ROMANIA'S INFORMATIVE INVENTORY REPORT 2024

Submission under

UNECE Convention on Long Range Transboundary Air Pollution
Directive (Eu) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the Reduction of National Emissions of Certain Atmospheric Pollutants, Amending Directive 2003/35/EC and Repealing Directive 2001/81/EC

Data sheet:

Romania's Informative Inventory Report 1990-2022

Date: 15 March 2024

National Environmental Protection Agency of Romania (N.E.P.A)

Inventory team coordinator:

Ionela BĂLAN

Authors:

Corina CRISTEA GASSLER – Energy/Stationary combustion, Non-road mobile machinery

Tincuța Marina IVAŞCU-COICA – Transport, Industry

Nicoleta Adriana FULGEANU – Agriculture, Industry

Michaela STÎNGĂ – Waste, Industry/Solvents

Cristian Ionuț DEACONU – Energy/Industry combustion, Fugitive emissions,

Gabriel Ion GROSU – Industry, Agriculture

Laurențiu Constantin BROJBĂ – Energy/Transport, Waste

Daniela VARDIANU - Energy/Stationary combustion, Non-road mobile machinery

Table of Contents

EXECUTIVE SUMMARY

The Romanian Informative Inventory Report (IIR) contains information on the Romania's inventories for the years 1990 to 2022, including descriptions of methods, data sources, key categories analysis and trends analysis.

New NFR categories were estimated and some recalculations for period 1990-2022 have been carried out, due to updated statistics and correlations with the activity data, according with the Emission Inventory review conducted in 2023.

New NFR categories were estimated and recalculated for period 1990-2022 on the following criteria:

- the recommendations from TERT in the 2023 NECD and CLRTAP Reviews;
- updated statistics;
- consistency/correlation with all relevant inventories.

Following the Emission Inventory Reviews in 2017-2023, large part of recommendations from TERT were assessed and implemented.

The energy sector represents the main source of emissions in Romania for most of pollutants. This includes stationary combustion in the energy industry and in the manufacturing industry, small combustion, including off-road mobile machinery, fugitive emissions from fuels and transport sectors.

The shares of the emissions from the energy sector in the national total in 2022 are provided in the table below:

Pollutant	Share of energy sector in the national total (%)	Pollutant	Share of energy sector in the national total (%)
NOx	85,34%	**Hg**	86.32%
NMVOC	50,27%	**As**	72.16%
SOx	98,46%	**Cr**	68.19%
NH3	6,60%	**Cu**	98.30%
PM2.5	95.03%	**Ni**	86.92%
PM10	75.84%	**Se**	94.13%
TSP	59,30%	**Zn**	88.94%
BC	97,97%	**PCDD/ PCDF**	58.58%
CO	97,07%	**PAHs**	90.18%
Pb	48.81%	**HCB**	51.13%
Cd	82.56%	**PCBs**	28.56%

The estimation for stationary combustion was largely based on fuel consumption provided by the EUROSTAT databases and emission factors from the EMEP/EEA Air Pollutant Emission Inventory Guidebook – 2019, except for public power sector, NFR 1.A.1.a, where emissions of TSP, SOx and NOx include mainly measured values from LCP installations and one category recalculation based on Guidebook 2023 (1A4ai - Tier2, gaseous fuels).

The public power sector was in 2022 a key source for SOx, NOx, Cd, Hg, As, Ni, Se and HCB. Compared to 1990 emissions, there was a significant decrease of emissions to atmosphere in the public power sector. For main pollutants, decreases are as high as 87% for NOx, 97% for SOx and 93% for PM2.5. Compared to 2005, the emissions decreased in 2022 with 82% for NOx, 96% for SOx and 91% for $PM_{2.5}$. The decrease is due to implementation of emissions reduction program in LCP installations as well as a general decrease in fuel consumption. Variations of emission values are also determined by the different mixing ratios of solid/liquid/gaseous fuels along the time series, contributing with different emission factors to the estimate of each pollutant.

The small combustion (NFRs 1A4-1A5), including the off-road mobile machineries, is the main contributor to the national emissions for particulate matter, BC, part of heavy metals, PCDD/F and PAH.

Within the small combustion sector, the residential combustion (NFR 1A4bi) is a key source for many pollutants, contributing to the 2022 national total with 84.47% for PM2.5, 71.85% for BC, 65.10% for PM10, 31.27% for NMVOC, 6.92% for NOx, 5.87% for NH3, 53.41% for PCDD/PCDF and 83.04% for PAH. The emissions originate mainly from the combustion of biomass (wood) for residential heating. Biomass consumption increased along the time-series, reached a maximum in 2010 and varied very slightly in the following period. This evolution is consistent with the shift from central to individual heating in small and medium cities and with the decrease of power plants activity and emissions.

Road transport contributed mainly to the national total in 2022 with 44.22% for NOx, 8.39% for NMVOC, 17.25% for BC, 12.74% for CO, 22.51% for Pb, 26.80 % for Cr, 93.25% for Cu and 19.43% for Zn.

Emissions from road transport were estimated with the COPERT software, with input data provided by the National Institute of Statistics (for fuel consumption from the Energy Balance), the Romanian Auto Registry (for fleet data) and the National Meteorological Administration (maximum and minimum temperatures and relative humidity).

Industrial processes and product use sector only covers process related emissions arising from industrial processes. Emissions due to fuel combustion in manufacturing industries have been allocated to NFR 1.A.2 Fuel Combustion in Manufacturing Industries and Construction.

Industrial processes and product use sector contribute to the 2022 national total with 69.51% for PCBs, 51.01% for Pb, 31.73% for Cr, 25.81% for NMVOC, 23.87% for TSP, 25.44% for As. The industrial processes and product use sector is a key category for NMVOC, PM10, TSP, Pb, Cd, Hg, As, Cr, Ni, Zn, PCDD/F and PCBs in different industries: Other solvent and product use, Food and beverages industry, Quarrying and mining, Construction and demolition, Iron and steel production. Details are given in the specific section.

The agricultural sector comprises emissions arising from the agricultural and zootechnical activities, including housing, manure storage and grazing, manure treatment and manure application. The main part of the NH3 emission (89.7%) is related to the agricultural sector. For the year 2022, the distribution of NH3 emissions by agriculture sources was as follows: 38.6% from manure management, 61.4% from manure applied to soils (also includes emissions from N-fertilizers application in agricultural sector) and only 0.01% from burning fields. For the year 2022, the contribution of NMVOC share from agriculture accounts for 22.9% of the national total. The distribution of NMVOC emissions by agricultural sources was as follows: 56.9% from manure management, 43.1% from manure applied to soils and only 0.038% from burning fields. The emission calculation was further carried out with the two tools, N-Flow and AgrEE Tool, using the national coefficients available from the Study "Romanian projections for pollutant emissions until 2030" (2018) and the average weights for finishing pigs. A small amount of manure used in anaerobic digestion was subtracted from the management manure and included to NFR 5B2, by questionnaires for time series 2013-2022. The emission of ammonia from inorganic fertilizer, estimated with the Tier 2 methodology, contributes in 2022 with 18.7% to the emission from the agricultural sector, and nitrogen oxide emission contributes in 2022 with a weight of 63.3%, representing the first source of emissions of NOx from the agricultural sector.

The waste sector covers emissions from the solid wastes disposal on land, biological treatment of waste by anaerobic digestion at biogas plants, clinical and industrial wastes incineration, cremation, small scale waste burning and compost manufacturing, wastewater handling and other waste (car fires and house fires). The waste sector contribute to the 2022 national total with 27.9% for PCDD/PCDF and with 46.4% for HCB.

Inclusion/exclusion of the condensable component from PM_{10} and $PM_{2.5}$

NFR	Source/sector name	PM emissions: the condensable component is included	PM emissions: the condensable component is excluded	EF reference and comments
1A1a	Public electricity and heat production		x	2019 EMEP/EEA Guidebook, all table: „The TSP, PM_{10} and $PM_{2.5}$ emission factors represent filterable PM emissions”.
1A4aii	Mobile (off-road) Combustion in Commercial/Institutional	x		2019 EMEP/EEA Guidebook, Table 3.1 – „PM factors represent total PM emissions (filterable and condensable fractions)”
1A4bii	Residential: Household and gardening (mobile)	x		2019 EMEP/EEA Guidebook, Table 3.1 – „PM factors represent total PM emissions (filterable and condensable fractions)”
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	x		2019 EMEP/EEA Guidebook, Table 3.1 – „PM factors represent total PM emissions (filterable and condensable fractions)”
1A2gvii	Stationary combustion in manufacturing industries and construction: Other	x		2019 EMEP/EEA Guidebook, Table 3.1 – „ PM factors represent total PM emissions (filterable and condensable fractions)”
1A2	Stationary combustion in manufacturing industries and construction (all 1A2			Table 3.2, solid fuels, 2019 EMEP/EEA Guidebook – „The basis of the TSP, PM_{10} and $PM_{2.5}$ emission factors could not be

NFR	Source/sector name	PM emissions: the condensable component is included	excluded	EF reference and comments
	industry)			determined in the reference”.
1A2	Stationary combustion in manufacturing industries and construction (all 1A2 industry)			Table 3.3, gaseous fuels, 2019EMEP/EEA Guidebook – “The TSP, PM_{10} and $PM_{2.5}$ emission factors have been reviewed and it is unclear whether they represent filterable PM or total PM (filterable and condensable) emissions”;
1A2	Stationary combustion in manufacturing industries and construction (all 1A2 industry)			Table 3.4 liquid fuel, 2019 EMEP/EEA Guidebook – “The TSP, PM_{10} and $PM_{2.5}$ emission factors have been reviewed and it is unclear whether they represent filterable PM or total PM (filterable and condensable) emissions”;
1A2	Stationary combustion in manufacturing industries and construction (all 1A2 industry)	x		Table 3.5, biomass, 2019 EMEP/EEA Guidebook – „The TSP, PM_{10} and $PM_{2.5}$ emission factors represent filterable PM”.
1A4ai	Commercial/Institutional			Tables 3.7 to 3.19, 2019 EMEP/EEA Guidebook – „The TSP, PM_{10} and $PM_{2.5}$ emission factors have been reviewed and it is unclear whether they represent filterable PM or total PM (filterable and condensable) emissions”. Table 3.10 – Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using solid biomass: “Emission factors have been recalculated to represent total particles (including condensable component) by assuming condensables represent 12% of the total PM mass for $PM_{2.5}$ (average of automatic and medium sized boilers from Denier van der Gon et al., 2015).”
1A4ci	Agriculture/Forestry/Fishing, Stationary			Tables 3.7 to 3.19, 2019 EMEP/EEA Guidebook – „The TSP, PM_{10} and $PM_{2.5}$ emission factors have been reviewed and it is unclear whether they represent filterable PM or total PM (filterable and condensable) emissions”. Table 3.10 – Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using solid biomass: “Emission factors have been recalculated to represent total particles (including condensable component) by assuming condensables represent 12% of the total PM mass for $PM_{2.5}$ (average of automatic and medium sized boilers from Denier van der Gon et al., 2015).”
1A5a	Other stationary			Tables 3.7 to 3.19, 2019 EMEP/EEA Guidebook – „The TSP, PM_{10} and $PM_{2.5}$ emission factors have been reviewed and it is unclear whether they represent filterable PM or total PM (filterable and condensable) emissions”. Table 3.10 – Tier

