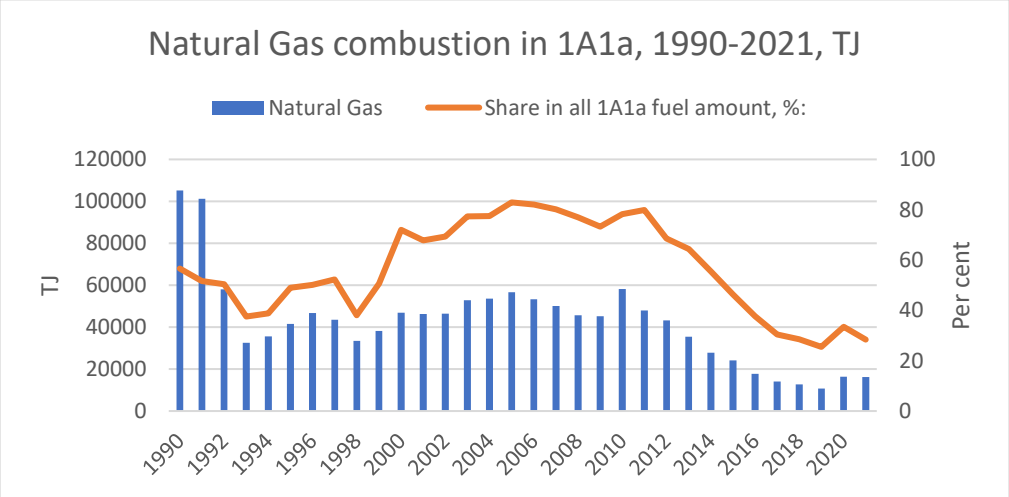


Figure 20. Natural Gas combustion in 1A1a, TJ

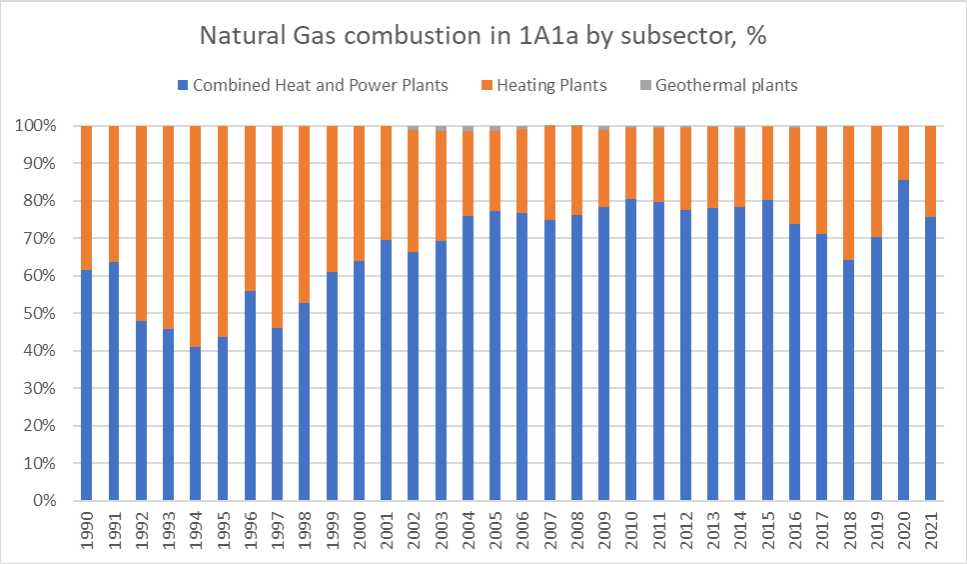


Figure 21. Natural Gas combustion in 1A1a by subsector

Natural gas in the geothermal plants were combusted in the stationary reciprocating engines. Emission factors from the Table 3.30 "Tier 2 emission factors for non-residential sources, reciprocating engines burning gas fuels" (GB2019, Chapter 1A4) were used.

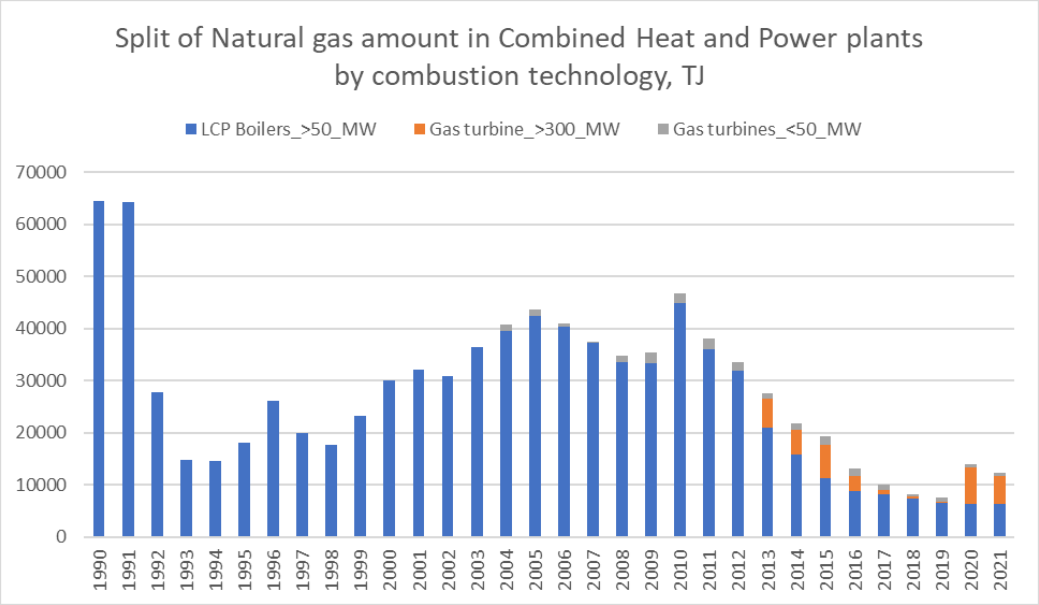


Figure 22. Split of Natural gas amount in Combined Heat and Power plants by combustion technology

The former LCP directive regulates natural gas NOx emission standards for boilers with capacity > 50 MW. According to the Pollution Permits, NOx emission limit value till 01.01.2008 was 350 mg/m3 (the corresponding EF was 89 g/GJ), in the period 01.01.2008-01.01.2019 ELV was 300 mg/m3 (EF was 76 g/GJ), from 01. 01.2019: ELV is 100 mg/m3 (EF is 25 g/GJ). These NOx emission factors were derived according to the methods provided in Annex D and Annex E (GB2019, chapter 1A1a). The emission factors of PM, CO, NMVOC, SO2, POPs, HM were

taken from the Table 3-12 „Tier 2 emission factors for source category 1.A.1.a, dry bottom boilers using natural gas“ (GB2019, Chapter 1A1a)

According to the LCP directive, NOx emission standard (ELV) for gas turbine with capacity > 300 MW is 50 mg/M3 (EF is 43 g/GJ). This NOx EF value was obtained from the Table D4 in GB2019, chapter 1A1, page 86. Emissions of other air pollutants from natural gas combustion in gas turbine with capacity > 300 MW were calculated on the basis of emission factors taken from the Table 3-17 „Tier 2 emission factors for source category 1.A.1.a, gas turbines using gaseous fuels“ (GB2019, chapter 1A1).

Natural Gas combustion in 1A1a Heating plants occured in 0,05-50 MW boilers. From the data obtained from Environmental information system (in lith. AIVIKS) natural gas distribution by boiler capacity was estimated: 5% in boilers 0,05-1 MW, 50% in boilers 1-5 MW, 45% in boilers 5-50 MW. NOx emissions were estimated on the basis of the principles in the „General methodological issues for stationary non-residential fuel combustion in Medium Combustion Plants”. The emission factors for other pollutants were taken from the Table 3.27 “Tier 2 emission factors for non-residential sources, medium sized (> 1 MWth to ≤ 50 MWth) boilers burning natural gas” (GB2019, chapter 1A4).