NFR	Source/sector name	PM emissions: the condensable component is included	excluded	EF reference and comments
				1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using solid biomass: "Emission factors have been recalculated to represent total particles (including condensable component) by assuming condensables represent 12% of the total PM mass for $PM_{2.5}$ (average of automatic and medium sized boilers from Denier van der Gon et al., 2015)."
1A4bi	Residential			Tables 3.3 to 3.5, coal, gaseous fuels and other liquid fuels, 2019 EMEP/EEA Guidebook – „The TSP, PM_{10} and $PM_{2.5}$ emission factors have been reviewed and it is unclear whether they represent filterable PM or total PM (filterable and condensable) emissions".
1A4bi	Residential	x		Tables Tier 2, 3.40, 3.43 and 3.44, wood combustion, 2019 EMEP/EEA Guidebook – "total particles" for TSP, PM_{10}, $PM_{2.5}$ and BC.
1.A.3.b	Road transport	x		2019 EMEP/EEA Guidebook, chapter 1.A.3.bi-iv: "… at a temperature lower than 52ºC. At this temperature, PM contains a large fraction of condensable species. Hence, PM mass emission factors in this chapter are considered to include both filterable and condensable material."
2C.1	Iron and steel production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions only (excluding any condensable fraction)".
2.C.2	Ferroalloys production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions only (excluding any condensable fraction)".
2.C.3	Aluminum production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions only (excluding any condensable fraction)".
2.C.5	Lead production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions only (excluding any condensable fraction)".
2.C.6	Zinc production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions only (excluding any condensable fraction)".
2.D.3.b	Road Paving with Asphalt		x	2019 EMEP/EEA Guidebook – „The TSP, PM_{10} and $PM_{2.5}$ emission factor represents filterable PM emissions. Note that US EPA (2004) includes condensable PM emission factors and factors for controlled plant".
3D	Crop production and agricultural soils			2019 EMEP/EEA Guidebook – „The processes which result in particulate emissions are largely low-temperature mechanical activities, and emissions are unlikely to include substantial quantities of condensable particulate material"

Recalculations and improvements were developed on the following categories:

NFR	Time series	Pollutants	Reason
1A3bi	1991-2004	NOx, NMVOC, CO	Slight change of EFs from COPERT 5.6.1 to the COPERT 5.7.3
1A3bii	1991-2004	NMVOC, CO	Slight change of EFs from COPERT 5.6.1 to the COPERT 5.7.3
1A3bi-1A3bvii	2005-2021	All pollutants	Recalculated using COPERT 5.7.3
1A3di(ii)	2005-2022	All pollutants(except NH3)	Estimate for the first time
1A3dii	1990-2021	PAHs	Updated to Guidebook 2023
1A4ai	1992-2021	NOx, NMVOC, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, As, Cr, Cu, Ni, Se, Zn, CO, PCDD/ PCDF, PAHs.	Change of EFs from Tier 1 (Table 3-8 Guidebook 2019) to Tier2 (Table 3-26 Guidebook 2023).
1A4bi	1990-2021	NOX, NMVOC, NH3, PM2.5, PM10, TSP, BC, DIOX, CO, Benzo(a), Benzo(b), Benzo(k), Indeno, total4PAHs, PCBs	Slight corrections of shares of technologies for biomass (stoves, pellets and boilers). Low impact on emissions.
1B2c	2021	All pollutants	Activity data update and recalculation
2A5b	2021	PM, TSP	Slight review of activity data by NIS
2D3a	1990-2021	NMVOC	Recalculated using EF from ESIG.
2D3d	1990-2021	NMVOC	Correction of activity data (total solvents), time period 2018-2021 New activity data SNAP 060105 coil coating, time period 2018-2021 New activity data SNAP 060106 boat building, time period 1990-2007 New activity data SNAP 060103+060104 domestic and building application time period 2003-2021.

NFR	Time series	Pollutants	Reason
2D3e	1990-2021	NMVOC	New activity data Xylen
2D3g	1990-2007 2021	NMVOC NMVOC	New activity data for SNAP 060306 Pharmaceutical products manufacturing Activity data update for SNAP 060301 Polyester processing
2D3h	2003-2007	NMVOC	New estimation activity data
2D3i	2021	NMVOC	Activity data update for SNAP 060407.
2G	2008-2021	NMVOC	Activity data update for SNAP 060603, "Use of shoes" activity.
2H2	1990-2021 2018-2021	PM10 NMVOC	New activity data for Handling of agricultural products (grains, soya) Activity data update for margarine.
3B1a, 3B1b, 3B3	2006-2013	NOx, NH3, NMVOC	Interpolation of AWMS percentage values at TERT recommendation
3B1a, 3B1b	2021	PM2.5, PM10, TSP	Error filling in the values
3B4gi	2021	NMVOC, NH3	Error of completion activity data
3B4gii, 3B4giii, 3B4giv	2008-2021	All pollutants	Recalculation of the activity data (as a result of the answers to the questionnaires in the country)
3Da1	2020, 2021 2021	NH3 NOx	Activity data update by NIS and IFA.
3Da2a	1990-2020	NOx	Activity data update
3Dc	2021	PM, TSP	Activity data update by NIS
3De	1990-2021	NMVOC	New calculation algorithm (Review RO_3De_2023-0001)
3F	1991-2021	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, benzo(a) pyrene, benzo(b), benzo(k), Indeno (1,2,3-	Activity data update

NFR	Time series	Pollutants	Reason
		cd).	
5A	2021	PM10, PM2,5,TSP	Activity data update
5B1	2021	NH3	Activity data update

1. INTRODUCTION

1.1. National Inventory Background

Romania's Reporting Obligations under the UNECE/CLRTAP Convention and National Framework for Inventory Preparation and Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC.

Romania is a Party of the Convention on Long Range Transboundary Air Pollution (CLRTAP), ratified by Law 8/1991. The CLRTAP protocols, namely Gothenburg Protocol, POPs Protocol and Heavy Metals Protocol, have been ratified by the Law 271/2003. Romania acceded to the EMEP Protocol by the Law 652/2002. Law 1/2012 and Law 263/2017 accept the adopted POPs, Gothenburg and Heavy Metals Protocols amendments.

The Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC has been transposed into national legislation, by Law no. 293/2018.

1.2.Institutional arrangements

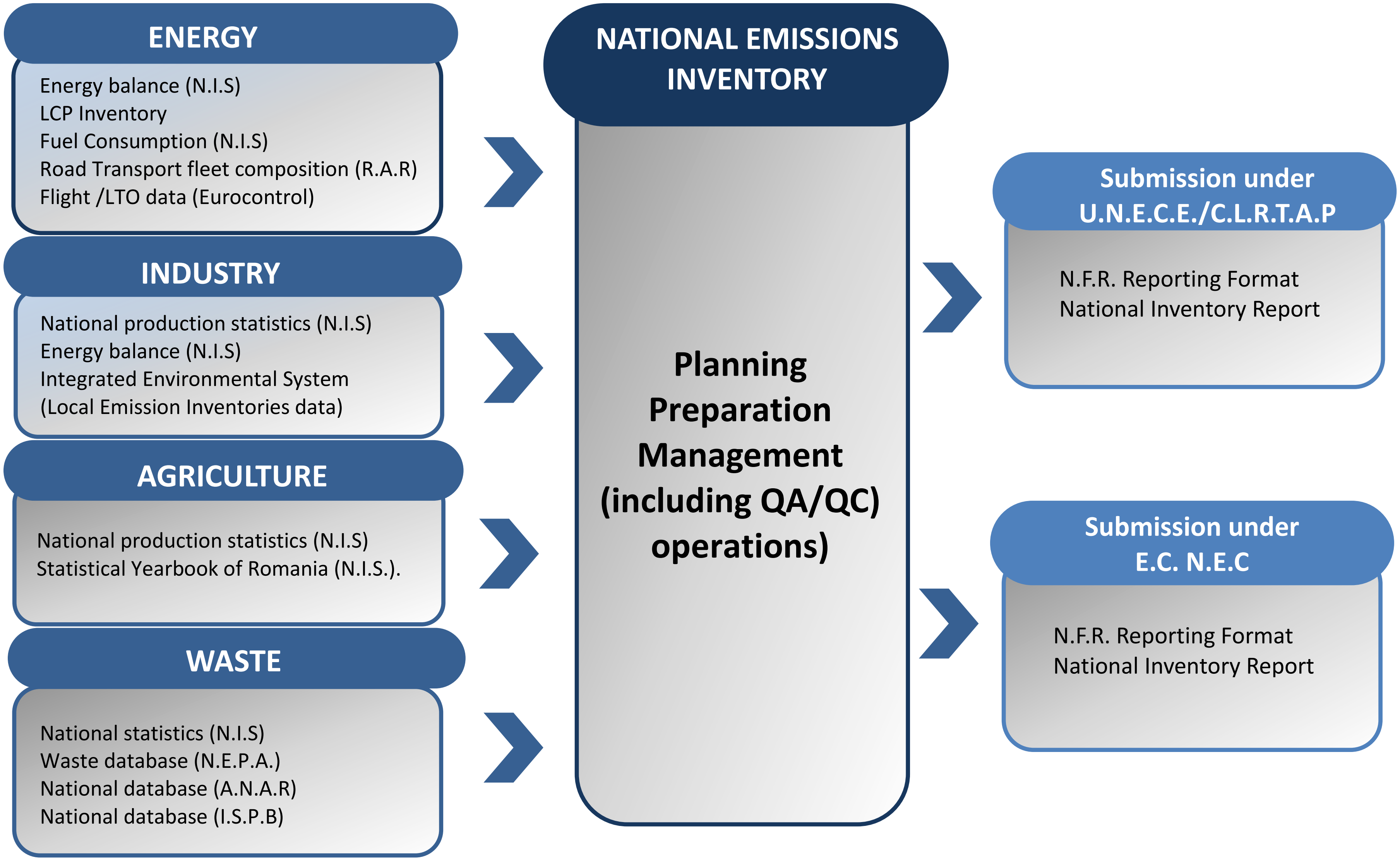
Romania prepares, maintains and reports on a yearly basis the National Emissions Inventory and the whole inventory time series, if required. Emission time series are resubmitted if any recalculation occurred due to the methodology/emission factors changes, new sources identification, updated activity data etc.

The methodology for estimating and reporting emissions is consistent with the "EMEP/EEA air pollutant emission inventory guidebook – 2019" and the Ministerial Order no 3.299/2012 for the approval of the methodology for compiling and reporting of air emissions inventories.

The inventory system currently used in Romania is presented in Figure 1.1.1. The National Environmental Protection Agency of Romania (N.E.P.A) is responsible for the national emissions inventory compilation.

In order to collect and compile the inventory data, institutional arrangements are made between N.E.P.A. and other administrative structures such as: National Institute of Statistics (N.I.S.), Romanian Auto Registry (R.A.R.), "Romanian Waters" National Administration (A.N.A.R) and Romania Public Health Institute (I.S.P.B.).

Figure 1.1.1 – National Emissions Inventory Data Sources and Structure



1.3. Inventory preparation process

Inventory compilation starts with the inventory planning process. This includes allocation of human resources, prioritization of actions and improvements. For sectorial/activity improvements, the Key Category Analysis provides a starting point in order to identify the emission sources that are to be given increased importance (emissions estimation based on superior Tier, detailed data collection – activity related data from economic operators/industry etc.).

The next step is inventory preparation. Input data are being collected; emission factors are being selected and all the work is documented. Afterwards, all this data is inserted in a Collect-ER database and emissions are estimated. Output data from Collect-ER is then exported to an excel file and fed to the online Integrated Environmental System application F3 – "National Emissions Inventory", that translates it to Annex I of the CLRTAP reporting format.

The pollutants covered by this methodology guide are NOx, NMVOC, SOx, NH_3, $PM_{2.5}$, PM_{10}, TSP, BC, CO, Heavy Metals, (Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn), POPs (dioxins/furans, PAHs, HCB and PCBs).

This step also includes expert allocation for different sectors and for activities required by the QA/QC procedures and data management.

1.4. Methods and data sources

The main methodology used for calculation of emissions includes product of activity data (e.g. the production statistics, fuel consumption, waste treated, number of animals, etc.) and corresponding emission factor. Emission factors applied to main pollutants emissions estimates are based mainly on 2019 EMEP/EEA Guidebook, with some exceptions due to recent recalculations, based on Guidebook 2023. Several emissions are provided by operators (NFR 1A1a).

Most of input data were processed using the Collect-ER software. The Collect-ER software was conducted in accordance with the recommendations TFEIP/EIONET and ETC/ACC European Environment Agency (EEA).

Emissions from the road transport sector were estimated and exported directly into the reporting formats required by the UNECE/CLRTAP Secretariat using the latest version of the COPERT software program.

A detailed description of the methodology is shown in sector-specific chapters of IIR in chapters from 3 to 6.

National Emission Inventory Data Sources:

Energy	Energy balance	NIS
Energy	Energy statistics	EUROSTAT
	LCP Inventory	NEPA
Energy	Road Transport fleet composition	RAR
	Flight/LTO data	EUROCONTROL
Industrial processes	National production statistics	NIS
Industrial processes	Integrated Environmental System	NEPA
Agriculture	National production statistics	NIS
Agriculture	Statistical Yearbook of Romania	NIS
Agriculture	IFA (www.fertilizer.org)	IFA (www.fertilizer.org)
Waste	National statistics	NIS
Waste	Waste database	NEPA
Waste	National database	ANAR
Waste	Building and car fires	CTIF, IGSU-MIA
Waste	National database	ISPB

.

1.5. Key Category Analysis

This chapter presents results of Romania's pollutant-specific key categories analysis.

The methodology follows the Good Practice Guidance approach to produce pollutant-specific key categories and covers both level and trend assessments. In Approach 1, key categories are identified using a predetermined cumulative emission threshold. Key categories are those which, when summed together in descending order of magnitude, cumulatively add up to 80% of the total level.

As the analysis was made for all different pollutants reported to the UNECE/CLRTAP/EU Commission and as these pollutants differ in their way of formation, most of the identified categories are key categories for one pollutant or more.

The following tables present the key category analysis for:

Table 1.5.1 Key Categories for NOx (2022)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A3biii	Road transport: Heavy duty vehicles and buses	43.100	21.24%	21.24%	1
1A3bi	Road transport: Passenger cars	33.381	16.45%	37.69%	2
3Da1	Inorganic N-fertilizers (includes also urea application)	18.361	9.05%	46.74%	3
1A1a	Public electricity and heat production	17.659	8.70%	55.45%	4
1A4bi	Residential: Stationary	14.032	6.92%	62.36%	5
1A3bii	Road transport: Light duty vehicles	13.164	6.49%	68.85%	6
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	10.178	5.02%	73.87%	7
3Da2a	Animal manure applied to soils	8.072	3.98%	77.85%	8
1A3c	Railways	5.282	2.60%	80.45%	9

Table 1.5.2 Key Categories for NMVOC (2022)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	73.587	31.27%	31.27%	1
2D3a	Domestic solvent use including fungicides	23.015	9.78%	41.05%	2
2D3g	Chemical products	15.499	6.59%	47.63%	3
3Da2a	Animal manure applied to soils	14.970	6.36%	53.99%	4
3B1a	Manure management - Dairy cattle	13.403	5.69%	59.69%	5
1A3bi	Road transport: Passenger cars	8.828	3.75%	63.44%	6
2H2	Food and beverages industry	7.958	3.38%	66.82%	7
3De	Cultivated crops	7.702	3.27%	70.09%	8
2D3d	Coating applications	6.476	2.75%	72.85%	9
1A3bv	Road transport: Gasoline evaporation	5.750	2.44%	75.29%	10
3B1b	Manure management - Non-dairy cattle	5.465	2.32%	77.61%	11
2D3i	Other solvent use (please specify in the IIR)	4.870	2.07%	79.68%	12
1B2aiv	Fugitive emissions oil: Refining / storage	4.699	2.00%	81.68%	13

Table 1.5.3 Key Categories for SOx (2022)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	18.527	39.8%	39.8%	1
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	14.452	31.0%	70.8%	2
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	3.669	7.9%	78.7%	3
1A4bi	Residential: Stationary	3.258	7.0%	85.6%	4

Table 1.5.4 Key Categories for NH_3 (2022)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
3Da2a	Animal manure applied to soils	38.515	25.70%	25.70%	1
3Da1	Inorganic N-fertilizers (includes also urea application)	25.155	16.79%	42.49%	2
3Da3	Urine and dung deposited by grazing animals	18.733	12.50%	54.99%	3
3B3	Manure management - Swine	14.655	9.78%	64.77%	4
3B1a	Manure management - Dairy cattle	13.150	8.78%	73.55%	5
1A4bi	Residential: Stationary	8.792	5.87%	79.42%	6
3B1b	Manure management - Non-dairy cattle	6.284	4.19%	83.61%	7

Table 1.5.5 Key Categories for $PM_{2.5}$ (2022)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	90.771	84.47%	84.47%	1

Table 1.5.6 Key Categories for PM_{10} (2022)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	93.180	65.10%	65.10%	1
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	17.558	12.27%	77.37%	2
2A5a	Quarrying and mining of minerals other than coal	5.020	3.51%	80.87%	3

Table 1.5.7 Key Categories for TSP (2022)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	98.059	49.74%	49.74%	1
2D3b	Road paving with asphalt	22.134	11.23%	60.97%	2
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	17.558	8.91%	69.88%	3
2A5a	Quarrying and mining of minerals other than coal	10.240	5.19%	75.07%	4
3B4gi	Manure management - Laying hens	7.958	4.04%	79.11%	5
2A5b	Construction and demolition	4.252	2.16%	81.26%	6

Table 1.5.8 Key Categories for BC (2022)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total	Rank
1A4bi	Residential: Stationary	9.307	71.85%	71.85%	1
1A3bi	Road transport: Passenger cars	0.911	7.03%	78.89%	2
1A3biii	Road transport: Heavy duty vehicles and buses	0.625	4.82%	83.71%	3

Table 1.5.9 Key Categories for CO (2022)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	511.065	57.06%	57.06%	1
1B2aiv	Fugitive emissions oil: Refining / storage	146.272	16.33%	73.39%	2
1A3bi	Road transport: Passenger cars	81.120	9.06%	82.45%	3

Table 1.5.10 Key Categories for Pb (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
2C1	Iron and steel production	18.367	45.14%	45.14%	1
1A3bvi	Road transport: Automobile tyre and brake wear	9.156	22.50%	67.64%	2
1A4bi	Residential: Stationary	3.720	9.14%	76.78%	3
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	2.150	5.28%	82.07%	4

Table 1.5.11 Key Categories for Cd (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	1.675	56.45%	56.45%	1
2C1	Iron and steel production	0.313	10.54%	66.99%	2
1B2aiv	Fugitive emissions oil: Refining / storage	0.236	7.96%	74.96%	3
1A1a	Public electricity and heat production	0.235	7.92%	82.88%	4