Waste combustion and air pollutant emission factors

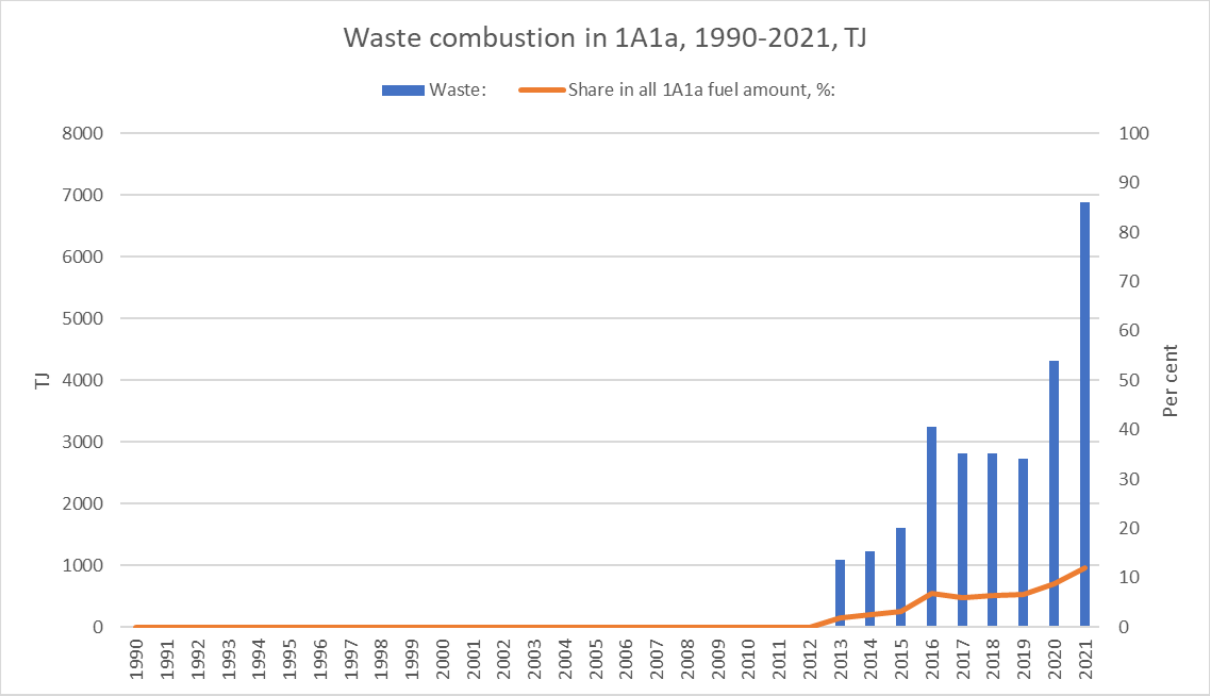


Figure 23. Waste combustion in 1A1a

NOx average emission limit value (ELV, mg/m3) in the pollution permits for waste combustion in 2013-2020 was 190 mg/m3 (corresponding EF was 1017 g/Mg waste), in 2021 emission limit value (ELV, mg/m3) was 170 (corresponding EF was 910 g/Mg waste). These NOx EF values were derived from the Table 3-1 “Tier 1 emission factors for source category 5.C.1.a

Municipal waste incineration" (GB2019, chapter 5.C.1.a Municipal waste incineration), assuming that NOx EF value provided in this table corresponds to the ELV (mg/m3) 200. Emission factors for other pollutants were taken from the same table.

Air pollutant emissions in 1A1a

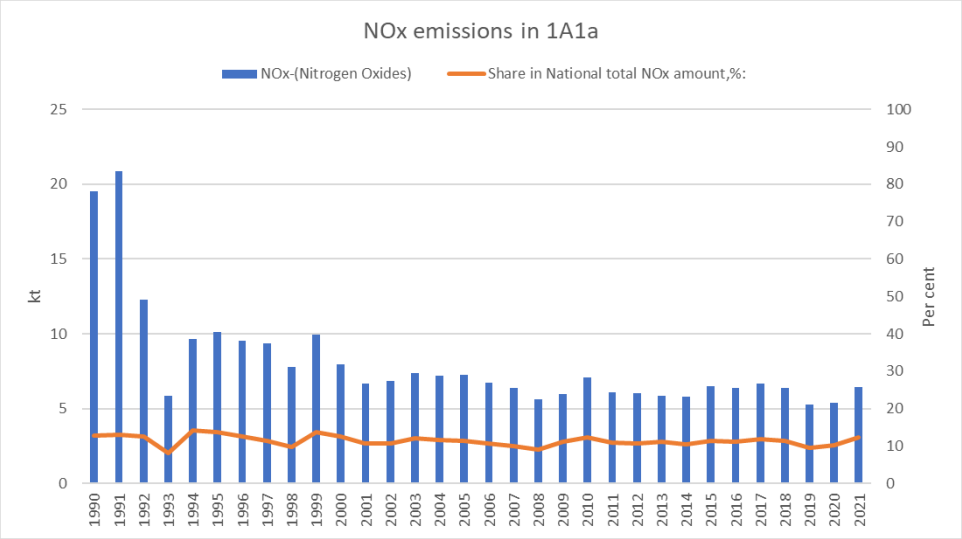


Figure 24a. NOx emissions in 1A1a

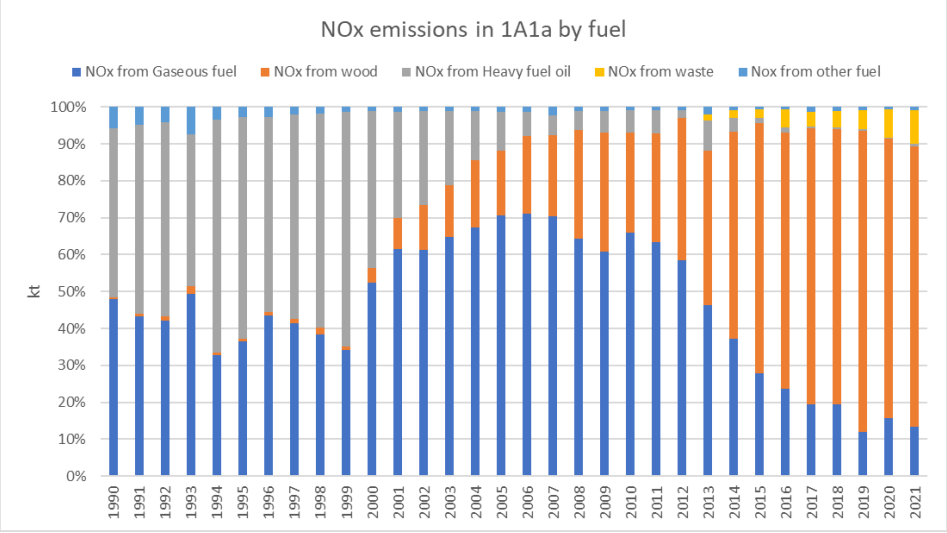


Figure 24b. NOx emissions in 1A1a by fuel

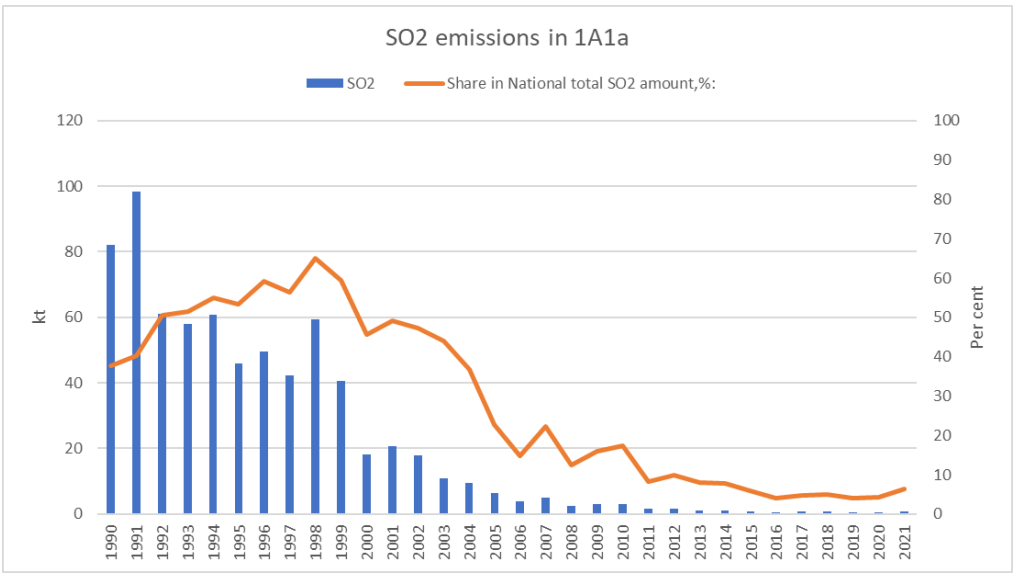


Figure 25. SO2 emissions in 1A1a

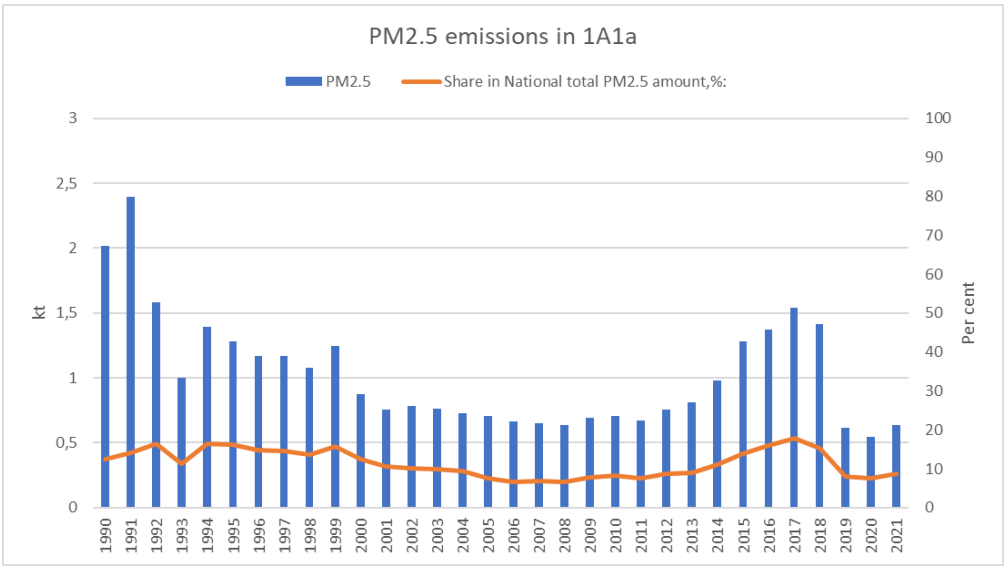


Figure 26a. PM2.5 emissions in 1A1a

The significant drop of PM2.5 emissions from the 2019 occurred due to the facts that some new wood combustion devices were installed complying MCP directive and for the old 1-50 MW wood boilers emission factors derived from the national EF research results were applied.

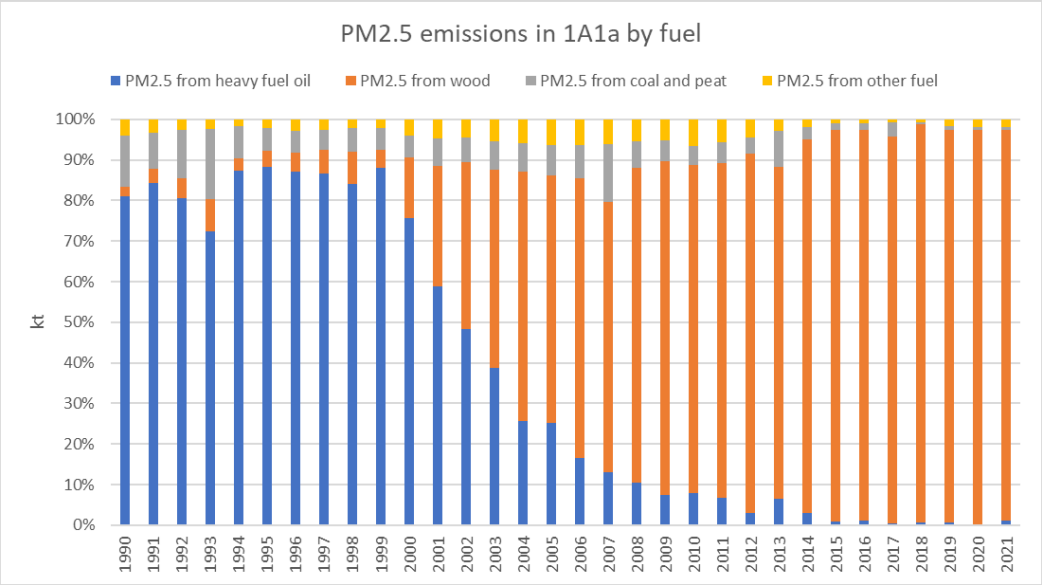


Figure 26b. PM2.5 emissions in 1A1a by fuel.

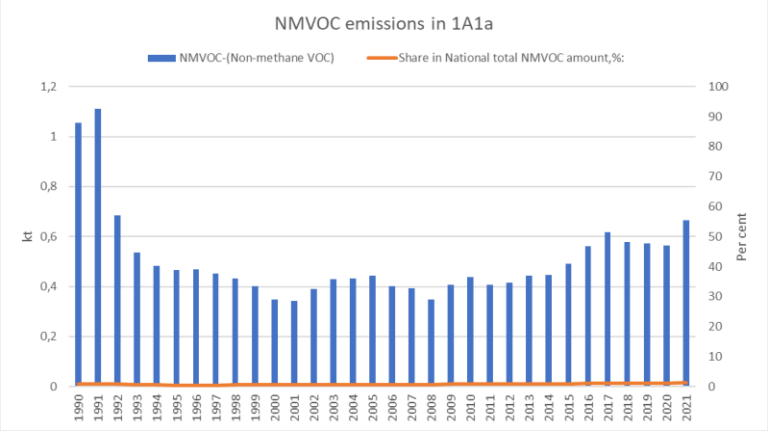


Figure 27. NMVOC emissions in 1A1a.

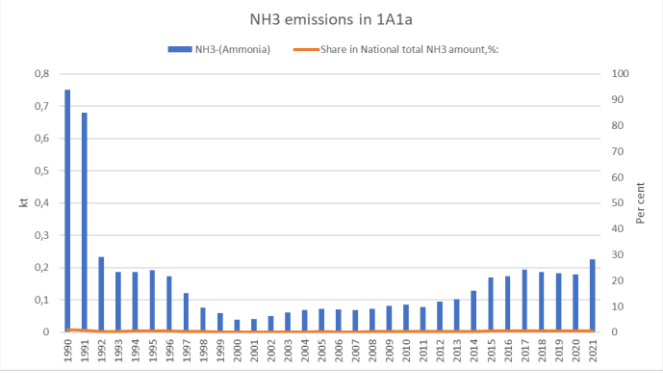


Figure 28. NH3 emissions in 1A1a

1.2. Fuel combustion in the 1A1b (Petroleum refining)

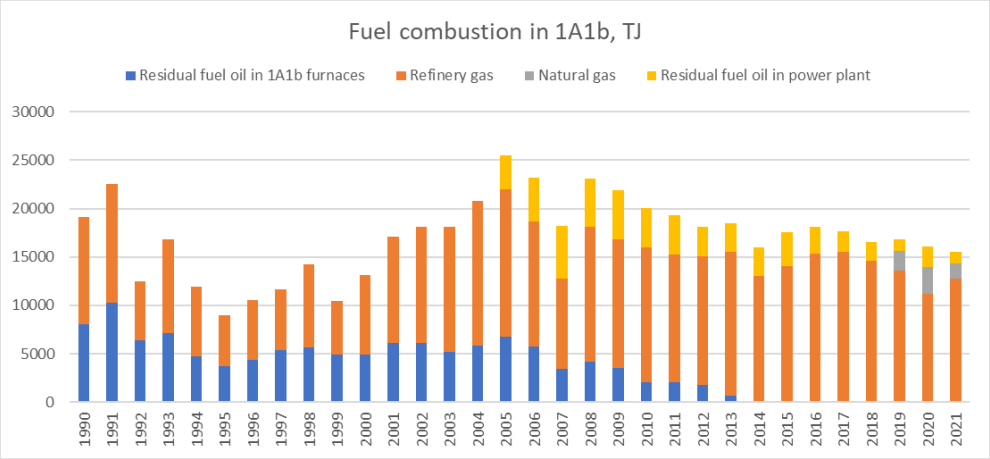


Figure 29. Fuel combustion in 1A1b

From 2005, fuel combusted in the oil refinery power plant is included in 1A1b (1990-2004 it was included in the 1A1a). Natural gas from 2019 is used in the oil refinery power plant.