Table 1.5.12 Key Categories for Hg (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	0.372	23.90%	23.90%	1
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.359	23.11%	47.01%	2
1B2aiv	Fugitive emissions oil: Refining / storage	0.263	16.89%	63.90%	3
2C1	Iron and steel production	0.179	11.49%	75.39%	4
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.138	8.84%	84.24%	5

Table 1.5.13 Key Categories for As (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	1.816	56.86%	56.86%	1
2C1	Iron and steel production	0.732	22.93%	79.79%	2
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.192	6.02%	85.81%	3

Table 1.5.14 Key Categories for Cr (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
2C1	Iron and steel production	3.994	30.78%	30.78%	1
1A3bvi	Road transport: Automobile tyre and brake wear	3.423	26.37%	57.15%	2
1A4bi	Residential: Stationary	2.979	22.96%	80.11%	3

Table 1.5.15 Key Categories for Cu (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A3bvi	Road transport: Automobile tyre and brake wear	75.190	93.20%	93.20%	1

Table 1.5.16 Key Categories for Ni (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	2.503	21.78%	21.78%	1
1B2aiv	Fugitive emissions oil: Refining / storage	2.288	19.91%	41.70%	2
1A5a	Other stationary (including military)	1.997	17.38%	59.08%	3
1A1c	Manufacture of solid fuels and other energy industries	1.221	10.63%	69.71%	4
2C1	Iron and steel production	1.119	9.74%	79.44%	5
1A3bvi	Road transport: Automobile tyre and brake wear	0.522	4.55%	83.99%	6

Table 1.5.17 Key Categories for Se (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	5.367	83.99%	83.99%	1

Table 1.5.18 Key Categories for Zn (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	66.263	54.61%	54.61%	1
1A3bvi	Road transport: Automobile tyre and brake wear	23.425	19.31%	73.92%	2
2C1	Iron and steel production	10.389	8.56%	82.48%	3

Table 1.5.19 Key Categories for PCDD/PCDF (2022)

NFR CODE	CATEGORY	Latest year estimate (g I-TEQ)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	99.394	53.41%	53.41%	1
5C1biii	Clinical waste incineration	40.564	21.80%	75.21%	2
2C1	Iron and steel production	25.015	13.44%	88.65%	3

Table 1.5.20 Key Categories for Total PAHs (2022)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	44.576	83.04%	83.04%	1

Table 1.5.21 Key Categories for HCB (2022)

NFR CODE	CATEGORY	Latest year estimate (kg)	Level assessment (%)	Cumulative total (%)	Rank
5C1biii	Clinical waste incineration	1.449	46.22%	46.22%	1
1A1a	Public electricity and heat production	0.840	26.80%	73.02%	2
1A4bi	Residential: Stationary	0.644	20.55%	93.58%	3

Table 1.5.22 Key Categories for PCBs (2022)

NFR CODE	CATEGORY	Latest year estimate (kg)	Level assessment (%)	Cumulative total (%)	Rank
2C1	Iron and steel production	10.471	69.51%	69.51%	1
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	2.727	18.10%	87.62%	2

Table 1.5.23 Key Categories by activity/pollutant – Main pollutants (2022)

Category		Main Pollutants (%)								
		NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
1A1a	Public electricity and heat production	8.70%		39.76%						
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel			31.02%						
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	5.02%		7.88%						
1A3bi	Road transport: Passenger cars	16.45%	3.75%						7.03%	9.06%
1A3bii	Road transport: Light duty vehicles	6.49%								
1A3biii	Road transport: Heavy duty vehicles and buses	21.24%							4.82%	
1A3bv	Road transport: Gasoline evaporation		2.44%							
1A3c	Railways	2.60%								
1A4bi	Residential: Stationary	6.92%	31.27%	6.99%	5.87%	84.47%	65.10%	49.74%	71.85%	57.06%
1B2aiv	Fugitive emissions oil: Refining and storage		2.00%							16.33%
2A5a	Quarrying and mining of minerals other than coal						3.51%	5.19%		
2A5b	Construction and demolition							2.16%		
2D3a	Domestic solvent use including fungicides		9.78%							
2D3b	Road paving with asphalt							11.23%		
2D3d	Coating applications		2.75%							
2D3g	Chemical products		6.59%							
2D3i	Other solvent use (please specify in the IIR)		2.07%							
2H2	Food and beverages industry		3.38%							
3B1a	Manure management - Dairy cattle		5.69%		8.78%					
3B1b	Manure management - Non-dairy cattle		2.32%		4.19%					
3B3	Manure management - Swine				9.78%					
3B4gi	Manure management - Laying hens							4.04%		
3Da1	Inorganic N-fertilizers (includes also urea application)	9.05%			16.79%					
3Da2a	Animal manure applied to soils	3.98%	6.36%		25.70%					
3Da3	Urine and dung deposited by grazing animals				12.50%					
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products						12.27%	8.91%		
3De	Cultivated crops		3.27%							
Cumulatively		80.45%	81.68%	85.64%	83.61%	84.47%	80.87%	81.26%	83.71%	82.45%

Table 1.5.24 Key Categories by activity/pollutant – Heavy Metals (2022)

Category		Heavy Metals (%)								
		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
1A1a	Public electricity and heat production		7.92%	23.90%	56.86%			21.78%	83.99%	
1A1c	Manufacture of solid fuels and other energy industries							10.63%		
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	5.28%		8.84%						
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals			23.11%	6.02%					
1A3bvi	Road transport: Automobile tyre and brake wear	22.50%				26.37%	93.20%	4.55%		19.31%
1A4bi	Residential: Stationary	9.14%	56.45%			22.96%				54.61%
1A5a	Other stationary (including military)							17.38%		
1B2aiv	Fugitive emissions oil: Refining and storage		7.96%	16.89%				19.91%		
2C1	Iron and steel production	45.14%	10.54%	11.49%	22.93%	30.78%		9.74%		8.56%
Cumulatively		82.07%	82.88%	84.24%	85.81%	80.11%	93.20%	83.99%	83.99%	82.48%

Table 1.5.25 Key Categories by activity/pollutant – POPs (2022)

Category		POPs			
		PCDD/ PCDF (dioxins/ furans)	Total 1-4	HCB	PCBs
1A1a	Public electricity and heat production			26.80%	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel				18.10%
1A4bi	Residential: Stationary	53.41%	83.04%	20.55%	
2C1	Iron and steel production	13.44%			69.51%
5C1biii	Clinical waste incineration	21.80%		46.22%	
Cumulatively		88.65%	83.04%	93.58%	87.62%

1.6. Quality Assurance and Quality Control (QA/QC)

QA/QC activities can be broken down into three key categories for the IIR framework:

Quality Controls are a system of routine technical checks and procedures that assess and maintain the quality of the inventory whilst minimizing the risk of an error occurring. Examples of this are raw data calculation and output checks.

Quality Assurance is a review of the inventory by independent experts e.g. Peer reviews and international reviews.

Verification is the collection of activities that help to establish the reliability of the inventory such as comparisons of the inventory made by other bodies or using alternative methods.

The National Environmental Protection Agency of Romania is responsible for the QA/QC of the emissions inventory. The Romania QA/QC plan aims to improve transparency, consistency, comparability, completeness and confidence of the national emissions inventories in line with the latest guidance (EMEP/EEA guidebook 2019 and 2006 IPCC guidelines). It establishes the procedures to be applied in the process of emission inventorying at all stages from data collection to national emission inventory compilation. The activities included in the plan are:

- QC activities
- Procedures for country specific methodologies
- Internal audits
- Inventory improvement plan
- Documenting and archiving
- Treatment of confidential data
- Annual review of responsibilities and management

Quality Controls

QC procedures are in place and documented throughout the inventory compilation process:

Primary Data is validated by L.E.P.A. Activity data provided by the operators is run through the "I.E.S-Integrated Environmental System".

- All emissions calculation workbooks have the same basic structure and automatic and manual checks in place. These checks include (version control, data log of Java Application and Oracle Databases).
- Additional checks for key category emissions and more complex sources are also in place.
- Checks when the data is retrieved from the database for reporting.

Verification

The verification methods for the emission inventory compilation include:

- Checking the quality of data used for compilation of the national inventory (checking if audited, qualitative rating of data);
- Checking the correctness of assumptions, mainly for key categories (emission factors, calculations);
- Checking the proper allocation of NFR codes;
- Identification of ‘outliers’, verification of plausibility and applying corrections if necessary;
- Checking if data collected using the bottom-up approach are comparable with those reported in national statistics;
- Checking if the emission inventory data is consistent and correlated with data reported under other reporting obligations;
- Checking the plausibility and completeness of the time series;
- Checking the consistency and documentation in case of recalculations;
- Checking the application of improvements or corrections required by reviews or methodology changes;
- Checking the application of archiving procedures.

Quality Assurance

Quality assurance activities may be conducted by external experts in order to verify and review the quality of emission inventories. The quality control procedures are being developed by N.E.P.A in cooperation with L.E.P.As.

An internal discussion forum has been set for a better communication between all N.E.P.A and L.E.P.As data providers and contributors to emissions inventory compilation. Discussions are structured on NFR categories/data collection questionnaires and the results of discussions, questions and the adequate solutions are further analyzed, summarized and included in the quality control procedures.

Independent reviews of the inventory occur regularly:

- Annual NECD review – an in-depth review of the main pollutants (NOx, SOx, NMVOC, NH_3 and $PM_{2.5}$) in the inventory is carried out every year by an expert team on behalf of the European Commission. This review also focuses on Metals, POPs, Projections and gridded data every couple of years.
- Annual Stage 1 and 2 CLRTAP reviews – This is a semi-automated review that checks the submission for timeliness, completeness and formats (stage 1) and then consistency, comparability, key category analysis and trends in emissions data (stage 2).

Archiving and Documentation

All activity data, emission factors and resulting emission data are stored in the inventory databases, which are constantly updated and extended to meet the requirements for emission reporting.

Access to emission data for selected years, sectors and pollutants is possible via Internet.

Inventory results are accessible from the EEA EIONET Central Data Repository (CDR).

RepDab Report (available at www.ceip.at) is also generated as an additional QA/QC activity.

The QA/QC plans and procedures are under continuous review and improvement.

1.7. General uncertainty evaluation

The convention on LRTAP states that “Parties shall quantify uncertainties in their emission estimates using the most appropriate methodologies available, taking into account guidance provided in the EMEP/EEA Guidebook. Uncertainties should be described in the IIR”.