Emissions of NOx, SO2, PM were taken from the refinery plant operator reports. Emissions of other pollutants (CO, NMVOC, POPs, HM) were calculated by the following method:

Fuel	***Industrial process***	***EF Table***
Residual fuel oil	Combustion in refinery power plant	GB2019, chapter 1A1, Table 3-11 "Tier 2 emission factors for source category 1.A.1.a, dry bottom boilers using residual oil"
Residual fuel oil	1A1b Process Furnaces, Heaters and Boilers	GB2019, chapter 1A1, Table 4-4 "Tier 2 emission factors for source category 1.A.1.b, process furnaces using residual oil"
Natural gas	Combustion in refinery power plant	GB2019, chapter 1A1, Table 3-12 "Tier 2 emission factors for source category 1.A.1.a, dry bottom boilers using natural gas"
Refinery gas	Combustion in refinery power plant; 1A1b Process Furnaces, Heaters and Boilers	GB2019, chapter 1A1, Table 4-2 "Tier 1 emission factors for source category 1.A.1.b, refinery gas"

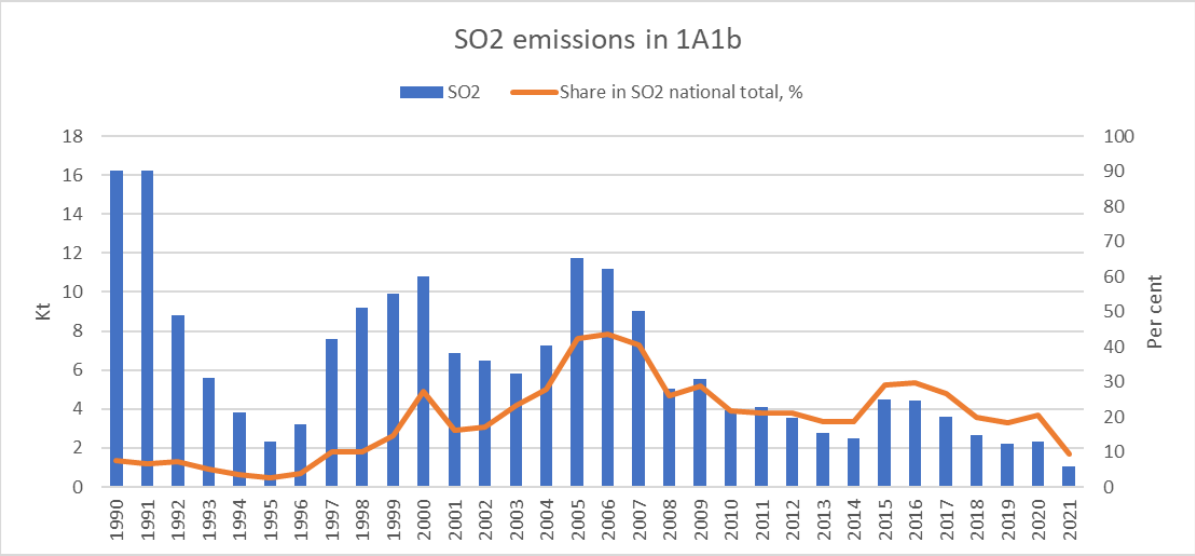


Figure 30. SO2 emissions in 1A1b

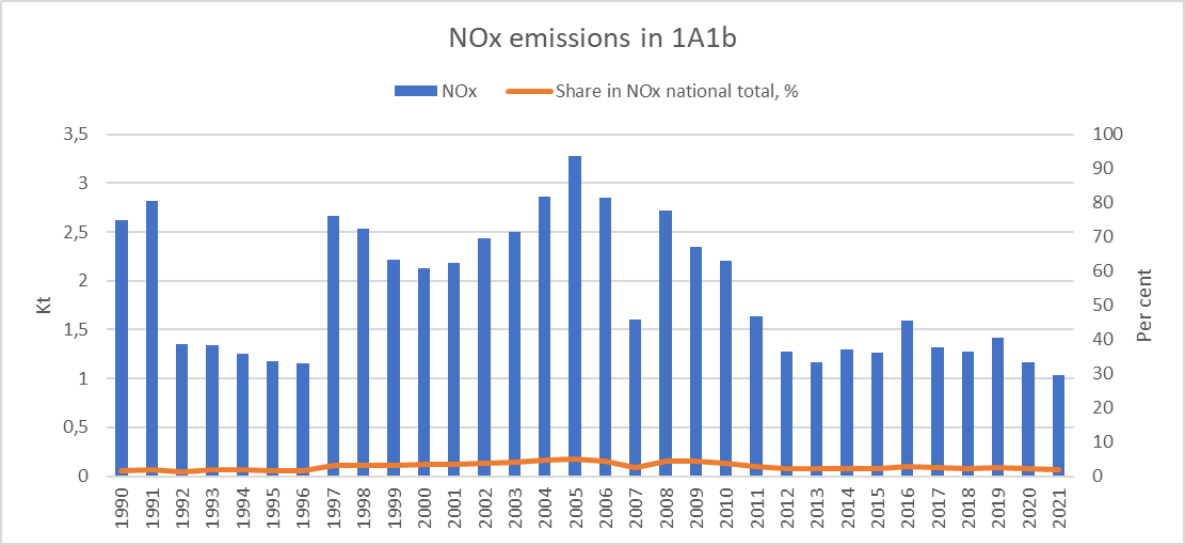


Figure 31. NOx emissions in 1A1b

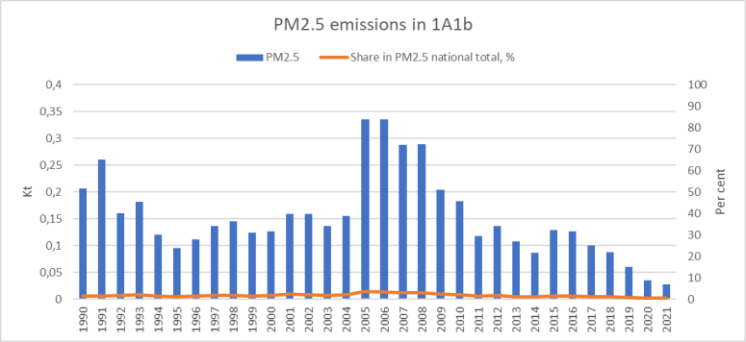


Figure 32. PM2.5 emissions in 1A1b

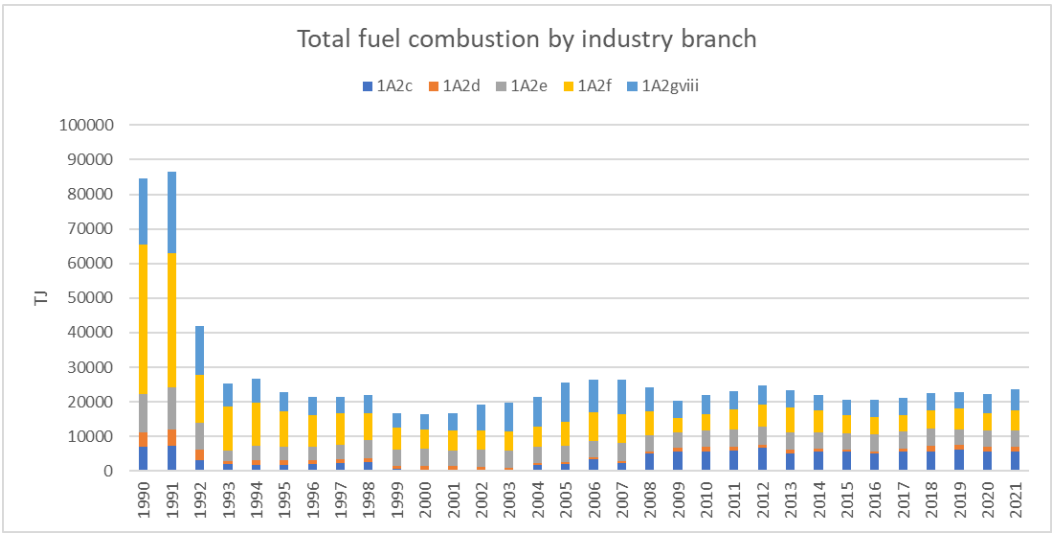
1.3. Manufacture of solid fuels and other energy industries (1A1c)

Combustion of natural gas in stationary reciprocating engine in the Floating Storage Regasification Unit (FSRU) at the Liquefied Natural Gas (LNG) terminal in Klaipeda is the main source of air pollution in this NFR sector.