In accordance with the methodology in the EMEP/EEA Guidebook 2019 the uncertainty analysis for Romania has been calculated.

Uncertainty in emission estimates is a function of the uncertainty of input data, the activity data and the emission factors, used to compile the inventory. All data in the inventory will have some kind of uncertainty associated with it. Hence, all data collected should have an individual uncertainty assessment.

Producing an uncertainty analysis is an important tool for the process of inventory improvement.

The IPCC Guidance states that the process of producing an uncertainty analysis can pragmatically be divided into four parts: (EMEP/EEA 2019)

(1) the rigorous investigation of the likely causes of data uncertainty and quality;

(2) the creation of quantitative uncertainty estimates and parameter correlations;

(3) the mathematical combination of those estimates when used as inputs to a statistical model(e.g., first-order error propagation or Monte Carlo method);

(4) the selection of inventory improvement actions (improvement plan) to take in response to the results of the previous three parts.

A quantitative analysis of the uncertainty for the remaining pollutants will be processed in the following submissions.

Method used:

- the Approach 1 was applied for the following pollutants: NOx, NMVOC, SOx, NH_3 and $PM_{2.5}$;
- the Approach 2 (Monte Carlo Simulation) was not included in this assessment.

Results of uncertainty estimation:

Uncertainty estimation of NOx, NMVOC, SOx, NH_3 and $PM_{2.5}$ for 2022
and trend for 1990 -2022

Pollutant	Unit	Emissions 2022	Level uncertainty 2022 (%)	Trend uncertainty 2022 (%)
NOx, (as NO_2)	kt	202.90	18.81	5.69
NMVOC	kt	235.34	42.19	19.73
SOx , (as SO_2)	kt	46.60	15.85	0.74
NH_3	kt	149.84	37.20	5.67
$PM_{2.5}$	kt	107.46	52.79	54.93

Uncertainty estimation of NOx emissions 1990 and 2022

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I∗F (Note C)	J∗E∗$\sqrt{2}$ (Note D)	$K^2 + L^2$
1A1a	NOx	146.591	17.659	3	20	20.0	3.029	-0.096	0.038	-1.907	0.159	3.661
1A1b Liquid Fuels	NOx	1.494	0.006	3	65	65.1	0.000	-0.001	0.000	-0.088	0.000	0.008
1A1b Gaseous Fuels	NOx	5.943	1.659	3	55	55.1	0.203	-0.002	0.004	-0.106	0.015	0.011
1A1b Biomass	NOx	0.000	0.000	3	62	62.1	0.000	0.000	0.000	0.000	0.000	0.000
1A1c Liquid Fuels	NOx	0.442	2.989	3	112	112.0	2.725	0.006	0.006	0.666	0.027	0.444
1A1c Gaseous Fuels	NOx	0.000	0.360	3	50	50.1	0.008	0.001	0.001	0.038	0.003	0.001
1A1c Biomass	NOx	0.000	0.000	3	38	38.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2a Solid Fuels	NOx	14.740	2.775	3	51	51.1	0.488	-0.008	0.006	-0.388	0.025	0.151
1A2a Gaseous Fuels	NOx	12.863	1.475	3	50	50.1	0.133	-0.009	0.003	-0.432	0.013	0.187
1A2a Biomass	NOx	0.000	0.000	3	38	38.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Liquid Fuels	NOx	0.000	0.005	3	50	50.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2c Solid Fuels	NOx	1.206	0.012	3	51	51.1	0.000	-0.001	0.000	-0.055	0.000	0.003
1A2c Gaseous Fuels	NOx	24.770	2.221	3	50	50.1	0.301	-0.018	0.005	-0.898	0.020	0.807
1A2c Biomass	NOx	0.000	0.012	3	38	38.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2d Solid Fuels	NOx	0.000	0.023	3	51	51.1	0.000	0.000	0.000	0.002	0.000	0.000
1A2d Gaseous Fuels	NOx	0.000	0.391	3	50	50.1	0.009	0.001	0.001	0.042	0.004	0.002
1A2d Biomass	NOx	0.000	0.015	3	38	38.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2e Liquid Fuels	NOx	0.000	0.013	3	50	50.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2e Solid Fuels	NOx	0.223	0.100	3	51	51.1	0.001	0.000	0.000	0.000	0.001	0.000
1A2e Gaseous Fuels	NOx	0.000	1.068	3	50	50.1	0.069	0.002	0.002	0.113	0.010	0.013
1A2e Biomass	NOx	0.000	0.086	3	38	38.1	0.000	0.000	0.000	0.007	0.001	0.000
1A2f clinker	NOx	0.000	8.744	3	101	101.0	18.960	0.019	0.019	1.876	0.079	3.527
1A2f Liquid Fuels	NOx	0.000	0.515	3	50	50.1	0.016	0.001	0.001	0.055	0.005	0.003

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I∗F (Note C)	J∗E∗$\sqrt{2}$ (Note D)	$K^2 + L^2$
1A2f Solid Fuels	NOx	0.491	0.188	3	51	51.1	0.002	0.000	0.000	-0.002	0.002	0.000
1A2f Gaseous Fuels	NOx	0.000	0.729	3	50	50.1	0.032	0.002	0.002	0.077	0.007	0.006
1A2f Biomass	NOx	0.000	0.002	3	38	38.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2gvii	NOx	0.000	3.529	3	100	100.0	3.028	0.007	0.007	0.750	0.032	0.563
1A2gviii Liquid Fuels	NOx	31.171	0.029	3	50	50.1	0.000	-0.028	0.000	-1.424	0.000	2.026
1A2gviii Solid Fuels	NOx	1.486	0.009	3	51	51.1	0.000	-0.001	0.000	-0.068	0.000	0.005
1A2gviii Gaseous Fuels	NOx	18.268	1.901	3	50	50.1	0.220	-0.013	0.004	-0.634	0.017	0.403
1A2gviii Biomass	NOx	0.000	0.661	3	38	38.1	0.015	0.001	0.001	0.053	0.006	0.003
1A3ai(i)	NOx	0.401	0.663	5	50	50.2	0.027	0.001	0.001	0.052	0.010	0.003
1A3aii(i)	NOx	0.013	0.077	5	50	50.2	0.000	0.000	0.000	0.008	0.001	0.000
1A3bi	NOx	59.421	33.381	3	50	50.1	67.912	0.016	0.071	0.824	0.301	0.769
1A3bii	NOx	4.192	13.164	3	50	50.1	10.561	0.024	0.028	1.206	0.119	1.469
1A3biii	NOx	38.209	43.100	3	50	50.1	113.212	0.057	0.092	2.827	0.389	8.140
1A3biv	NOx	0.235	0.079	3	50	50.1	0.000	0.000	0.000	-0.002	0.001	0.000
1A3c	NOx	7.019	5.282	5	56	56.2	2.142	0.005	0.011	0.268	0.079	0.078
1A3di(ii)	NOx	0.000	0.614	5	100	100.1	0.092	0.001	0.001	0.130	0.009	0.017
1A3dii	NOx	22.596	3.218	5	100	100.1	2.522	-0.014	0.007	-1.385	0.048	1.921
1A4ai Liquid Fuels	NOx	0.000	0.054	3	112	112.0	0.001	0.000	0.000	0.013	0.000	0.000
1A4ai Solid Fuels	NOx	0.000	0.030	3	51	51.1	0.000	0.000	0.000	0.003	0.000	0.000
1A4ai Gaseous Fuels	NOx	0.000	2.756	3	51	51.1	0.482	0.006	0.006	0.299	0.025	0.090
1A4ai Biomass	NOx	0.000	0.300	3	38	38.1	0.003	0.001	0.001	0.024	0.003	0.001
1A4aii	NOx	0.000	0.327	3	100	100.0	0.026	0.001	0.001	0.070	0.003	0.005
1A4bi Liquid Fuels	NOx	0.186	0.065	3	50	50.1	0.000	0.000	0.000	-0.002	0.001	0.000
1A4bi Solid Fuels	NOx	3.599	0.209	3	54	54.1	0.003	-0.003	0.000	-0.154	0.002	0.024
1A4bi Gaseous Fuels	NOx	5.331	6.930	3	50	50.1	2.927	0.010	0.015	0.492	0.062	0.246

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I∗F (Note C)	J∗E∗$\sqrt{2}$ (Note D)	$K^2 + L^2$
1A4bi Biomass	NOx	1.219	6.827	3	90	90.0	9.182	0.013	0.015	1.205	0.062	1.456
1A4ci Liquid Fuels	NOx	0.038	0.999	3	112	112.0	0.304	0.002	0.002	0.234	0.009	0.055
1A4ci Solid Fuels	NOx	0.113	0.131	3	51	51.1	0.001	0.000	0.000	0.009	0.001	0.000
1A4ci Gaseous Fuels	NOx	2.570	0.295	3	50	50.1	0.005	-0.002	0.001	-0.086	0.003	0.007
1A4ci Biomass	NOx	0.000	0.037	3	38	38.1	0.000	0.000	0.000	0.003	0.000	0.000
1A4cii	NOx	0.000	1.648	3	100	100.0	0.661	0.004	0.004	0.350	0.015	0.123
1A5a Liquid Fuels	NOx	0.140	4.888	3	112	112.0	7.285	0.010	0.010	1.149	0.044	1.321
1A5a Solid Fuels	NOx	2.107	0.000	0	0	0.0	0.000	-0.002	0.000	0.000	0.000	0.000
1A5a Gaseous Fuels	NOx	0.003	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1B1b	NOx	0.004	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1B2aiv	NOx	0.785	0.750	2	51	51.0	0.036	0.001	0.002	0.045	0.005	0.002
1B2c	NOx	0.263	0.148	2	80	80.0	0.003	0.000	0.000	0.006	0.001	0.000
2B1	NOx	2.178	0.000	2	120	120.0	0.000	-0.002	0.000	-0.239	0.000	0.057
2B2	NOx	9.708	0.037	5	55	55.2	0.000	-0.009	0.000	-0.485	0.001	0.235
2B3	NOx	0.049	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
2B10a	NOx	0.870	0.000	0	0	0.0	0.000	-0.001	0.000	0.000	0.000	0.000
2C1	NOx	0.362	0.140	2	45	45.0	0.001	0.000	0.000	-0.002	0.001	0.000
2C3	NOx	0.168	0.081	2	100	100.0	0.002	0.000	0.000	0.002	0.000	0.000
2G	NOx	0.049	0.047	2	49	49.0	0.000	0.000	0.000	0.003	0.000	0.000
2H1	NOx	0.380	0.001	2	86	86.0	0.000	0.000	0.000	-0.030	0.000	0.001
3B1a	NOx	2.191	0.562	10	300	300.2	0.692	-0.001	0.001	-0.243	0.017	0.060
3B1b	NOx	0.487	0.115	10	300	300.2	0.029	0.000	0.000	-0.061	0.003	0.004
3B2	NOx	0.169	0.123	10	300	300.2	0.033	0.000	0.000	0.032	0.004	0.001
3B3	NOx	0.403	0.065	10	300	300.2	0.009	0.000	0.000	-0.069	0.002	0.005
3B4a	NOx	0.005	0.001	10	300	300.2	0.000	0.000	0.000	-0.001	0.000	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I∗F (Note C)	J∗E∗$\sqrt{2}$ (Note D)	$K^2 + L^2$
3B4d	NOx	0.012	0.018	10	300	300.2	0.001	0.000	0.000	0.008	0.001	0.000
3B4e	NOx	0.168	0.081	10	300	300.2	0.014	0.000	0.000	0.006	0.002	0.000
3B4gi	NOx	0.721	0.586	10	300	300.2	0.752	0.001	0.001	0.176	0.018	0.031
3B4gii	NOx	1.887	0.952	10	300	300.2	1.983	0.000	0.002	0.088	0.029	0.009
3B4giii	NOx	0.000	0.028	2	300	300.0	0.002	0.000	0.000	0.018	0.000	0.000
3B4giv	NOx	0.000	0.001	2	300	300.0	0.000	0.000	0.000	0.001	0.000	0.000
3B4h	NOx	0.001	0.000	10	300	300.2	0.000	0.000	0.000	0.000	0.000	0.000
3Da1	NOx	26.244	18.361	25	100	103.1	87.004	0.015	0.039	1.496	1.379	4.142
3Da2a	NOx	16.007	8.072	20	100	102.0	16.461	0.002	0.017	0.249	0.485	0.297
3Da2b	NOx	0.006	0.022	20	100	102.0	0.000	0.000	0.000	0.004	0.001	0.000
3F	NOx	0.012	0.012	20	254.4	255.2	0.000	0.000	0.000	0.003	0.001	0.000
5C1bi	NOx	0.000	0.002	20	253	253.8	0.000	0.000	0.000	0.001	0.000	0.000
5C1biii	NOx	0.004	0.026	20	49	52.9	0.000	0.000	0.000	0.003	0.002	0.000
5C1bv	NOx	0.001	0.002	2	253	253.0	0.000	0.000	0.000	0.001	0.000	0.000
5C2	NOx	0.453	0.412	2	83	83.0	0.028	0.000	0.001	0.038	0.002	0.001
Total		**470.67**	**202.90**				**353.64**					**32.39**
Total Uncertainties						**Uncertainty in total inventory %:**	**18.81**				**Trend uncertainty %:**	**5.69**

Uncertainty estimation of NMVOC emissions 1990 and 2022

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I*F (Note C)	J*E*$\sqrt{2}$ (Note D)	$K^2 + L^2$
1A1a	NMVOC	2.011	0.558	3	100	100.0	0.056	-0.001	0.001	-0.124	0.005	0.015
1A1b Liquid Fuels	NMVOC	0.024	0.000	3	50	50.1	0.000	0.000	0.000	-0.002	0.000	0.000
1A1b Gaseous Fuels	NMVOC	0.174	0.048	3	106	106.0	0.000	0.000	0.000	-0.011	0.000	0.000
1A1b Biomass	NMVOC	0.000	0.000	3	83	83.1	0.000	0.000	0.000	0.000	0.000	0.000
1A1c Liquid Fuels	NMVOC	0.029	0.195	3	88	88.1	0.005	0.000	0.000	0.037	0.002	0.001
1A1c Gaseous Fuels	NMVOC	0.000	0.112	3	51	51.1	0.001	0.000	0.000	0.013	0.001	0.000
1A1c Biomass	NMVOC	0.000	0.001	3	42	42.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2a Solid Fuels	NMVOC	7.566	1.425	3	87	87.1	0.278	-0.006	0.003	-0.540	0.014	0.292
1A2a Gaseous Fuels	NMVOC	3.998	0.458	3	51	51.1	0.010	-0.004	0.001	-0.202	0.004	0.041
1A2a Biomass	NMVOC	0.000	0.001	3	42	42.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Liquid Fuels	NMVOC	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Solid Fuels	NMVOC	0.619	0.006	3	87	87.1	0.000	-0.001	0.000	-0.066	0.000	0.004
1A2c Gaseous Fuels	NMVOC	7.699	0.690	3	51	51.1	0.022	-0.008	0.002	-0.412	0.007	0.170
1A2c Biomass	NMVOC	0.000	0.041	3	42	42.1	0.000	0.000	0.000	0.004	0.000	0.000
1A2d Solid Fuels	NMVOC	0.000	0.012	3	87	87.1	0.000	0.000	0.000	0.002	0.000	0.000
1A2d Gaseous Fuels	NMVOC	0.000	0.121	3	51	51.1	0.001	0.000	0.000	0.014	0.001	0.000
1A2d Biomass	NMVOC	0.000	0.048	3	42	42.1	0.000	0.000	0.000	0.005	0.000	0.000
1A2e Liquid Fuels	NMVOC	0.000	0.001	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Solid Fuels	NMVOC	0.115	0.051	3	87	87.1	0.000	0.000	0.000	-0.002	0.001	0.000
1A2e Gaseous Fuels	NMVOC	0.000	0.332	3	51	51.1	0.005	0.001	0.001	0.039	0.003	0.002
1A2e Biomass	NMVOC	0.000	0.285	3	42	42.1	0.003	0.001	0.001	0.028	0.003	0.001
1A2f clinker	NMVOC	0.000	0.127	3	195	195.0	0.011	0.000	0.000	0.057	0.001	0.003
1A2f Liquid Fuels	NMVOC	0.000	0.025	3	50	50.1	0.000	0.000	0.000	0.003	0.000	0.000
1A2f Solid Fuels	NMVOC	0.252	0.097	3	87	87.1	0.001	0.000	0.000	-0.008	0.001	0.000
1A2f Gaseous Fuels	NMVOC	0.000	0.227	3	51	51.1	0.002	0.001	0.001	0.027	0.002	0.001
1A2f Biomass	NMVOC	0.000	0.006	3	42	42.1	0.000	0.000	0.000	0.001	0.000	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I*F (Note C)	J*E*√2 (Note D)	$K^2 + L^2$
1A2gvii	NMVOC	0.000	0.752	3	100	100.0	0.102	0.002	0.002	0.174	0.007	0.030
1A2gviii Liquid Fuels	NMVOC	1.519	0.001	3	50	50.1	0.000	-0.002	0.000	-0.095	0.000	0.009
1A2gviii Solid Fuels	NMVOC	0.763	0.004	3	87	87.1	0.000	-0.001	0.000	-0.082	0.000	0.007
1A2gviii Gaseous Fuels	NMVOC	5.678	0.591	3	51	51.1	0.016	-0.006	0.001	-0.294	0.006	0.087
1A2gviii Biomass	NMVOC	0.000	2.180	3	42	42.1	0.152	0.005	0.005	0.212	0.021	0.045
1A3ai(i)	NMVOC	0.049	0.031	5	50	50.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3aii(i)	NMVOC	0.002	0.005	5	50	50.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3bi	NMVOC	67.326	8.828	3	50	50.1	3.531	-0.064	0.020	-3.204	0.087	10.271
1A3bii	NMVOC	2.905	1.853	3	50	50.1	0.155	0.001	0.004	0.032	0.018	0.001
1A3biii	NMVOC	3.762	2.672	3	50	50.1	0.324	0.001	0.006	0.072	0.026	0.006
1A3biv	NMVOC	7.983	0.641	3	50	50.1	0.019	-0.009	0.001	-0.427	0.006	0.183
1A3bv	NMVOC	3.919	5.750	3	50	50.1	1.498	0.008	0.013	0.418	0.056	0.178
1A3c	NMVOC	0.623	0.469	5	54	54.2	0.012	0.000	0.001	0.016	0.008	0.000
1A3di(ii)	NMVOC	0.000	0.015	5	100	100.1	0.000	0.000	0.000	0.003	0.000	0.000
1A3dii	NMVOC	0.546	0.078	5	100	100.1	0.001	-0.001	0.000	-0.051	0.001	0.003
1A4ai Liquid Fuels	NMVOC	0.000	0.004	3	88	88.1	0.000	0.000	0.000	0.001	0.000	0.000
1A4ai Solid Fuels	NMVOC	0.000	0.015	3	87	87.1	0.000	0.000	0.000	0.003	0.000	0.000
1A4ai Gaseous Fuels	NMVOC	0.000	0.014	3	49	49.1	0.000	0.000	0.000	0.002	0.000	0.000
1A4ai Biomass	NMVOC	0.000	0.514	3	42	42.1	0.008	0.001	0.001	0.050	0.005	0.003
1A4aii	NMVOC	0.000	1.406	3	100	100.0	0.357	0.003	0.003	0.325	0.014	0.106
1A4bi Liquid Fuels	NMVOC	0.003	0.001	3	51	51.1	0.000	0.000	0.000	0.000	0.000	0.000
1A4bi Solid Fuels	NMVOC	15.835	0.921	3	56	56.1	0.048	-0.018	0.002	-0.994	0.009	0.989
1A4bi Gaseous Fuels	NMVOC	0.199	0.258	3	49	49.1	0.003	0.000	0.001	0.017	0.003	0.000
1A4bi Biomass	NMVOC	14.338	72.406	3	126	126.0	1503.592	0.149	0.167	18.801	0.710	353.993
1A4ci Liquid Fuels	NMVOC	0.002	0.065	3	88	88.1	0.001	0.000	0.000	0.013	0.001	0.000
1A4ci Solid Fuels	NMVOC	0.058	0.067	3	87	87.1	0.001	0.000	0.000	0.007	0.001	0.000
1A4ci Gaseous Fuels	NMVOC	0.799	0.092	3	51	51.1	0.000	-0.001	0.000	-0.040	0.001	0.002
1A4ci Biomass	NMVOC	0.000	0.123	3	42	42.1	0.000	0.000	0.000	0.012	0.001	0.000
1A4cii	NMVOC	0.000	0.418	3	100	100.0	0.032	0.001	0.001	0.097	0.004	0.009