1.4. Stationary fuel combustion in the 1A2 (Manufacturing industries and construction)

The Statistics Lithuania fuel balance was used as the activity data for calculation of the historical emissions (1990-2021).

All fuel by industry, PJ	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
1A2c	6,88	1,84	0,21	2,03	5,61	5,66	4,98	5,58	5,70	6,17	5,58	5,63
1A2d	4,27	1,16	1,27	0,45	1,30	0,55	0,71	0,85	1,54	1,47	1,33	1,30
1A2e	11,13	3,89	4,83	4,75	4,71	4,77	4,86	4,86	4,89	4,44	4,77	4,75
1A2f	43,19	10,24	5,69	6,89	4,83	5,26	4,99	4,73	5,43	5,87	5,07	5,83
1A2gviii	19,22	5,59	4,32	11,43	5,61	4,47	5,13	5,08	5,01	4,90	5,43	6,01



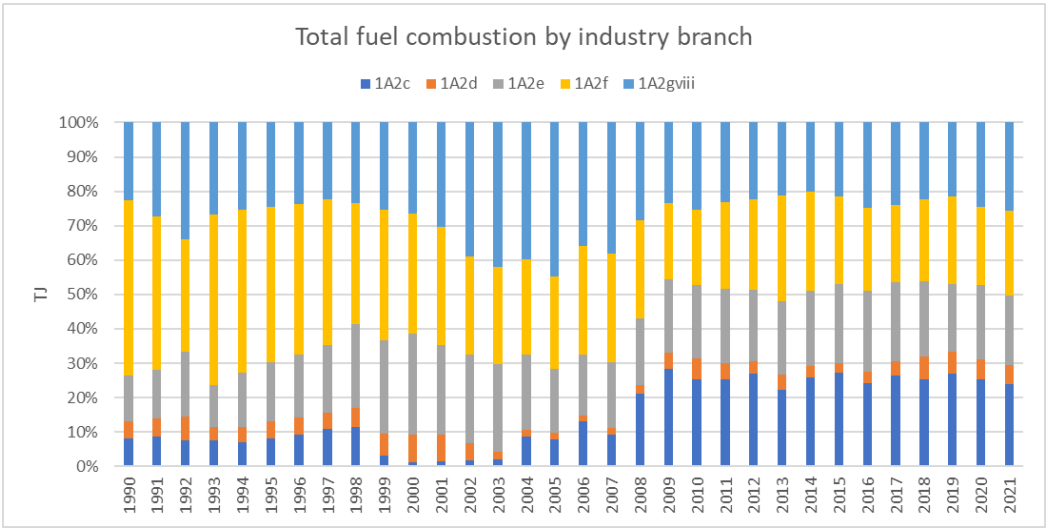


Figure 33. Fuel consumption by industry branch

Heavy fuel oil combustion and air pollutant emission factors

Heavy fuel oil, PJ	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
1A2c	0,88	0,28	0,02	0,00	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1A2d	0,88	0,40	0,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1A2e	2,25	1,61	1,57	0,33	0,21	0,27	0,27	0,29	0,18	0,24	0,25	0,17
1A2f. clinker prod.	19,11	3,71	3,03	0,98	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1A2f. other activities	16,33	4,08	0,49	0,20	0,11	0,06	0,05	0,09	0,01	0,02	0,02	0,03
1A2gviii	5,58	1,65	0,45	0,30	0,11	0,05	0,04	0,05	0,02	0,02	0,02	0,01

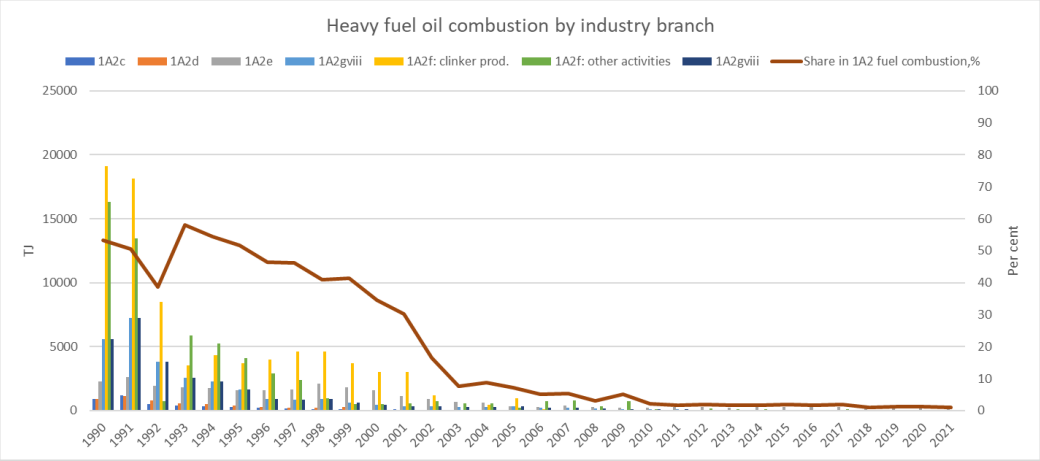


Figure 34. Heavy fuel oil consumption by industry branch

For heavy fuel oil combustion (apart clinker production) the emission factors were taken from the Table 3-25 " Tier 2 emission factors for non-residential sources, medium sized (> 1 MWth to ≤ 50 MWth) boilers liquid fuels "(GB2019, Chapter 1A4).

Gaseous fuel combustion and air pollutant emission factors

Gaseous fuel, PJ	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004		
1A2c: Natural Gas in gas turbines	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00		
1A2c: Gaseous in boilers	6,00	6,24	2,69	1,52	1,54	1,56	1,76	2,16	2,37	0,43	0,19	0,19	0,25	0,36	1,85		
1A2d	3,39	3,54	2,15	0,44	0,66	0,75	0,78	0,78	0,97	0,76	1,20	1,24	0,93	0,46	0,40		
1A2e	8,50	8,99	5,48	0,96	2,19	2,08	1,92	2,36	2,77	2,47	3,01	3,05	3,86	4,10	3,81		
1A2f	6,93	5,77	2,82	1,51	1,65	1,83	1,89	1,72	1,74	1,74	1,78	1,85	1,29	1,29	1,19		
1A2gviii	12,37	14,96	9,20	3,33	3,32	2,96	2,55	2,65	2,74	2,39	2,64	3,00	4,08	4,43	4,39		
Gaseous fuel, PJ	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1A2c: Natural Gas in gas turbines	0,00	1,96	0,85	0,07	0,90	0,90	1,30	2,99	1,53	2,36	2,77	2,42	2,29	1,63	3,08	2,73	2,36
1A2c: Gaseous in boilers	2,03	1,46	1,57	5,04	4,82	4,67	4,54	3,72	3,67	3,35	2,82	2,44	2,69	3,61	2,64	2,40	2,81
1A2d	0,45	0,39	0,48	0,61	0,90	1,18	0,93	0,78	0,79	0,48	0,39	0,52	0,59	0,75	0,68	0,56	0,53
1A2e	3,85	4,08	4,45	4,15	3,85	4,21	4,50	4,64	4,41	3,75	3,62	3,77	3,74	4,03	3,61	3,72	3,72
1A2f	1,62	1,70	1,79	1,55	0,82	0,91	1,01	1,01	0,95	0,96	0,95	1,06	0,99	1,00	0,96	0,91	0,94
1A2gviii	7,44	5,70	6,41	3,68	2,29	2,81	2,64	2,33	2,09	1,97	1,83	2,35	2,47	2,56	2,36	2,37	2,83

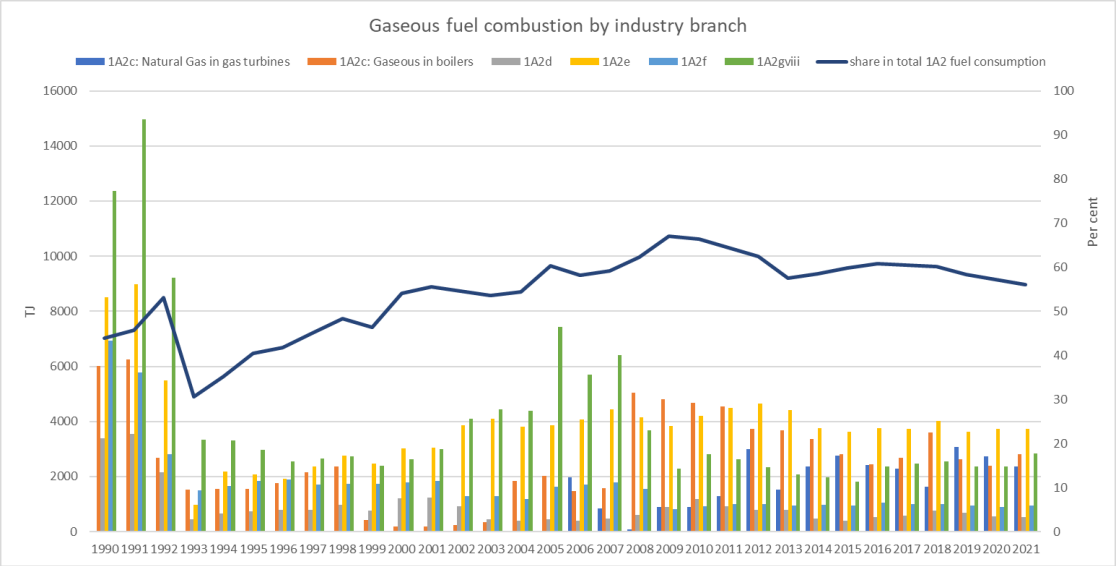


Figure 35. Gaseous fuel consumption by industry branch

For natural gas combustion in gas turbines, EFs from Table 3.28 „Tier 2 emission factors for non-residential sources, gas turbines burning natural gas“ (GB2019, chapter 1A4) were used.

Natural Gas combustion in 1A2 also was performed in 0,05-50 MW boilers. From the data obtained from Environmental information system (in lith. AIVIKS) natural gas distribution by boiler capacity was estimated: 5% in boilers 0,05-1 MW, 50% in boilers 1-5 MW, 45% in boilers 5-50 MW. NOx emissions were estimated on the basis of the principles in the „General methodological issues for stationary non-residential fuel combustion in Medium Combustion Plants”. The emission factors for other pollutants were taken from the Table 3.27 “Tier 2 emission factors for non-residential sources, medium sized (> 1 MWth to ≤ 50 MWth) boilers burning natural gas” (GB2019, chapter 1A4).

Coal combustion and air pollutant emission factors

Solid fuel (coal, coke, peat) combustion, PJ	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*		
1A2c	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000		
1A2d	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000		
1A2e	0,352	0,452	0,402	0,276	0,201	0,151	0,100	0,076	0,302	0,217	0,173	0,137	0,160	0,148	0,112		
1A2f: coal in clinker prod.	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	2,920	2,926		
1A2f: other activities	0,793	1,460	1,681	1,556	1,253	0,552	0,438	0,229	0,260	0,211	0,233	0,225	2,048	0,244	0,256		
1A2gviii	0,829	0,980	0,954	0,401	0,302	0,251	0,343	0,431	0,231	0,263	0,132	0,088	0,079	0,091	0,102		
Solid fuel (coal, coke, peat) combustion, PJ	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
1A2c	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1A2d	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1A2e	0,119	0,105	0,098	0,063	0,089	0,107	0,113	0,109	0,116	0,127	0,088	0,101	0,112	0,094	0,073	0,098	0,075
1A2f: coal in clinker prod.	2,970	4,653	5,319	4,259	2,918	3,021	3,615	4,109	4,854	4,098	3,319	2,898	2,810	3,327	3,857	3,138	3,756
1A2f: other activities	0,409	0,589	0,589	0,417	0,246	0,491	0,640	0,741	0,719	0,672	0,595	0,643	0,612	0,536	0,479	0,454	0,518
1A2gviii	0,175	0,175	0,149	0,111	0,070	0,077	0,087	0,086	0,077	0,093	0,054	0,057	0,069	0,067	0,053	0,021	0,019

Figure 36. Solid fuel consumption by industry branch

For solid fuel combustion (apart clinker production) the emission factors were taken from the Table 3.21 “ Tier 2 emission factors for non-residential sources, medium-size (> 1 MWth to ≤ 50 MWth) boilers burning coal fuels “(GB2019, Chapter 1A4).

Clinker production and air pollutant emission factors

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004		
Clinker production, mln. t	3,058	2,855	1,366	0,656	0,691	0,568	0,586	0,668	0,753	0,632	0,540	0,517	0,524	0,526	0,633		
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Clinker production, mln. t	0,729	0,956	0,966	0,842	0,522	0,536	0,602	0,730	0,855	0,754	0,963	0,852	0,839	0,952	1,074	1,039	1,059

Emissions of NOx and SO2 were provided by the cement plant operator. Emissions of other pollutants were estimated using EFs from the Table 3-24 “Tier 2 emission factors for source category 1.A.2.f.i, Cement production” (GB2019, chapter 1.A.2).

Biomass combustion and air pollutant emission factors

Wood, PJ	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1A2c	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
1A2d	0,003	0,004	0,003	0,003	0,004	0,005	0,004	0,004	0,002	0,002	0,001	0,030	0,025	0,007	0,000	0,000
1A2e	0,036	0,047	0,034	0,067	0,046	0,057	0,078	0,082	0,093	0,059	0,077	0,043	0,049	0,071	0,112	0,297
1A2f	0,019	0,009	0,020	0,039	0,065	0,063	0,073	0,117	0,103	0,238	0,152	0,159	0,367	0,607	0,581	0,566
1A2gviii	0,446	0,310	0,342	0,534	0,857	0,736	0,832	0,881	1,209	0,950	1,088	1,699	2,941	3,480	3,622	3,370
Wood, PJ	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
1A2c	0,000	0,000	0,000	0,002	0,000	0,000	0,000	0,000	0,000	0,066	0,113	0,607	0,459	0,451	0,445	0,454
1A2d	0,000	0,001	0,000	0,085	0,128	0,140	0,086	0,217	0,215	0,161	0,195	0,258	0,778	0,792	0,765	0,762
1A2e	0,140	0,082	0,102	0,078	0,093	0,088	0,063	0,193	0,561	0,684	0,664	0,649	0,507	0,422	0,586	0,656
1A2f	0,469	0,528	0,501	0,360	0,345	0,502	0,463	0,455	0,429	0,266	0,302	0,166	0,471	0,449	0,439	0,457
1A2gviii	3,219	3,162	2,866	2,239	2,508	2,449	2,951	2,653	2,212	2,421	2,603	2,403	2,258	2,348	2,861	2,968

All wood in 1A2 was burned in boilers 0,05-50 MW. Details on EFs are provided in the paragraph “General methodological issues for stationary non-residential fuel combustion in Medium Combustion Plants”.