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I∗F (Note C)	J∗E∗√2 (Note D)	$K^2 + L^2$
1A5a Liquid Fuels	NMVOC	0.009	0.319	3	88	88.1	0.014	0.001	0.001	0.064	0.003	0.004
1A5a Solid Fuels	NMVOC	1.082	0.000	0	0	0.0	0.000	-0.001	0.000	0.000	0.000	0.000
1A5a Gaseous Fuels	NMVOC	0.001	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1B1a	NMVOC	34.266	4.174	3	68	68.1	1.458	-0.033	0.010	-2.269	0.041	5.151
1B1b	NMVOC	0.031	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1B2ai	NMVOC	4.797	2.322	3	801	801.0	62.480	-0.001	0.005	-0.529	0.023	0.280
1B2aiv	NMVOC	3.359	4.699	2	77	77.0	2.365	0.007	0.011	0.511	0.031	0.262
1B2av	NMVOC	4.721	0.546	3	2	3.6	0.000	-0.005	0.001	-0.009	0.005	0.000
1B2b	NMVOC	3.567	1.191	3	1550	1550.0	61.538	-0.002	0.003	-2.679	0.012	7.176
1B2c	NMVOC	0.338	0.0099	2	74	74.0	0.000	0.000	0.000	-0.030	0.000	0.001
2A3	NMVOC	0.013	0.012	5	145	145.1	0.000	0.000	0.000	0.002	0.000	0.000
2B10a	NMVOC	14.772	1.090	2	65	65.0	0.091	-0.016	0.003	-1.042	0.007	1.086
2C1	NMVOC	1.546	0.426	2	70	70.0	0.016	-0.001	0.001	-0.067	0.003	0.005
2D3a	NMVOC	26.961	23.015	3	40	40.1	15.387	0.019	0.053	0.772	0.226	0.646
2D3b	NMVOC	0.007	0.024	3	161	161.0	0.000	0.000	0.000	0.007	0.000	0.000
2D3c	NMVOC	0.013	0.000	3	85	85.1	0.000	0.000	0.000	-0.001	0.000	0.000
2D3d	NMVOC	6.241	6.476	2	2	2.8	0.006	0.007	0.015	0.014	0.042	0.002
2D3e	NMVOC	24.823	0.002	3	39	39.1	0.000	-0.031	0.000	-1.215	0.000	1.477
2D3f	NMVOC	1.242	0.179	3	50	50.1	0.001	-0.001	0.000	-0.057	0.002	0.003
2D3g	NMVOC	19.287	15.499	2	45	45.0	8.800	0.012	0.036	0.521	0.101	0.282
2D3h	NMVOC	0.000	0.696	2	2	2.8	0.000	0.002	0.002	0.003	0.005	0.000
2D3i	NMVOC	5.971	4.870	2	8	8.2	0.029	0.004	0.011	0.030	0.032	0.002
2G	NMVOC	0.131	0.501	2	16	16.1	0.001	0.001	0.001	0.016	0.003	0.000
2H1	NMVOC	0.760	0.001	3	63	63.1	0.000	-0.001	0.000	-0.060	0.000	0.004
2H2	NMVOC	10.009	7.958	3	118	118.0	15.930	0.006	0.018	0.686	0.078	0.476
3B1a	NMVOC	30.163	13.403	10	100	100.5	32.756	-0.007	0.031	-0.692	0.438	0.671
3B1b	NMVOC	17.906	5.465	10	100	100.5	5.447	-0.010	0.013	-0.986	0.179	1.004
3B2	NMVOC	2.423	1.766	10	200	200.2	2.257	0.001	0.004	0.207	0.058	0.046
3B3	NMVOC	7.710	2.162	10	200	200.2	3.385	-0.005	0.005	-0.938	0.071	0.884

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I∗F (Note C)	J∗E∗√2 (Note D)	$K^2 + L^2$
3B4a	NMVOC	0.284	0.078	10	200	200.2	0.004	0.000	0.000	-0.035	0.003	0.001
3B4d	NMVOC	0.547	0.808	10	200	200.2	0.472	0.001	0.002	0.236	0.026	0.056
3B4e	NMVOC	2.864	1.382	10	200	200.2	1.384	0.000	0.003	-0.081	0.045	0.009
3B4gi	NMVOC	2.230	1.814	10	100	100.5	0.600	0.001	0.004	0.139	0.059	0.023
3B4gii	NMVOC	6.569	3.314	10	100	100.5	2.003	-0.001	0.008	-0.059	0.108	0.015
3B4giii	NMVOC	0.003	0.501	2	200	200.0	0.181	0.001	0.001	0.231	0.003	0.053
3B4giv	NMVOC	0.010	0.027	2	200	200.0	0.001	0.000	0.000	0.010	0.000	0.000
3B4h	NMVOC	0.078	0.012	10	200	200.2	0.000	0.000	0.000	-0.014	0.000	0.000
3Da2a	NMVOC	39.505	14.970	10	100	100.5	40.866	-0.015	0.035	-1.502	0.489	2.497
3Da3	NMVOC	1.467	0.591	10	100	100.5	0.064	0.000	0.001	-0.048	0.019	0.003
3De	NMVOC	7.500	7.702	2	106	106.0	12.038	0.008	0.018	0.887	0.050	0.790
3F	NMVOC	0.024	0.020	5	250.1	250.2	0.000	0.000	0.000	0.004	0.000	0.000
5A	NMVOC	0.650	2.063	20	56	59.5	0.272	0.004	0.005	0.221	0.135	0.067
5C1bi	NMVOC	0.002	0.014	20	253	253.8	0.000	0.000	0.000	0.007	0.001	0.000
5C1biii	NMVOC	0.002	0.010	20	61	64.2	0.000	0.000	0.000	0.001	0.001	0.000
5C1bv	NMVOC	0.000	0.000	2	253	253.0	0.000	0.000	0.000	0.000	0.000	0.000
5C2	NMVOC	0.175	0.159	2	84	84.0	0.003	0.000	0.000	0.012	0.001	0.000
5D3	NMVOC	0.000	0.024	2	92	92.0	0.000	0.000	0.000	0.005	0.000	0.000
Total		**432.85**	**235.34**				**1780.10**					**389.43**
Total uncertainties						**Uncertainty in total inventory %:**	**42.19**				**Trend uncertainty %:**	**19.73**

Uncertainty estimation of SOx emissions 1990 and 2022

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I∗F (Note C)	J∗E∗$\sqrt{2}$ (Note D)	K² + L²
1A1a	SOx	646.896	18.527	3	20	20.2	64.662	-0.022	0.023	-0.442	0.096	0.205
1A1b Liquid Fuels	SOx	5.207	0.021	3	93	93.0	0.002	0.000	0.000	-0.031	0.000	0.001
1A1b Gaseous Fuels	SOx	0.019	0.005	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A1b Biomass	SOx	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A1c Liquid Fuels	SOx	0.136	0.918	3	45	45.1	0.790	0.001	0.001	0.050	0.005	0.003
1A1c Gaseous Fuels	SOx	0.000	0.003	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A1c Biomass	SOx	0.000	0.000	3	109	109.0	0.000	0.000	0.000	0.000	0.000	0.000
1A2a Solid Fuels	SOx	76.682	14.438	3	40	40.1	154.489	0.012	0.018	0.492	0.075	0.247
1A2a Gaseous Fuels	SOx	0.116	0.013	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2a Biomass	SOx	0.000	0.000	3	46	46.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Liquid Fuels	SOx	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Solid Fuels	SOx	6.275	0.064	3	40	40.1	0.003	0.000	0.000	-0.014	0.000	0.000
1A2c Gaseous Fuels	SOx	0.224	0.020	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Biomass	SOx	0.000	0.001	3	46	46.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2d Solid Fuels	SOx	0.000	0.120	3	40	40.1	0.011	0.000	0.000	0.006	0.001	0.000
1A2d Gaseous Fuels	SOx	0.000	0.004	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2d Biomass	SOx	0.000	0.002	3	46	46.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Liquid Fuels	SOx	0.000	0.001	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Solid Fuels	SOx	1.162	0.518	3	40	40.1	0.199	0.001	0.001	0.022	0.003	0.000
1A2e Gaseous Fuels	SOx	0.000	0.010	3	50	50.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2e Biomass	SOx	0.000	0.010	3	46	46.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2f clinker	SOx	0.000	2.635	3	50	50.1	8.024	0.003	0.003	0.161	0.014	0.026
1A2f Liquid Fuels	SOx	0.000	0.047	3	50	50.1	0.003	0.000	0.000	0.003	0.000	0.000
1A2f Solid Fuels	SOx	2.552	0.980	3	40	40.1	0.712	0.001	0.001	0.041	0.005	0.002