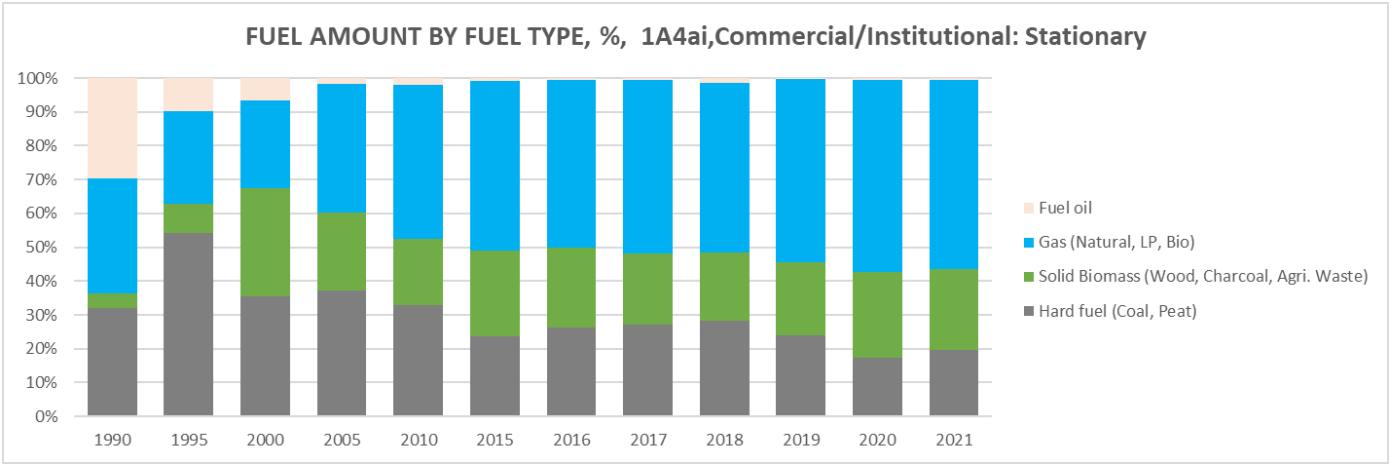
Light fuel oil combustion and air pollutant emission factors

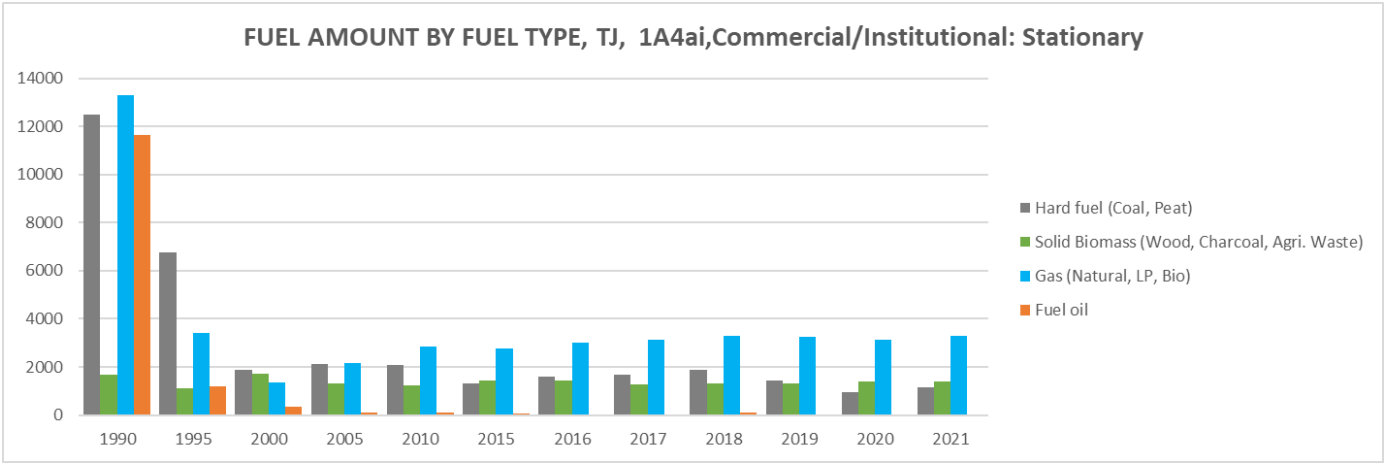
		Heating and other gasoil (with biofuels)		Shale oil and other distillates	
		Final consumption in industry	Final consumption in construction	Final consumption in industry	Final consumption in construction
Fuel commodities balances | TJ	2021	378	75		
	2020	328	64		
	2019	264	57		
	2018	232	54		
	2017	193	44		
	2016	138	39		
	2015	228	67		
	2014	286	80		
	2013	200	60		
	2012	240	63		
	2011	214	49		
	2010	220	47		
	2009	188	26		
	2008	233	33	27	
	2007	198	31	22	
	2006	240	22	40	
	2005	405	25	13	
	2004	127	30	5	
	2003	98	15		
	2002	13	5		
	2001	6			
	2000	7	7		
	1999	85	42		
	1998	85	42		
	1997	84			
	1996	633			
	1995				
	1994				
	1993				
	1992				
	1991				
	1990				

Emission factors from the Table 3-24 “Tier 2 emission factors for non-residential sources, medium-sized (> 50 kWth to ≤ 1 MWth) boilers liquid fuels” (GB2019, Chapter 1A4) (SO2 - Table 4.1 , GB2019, chapter 1A4) were used to evaluate emissions from this source.

1.5. Stationary fuel combustion in the 1A4ai,Commercial/Institutional: Stationary

FUEL AMOUNT BY FUEL TYPE													
NFR:	1A4ai,Commercial/Institutional: Stationary												
Scenario:	Historical												
Fuel data source	Fuel balance of Statistics Lithuania												
Amount unit	TJ												
Years:			1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021
All fuels			39104	12462	5307	5661	6300	5568	6051	6138	6591	6042	5519	5928
Hard fuel (Coal, Peat)			12473	6743	1884	2110	2064	1313	1584	1668	1869	1446	957	1171
Solid Biomass (Wood, Charcoal, Agri. Waste)			1699	1104	1703	1298	1244	1418	1431	1290	1332	1310	1404	1414
Fuel oil			11641	1204	356	91	123	51	33	40	100	22	29	33
Gas (Natural, LP, Bio)			13291	3411	1364	2162	2869	2786	3003	3140	3290	3264	3129	3310





IIASA GAINS model suggested fuel distribution by device type was used. The details on activity data for 1A4ai and applied emission factors can be found in the "NIIR Energy annex 1A4ai.xlsx"

1.6. Stationary fuel combustion in 1A4bi (residential)

FUEL STRUCTURE IN LITHUANIAN 1A4bi, PJ																
NFR:	1A4bi															
Data source:	Statistics Lithuania fuel balance															
Fuel	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*
Hard Coal / Akmens anglis, PJ	15,2	16,0	4,3	3,6	2,4	1,4	2,1	2,1	1,1	1,1	0,7	0,7	0,9	1,1	1,0	1,0
Peat / Durpės, PJ	0,1	0,1	0,2	0,3	0,3	0,3	0,3	0,5	0,5	0,5	0,3	0,2	0,3	0,4	0,4	0,5
Wood / Mediena, PJ	9,0	9,0	9,3	15,1	15,2	16,6	17,9	18,3	19,7	20,7	22,0	22,5	22,1	22,3	22,7	23,3
LPG / Susk. Naftos dujos, PJ	4,6	5,0	3,4	3,1	3,4	2,8	1,9	2,8	2,8	2,8	3,2	3,2	3,1	3,0	2,7	2,6
Natural Gas / Gamtinės dujos, PJ	9,2	14,2	11,5	11,3	8,7	7,7	7,6	6,2	5,2	4,5	4,4	4,5	4,6	4,9	5,3	5,6
Gasoil / Gazolis, PJ	0,1	0,0	0,2	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1
All fuel, PJ	38,3	44,4	28,9	33,4	30,0	28,8	29,9	29,8	29,2	29,5	30,5	31,2	31,0	31,7	32,0	33,1
Fuel	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Hard Coal / Akmens anglis, PJ	1,5	1,7	1,6	1,5	2,1	2,1	2,0	2,1	1,8	1,5	1,5	1,7	1,6	1,3	1,0	1,3
Peat / Durpės, PJ	0,5	0,4	0,5	0,5	0,6	0,7	0,8	0,8	0,6	0,5	0,6	0,7	0,8	0,6	0,4	0,5
Wood / Mediena, PJ	24,0	23,1	24,0	24,5	24,0	23,4	23,5	22,6	21,3	20,5	20,3	19,7	20,1	19,3	19,3	19,4
LPG / Susk. Naftos dujos, PJ	2,3	1,6	1,5	1,5	1,7	1,9	2,0	1,6	1,5	1,3	1,4	1,5	1,5	1,6	1,3	1,1
Natural Gas / Gamtinės dujos, PJ	5,9	6,2	6,1	6,1	6,6	6,1	5,7	5,2	5,0	5,1	6,1	6,4	6,9	6,7	7,3	9,2
Gasoil / Gazolis, PJ	0,0	0,0	0,1	0,1	0,3	0,4	0,5	0,4	0,5	0,4	0,6	0,8	0,8	0,9	0,9	1,1
All fuel, PJ	34,2	33,0	33,9	34,2	35,3	34,4	34,3	32,6	30,7	29,3	30,5	30,8	31,6	30,5	30,3	32,5

IIASA GAINS model and IIASA TSAP 16 Underlying assumptions - GAINS details.xlsx database suggested fuel distribution by device type was used. The details on activity data for 1A4bi and applied emission factors can be found in the "NIIR Energy annex 1A4bi.xlsx". Data on PM2.5 condensables is located in sheet "PM2.5 condensables". Lithuania does not include this fraction in the PM2.5 national inventory. For mobile combustion in households activity data (40 TJ) proposed by IIASA GAINS model was used.

1.7. Stationary fuel combustion in 1A4ci (agriculture)

Activity data were taken from fuel balance chapter "Fuel consumption in agriculture". Regarding emission factors please refer to "General methodological issues for stationary non-residential fuel combustion in Medium Combustion Plants"

2. Fugitive emissions from the fuels (1B)

1B1a Fugitive emission from solid fuels: Coal mining and handling

PM emissions from coal public storage were estimated. By the visual inspection it was estimated that open-stacked coal piles are about 3-3.5 meters high. The storage area was estimated from the amount of coal for the non-industrial use taken from the fuel balance of Statistics Lithuania. Coal for industrial use is stored in the covered premises and do not emmit PM to the atmosfere. The emission factors from the Table 3-4 „Tier 2 emission factors for source category 1.B.1.a Coal Mining and Handling,
Storage of coal, uncontrolled“ (GB2019, chapter 1.B.1.a Fugitive emissions from solid fuels: coal mining and handling) were used.

1B2ai Fugitive emissions oil: Exploration, production, transport

Crude oil production activity data are taken from fuel balance by Statistics Lithuania, emission factors were used as follows:

Table 3-3 Tier 2 emission factors for source category 1.B.2.a.i Exploration production, transport, Onshore facilities

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.i	Exploration production, transport			
Fuel	NA				
SNAP (if applicable)	050201	Land-based activities			
Technologies/Practices	Facilities producing oil only				
Region or regional conditions					
Abatement technologies					
Not applicable	NOx, CO, NH3, TSP, PM10, PM2.5, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCB, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, HCB				
Not estimated	SOx, PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NMVOC	0.1	kg/Mg oil	0.045	0.2	CORINAIR (1990)

1B2b Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)

Data on gas leakage from the pipelines are taken from the GHG inventory. Chemical composition of natural gas are provided by the gas transmission system operator and looks like this:

Eil. Nr.	Komponentė	Žymėjimas	Vidutinė vertė	Matavimo vnt.
1	Metanas	CH_4	96,1910	% molio
2	Etanas	C_2H_6	2,5844	% molio
3	Propanas	C_3H_8	0,4041	% molio
4	i-Butanas	C_4H_{10}	0,0675	% molio
5	n-Butanas	C_4H_{10}	0,0602	% molio
6	neo-Pentanas	C_5H_{12}	0,0017	% molio
7	i-Pentanas	C_5H_{12}	0,0096	% molio
8	n-Pentanas	C_5H_{12}	0,0059	% molio
9	C_6 plus	C_{6+}	0,0184	% molio
10	Azotas	N_2	0,4948	% molio
11	Anglies dioksidas	CO_2	0,1624	% molio

Methan, Carbon 6, Nitrogen, CO2 are excluded from leakage.

1B2aiv Fugitive emissions oil: Refining and storage

SO2, NMVOC, NOx emission are provided by the refinery plant. The plant performed methodological improvements in NMVOC leakage accounting (more direct measurements were implemented) in 2022. Emission of heavy metals and PAHs were evaluated applying

Table 3-2 Tier 2 emission factors for source category 1.B.2.a.iv Refining, storage, Fluid catalytic cracking - CO boiler (not installed)

Tier 2 emission factors					
	Code	Name			
NFR Source Category	1.B.2.a.iv	Fugitive emissions oil: Refining / storage			
Fuel	NA				
SNAP (if applicable)	040102	Fluid catalytic cracking - CO boiler			
Technologies/Practices	Catalytic Cracking unit regenerators Partial burn without CO boiler				
Region or regional conditions					
Abatement technologies	Cyclone systems installed internally within the regenerator				
Not applicable	HCB, PCB				
Not estimated	PCDD/F				
Pollutant	**Value**	**Unit**	**95% confidence interval**		**Reference**
			Lower	**Upper**	
NO_x	0.2	kg/m3 fresh feed	0.12	0.29	CONCAWE (2015A)
CO	39	kg/m3 fresh feed	24	55	CONCAWE (2015A)
NMVOC	0.63	kg/m3 fresh feed	0.38	0.88	CONCAWE (2015A)
SOx	1.4	kg/m3 fresh feed	0.85	2	CONCAWE (2015A)
NH_3	0.16	kg/m3 fresh feed	0.093	0.22	CONCAWE (2015A)
TSP	0.7	kg/m3 fresh feed	0.05	2	Environment Australia, 1999
PM10	0.55	kg/m3 fresh feed	0.18	1.6	CONCAWE (2015A)
$PM_{2.5}$	0.24	kg/m3 fresh feed	0.08	0.5	1)
BC[(a)]	0.13	% of PM2.5	0.05	0.2	2)
Pb	0.32	g/m3 fresh feed	0.11	0.96	CONCAWE (2015A)
Cd	0.063	g/m3 fresh feed	0.021	0.19	CONCAWE (2015A)
Hg	0.07	g/m3 fresh feed	0.023	0.21	CONCAWE (2015A)
As	0.014	g/m3 fresh feed	0.0046	0.042	CONCAWE (2015A)
Cr	0.33	g/Mg coke burned	0.1	1	Bertrand & Siegell, 2002; CONCAWE (2015A) [(b)]
Cu	0.14	g/m3 fresh feed	0.046	0.42	CONCAWE (2015A)
Ni	0.61	g/m3 fresh feed	0.2	1.8	CONCAWE (2015A)
Se	0.014	g/m3 fresh feed	0.005	0.042	CONCAWE (2015A)
Zn	0.12	g/m3 fresh feed	0.039	0.35	CONCAWE (2015A)
Benzo(a)pyrene	0.71	mg/Mg coke burned	0.4	1.4	CONCAWE (2015A)
Benzo(b)fluoranthene	1.2	mg/Mg coke burned	0.6	2.4	CONCAWE (2015A)
Benzo(k)fluoranthene	0.82	mg/Mg coke burned	0.4	1.6	CONCAWE (2015A)
Indeno(1,2,3-cd)pyrene	0.62	mg/Mg coke burned	0.3	1.2	CONCAWE (2015A)

Amount of coke burned was taken from the fuel balance, feed was estimated on the basis of the refinery continuous air pollution monitoring reports.

1B2av Distribution of oil products

Source category description In Lithuania, oil terminals and service stations must have permits with overload >100 m3 per year. Two complementary directives aim jointly to reduce NMVOC emissions from the storage and distribution of petrol: • Directive 94/63/EC concerning emissions of NMVOCs from the storage of petrol and distribution from terminals to service stations (the VOC-I Directive), which covers refineries and the delivery of petrol to service stations; • Directive 2009/126/EC concerning petrol vapor recovery during refueling of motor vehicles at service stations (the VOC - II Directive). Since 1 January 2004 requirements entered into force in major installations: terminals with an annual gasoline turnover of more than 50 000 tons per year, and in terminals where gasoline is transported to railway tanks, tank-vehicles and/or vessels with an annual petroleum turnover of more than 150 thous. tons per year, as well as petrol stations with a petrol turnover of 1000 m3 per year, as well as in petrol stations in cities.

Methodological issues. The calculation of the NMVOC time series for fugitive emissions from gasoline distribution, can be based on methods given by CONCAWE, including annual national gasoline consumption and assumptions on the share of gasoline evaporated at different stages of the handling procedure, as well as effects of applied abatement technology at gasoline stations. Algorithms are provided for the following sources: • Storage tanks; • Automobile refueling. Gasoline vapor emissions at service stations can be controlled using “vapor balancing” techniques: Storage tank filling: When the storage tank is filled the vapors normally vented to atmosphere can be fed back into the tanker cargo tank (compartment) from which the gasoline is being offloaded. This technique is called “Stage 1B” vapor balancing.