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I∗F (Note C)	J∗E∗√2 (Note D)	$K^2 + L^2$
1A2f Gaseous Fuels	SOx	0.000	0.007	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2f Biomass	SOx	0.000	0.000	3	46	46.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2gvii	SOx	0.000	0.007	3	100	100.0	0.000	0.000	0.000	0.001	0.000	0.000
1A2gviii Liquid Fuels	SOx	2.856	0.003	3	50	50.1	0.000	0.000	0.000	-0.010	0.000	0.000
1A2gviii Solid Fuels	SOx	7.731	0.045	3	40	40.1	0.001	0.000	0.000	-0.019	0.000	0.000
1A2gviii Gaseous Fuels	SOx	0.165	0.017	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2gviii Biomass	SOx	0.000	0.080	3	46	46.1	0.006	0.000	0.000	0.004	0.000	0.000
1A3ai(i)	SOx	0.029	0.039	5	20	20.6	0.000	0.000	0.000	0.001	0.000	0.000
1A3aii(i)	SOx	0.001	0.005	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
1A3bi	SOx	0.707	0.066	3	20	20.2	0.001	0.000	0.000	0.001	0.000	0.000
1A3bii	SOx	0.100	0.017	3	20	20.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3biii	SOx	0.798	0.044	3	20	20.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3biv	SOx	0.007	0.000	3	20	20.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	SOx	0.268	0.002	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
1A3di(ii)	SOx	0.000	0.017	5	40	40.3	0.000	0.000	0.000	0.001	0.000	0.000
1A3dii	SOx	17.658	0.089	5	40	40.3	0.006	-0.001	0.000	-0.045	0.001	0.002
1A4ai Liquid Fuels	SOx	0.000	0.017	3	45	45.1	0.000	0.000	0.000	0.001	0.000	0.000
1A4ai Solid Fuels	SOx	0.000	0.144	3	43	43.1	0.018	0.000	0.000	0.008	0.001	0.000
1A4ai Gaseous Fuels	SOx	0.000	0.053	3	50	50.1	0.003	0.000	0.000	0.003	0.000	0.000
1A4ai Biomass	SOx	0.000	0.036	3	109	109.0	0.007	0.000	0.000	0.005	0.000	0.000
1A4aii	SOx	0.000	0.001	3	100	100.0	0.000	0.000	0.000	0.000	0.000	0.000
1A4bi Liquid Fuels	SOx	0.256	0.090	3	50	50.1	0.009	0.000	0.000	0.005	0.000	0.000
1A4bi Solid Fuels	SOx	29.444	1.713	3	36	36.1	1.765	0.000	0.002	0.002	0.009	0.000
1A4bi Gaseous Fuels	SOx	0.031	0.041	3	50	50.1	0.002	0.000	0.000	0.002	0.000	0.000
1A4bi Biomass	SOx	0.265	1.415	3	109	109.0	10.959	0.002	0.002	0.186	0.007	0.035
1A4ci Liquid Fuels	SOx	0.012	0.307	3	45	45.1	0.088	0.000	0.000	0.017	0.002	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I∗F (Note C)	J∗E∗√2 (Note D)	$K^2 + L^2$
1A4ci Solid Fuels	SOx	0.548	0.635	3	43	43.1	0.345	0.001	0.001	0.032	0.003	0.001
1A4ci Gaseous Fuels	SOx	0.023	0.003	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A4ci Biomass	SOx	0.000	0.005	3	109	109.0	0.000	0.000	0.000	0.001	0.000	0.000
1A4cii	SOx	0.000	0.006	3	100	100.0	0.000	0.000	0.000	0.001	0.000	0.000
1A5a Liquid fuels	SOx	0.043	1.501	3	43	43.1	1.929	0.002	0.002	0.079	0.008	0.006
1A5a Solid Fuels	SOx	10.231	0.000	0	0	0.0	0.000	-0.001	0.000	0.000	0.000	0.000
1A5a Gaseous Fuels	SOx	0.000	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1B1b	SOx	0.003	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1B2aiv	SOx	5.498	0.931	2	66	66.0	1.740	0.001	0.001	0.050	0.003	0.002
1B2c	SOx	0.002	0.206	2	50	50.0	0.049	0.000	0.000	0.013	0.001	0.000
2B10a	SOx	1.276	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
2C1	SOx	0.143	0.057	2	64	64.0	0.006	0.000	0.000	0.004	0.000	0.000
2C3	SOx	0.839	0.407	2	250	250.0	4.770	0.000	0.000	0.110	0.001	0.012
2C4	SOx	0.000	0.159	2	226	226.0	0.592	0.000	0.000	0.044	0.001	0.002
2C5	SOx	0.019	0.067	2	64	64.0	0.009	0.000	0.000	0.005	0.000	0.000
2C6	SOx	0.015	0.001	2	170	170.0	0.000	0.000	0.000	0.000	0.000	0.000
2C7a	SOx	0.324	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
2G	SOx	0.000	0.007	2	50	50.0	0.000	0.000	0.000	0.000	0.000	0.000
2H1	SOx	0.760	0.001	2	51	51.0	0.000	0.000	0.000	-0.003	0.000	0.000
3F	SOx	0.002	0.002	2	250.2	250.2	0.000	0.000	0.000	0.000	0.000	0.000
5C1bi	SOx	0.000	0.000	20	253	253.8	0.000	0.000	0.000	0.000	0.000	0.000
5C1biii	SOx	0.000	0.001	20	50	53.9	0.000	0.000	0.000	0.000	0.000	0.000
5C1bv	SOx	0.000	0.000	2	253	253.0	0.000	0.000	0.000	0.000	0.000	0.000
5C2	SOx	0.016	0.014	2	82	82.0	0.001	0.000	0.000	0.001	0.000	0.000
Total		**819.34**	**46.60**				**251.20**					**0.55**
Total Uncertainties				**Uncertainty in total inventory %:**			**15.85**			**Trend uncertainty %:**		**0.74**

Uncertainty estimation of NH_3 emissions 1990 and 2022

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I∗F (Note C)	J∗E∗√2 (Note D)	$K^2 + L^2$
1A1c Biomass	NH3	0.000	0.000	3	62	62.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2a Biomass	NH3	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Biomass	NH3	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2d Biomass	NH3	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Biomass	NH3	0.000	0.001	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2f Biomass	NH3	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2gvii	NH3	0.000	0.003	3	200	200.0	0.000	0.000	0.000	0.002	0.000	0.000
1A2gviii Biomass	NH3	0.000	0.009	3	50	50.1	0.000	0.000	0.000	0.001	0.000	0.000
1A3bi	NH3	2.825	0.806	3	50	50.1	0.073	-0.002	0.003	-0.081	0.011	0.007
1A3bii	NH3	0.122	0.058	3	50	50.1	0.000	0.000	0.000	0.000	0.001	0.000
1A3biii	NH3	0.018	0.075	3	50	50.1	0.001	0.000	0.000	0.010	0.001	0.000
1A3biv	NH3	0.001	0.001	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A3c	NH3	0.001	0.001	5	57	57.2	0.000	0.000	0.000	0.000	0.000	0.000
1A4ai biomass	NH3	0.000	0.122	3	62	62.1	0.003	0.000	0.000	0.024	0.002	0.001
1A4aii	NH3	0.000	0.000	3	200	200.0	0.000	0.000	0.000	0.000	0.000	0.000
1A4bi solid	NH3	0.010	0.001	3	592	592.0	0.000	0.000	0.000	-0.007	0.000	0.000
1A4bi biomass	NH3	1.689	8.792	3	63	63.1	13.695	0.025	0.027	1.574	0.116	2.491
1A4ci biomass	NH3	0.000	0.015	3	62	62.1	0.000	0.000	0.000	0.003	0.000	0.000
1A4cii	NH3	0.000	0.002	3	200	200.0	0.000	0.000	0.000	0.002	0.000	0.000
1B1b	NH3	0.015	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I∗F (Note C)	J∗E∗√2 (Note D)	K² + L²
1B2aiv	NH3	0.628	0.003	2	49	49.0	0.000	-0.001	0.000	-0.045	0.000	0.002
2A3	NH3	0.037	0.035	5	121	121.1	0.001	0.000	0.000	0.007	0.001	0.000
2B1	NH3	0.022	0.000	5	95	95.1	0.000	0.000	0.000	-0.003	0.000	0.000
2B7	NH3	0.569	0.000	0	0	0.0	0.000	-0.001	0.000	0.000	0.000	0.000
2B10a	NH3	0.000	0.004	2	160	160.0	0.000	0.000	0.000	0.002	0.000	0.000
2G	NH3	0.112	0.107	2	50	50.0	0.001	0.000	0.000	0.009	0.001	0.000
3B1a	NH3	32.471	13.150	10	100	100.5	77.790	-0.006	0.041	-0.636	0.581	0.742
3B1b	NH3	16.171	6.284	10	100	100.5	17.765	-0.004	0.020	-0.400	0.277	0.237
3B2	NH3	6.832	4.978	10	100	100.5	11.149	0.006	0.016	0.556	0.220	0.358
3B3	NH3	51.838	14.655	10	100	100.5	96.609	-0.030	0.046	-2.991	0.647	9.367
3B4a	NH3	0.278	0.077	10	150	150.3	0.006	0.000	0.000	-0.025	0.003	0.001
3B4d	NH3	0.402	0.593	10	150	150.3	0.354	0.001	0.002	0.190	0.026	0.037
3B4e	NH3	4.690	2.264	10	150	150.3	5.157	0.000	0.007	0.033	0.100	0.011
3B4gi	NH3	5.772	4.697	10	100	100.5	9.924	0.006	0.015	0.623	0.207	0.431
3B4gii	NH3	9.084	4.584	10	150	150.3	21.147	0.001	0.014	0.156	0.202	0.065
3B4giii	NH3	0.003	0.574	2	100	100.0	0.147	0.002	0.002	0.179	0.005	0.032
3B4giv	NH3	0.009	0.025	2	100	100.0	0.000	0.000	0.000	0.006	0.000	0.000
3B4h	NH3	0.027	0.004	10	100	100.5	0.000	0.000	0.000	-0.003	0.000	0.000
3Da1	NH3	41.569	25.155	25	100	103.1	299.448	0.018	0.079	1.780	2.777	10.878
3Da2a	NH3	94.607	38.515	10	100	100.5	667.298	-0.018	0.120	-1.788	1.701	6.090
3Da2b	NH3	0.019	0.075	25	100	103.1	0.003	0.000	0.000	0.021	0.008	0.000
3Da3	NH3	35.054	18.733	10	100	100.5	157.860	0.007	0.058	0.728	0.827	1.214
3F	NH3	0.014	0.013	2	250.2	250.2	0.000	0.000	0.000	0.005	0.000	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2 + F^2}$	$\frac{(G * D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I∗F (Note C)	J∗E∗√2 (Note D)	$K^2 + L^2$
5B1	NH3	0.000	0.024	2	83	83.0	0.000	0.000	0.000	0.006	0.000	0.000
5B2	NH3	0.000	0.019	10	58	58.9	0.000	0.000	0.000	0.003	0.001	0.000
5D3	NH3	15.403	5.388	2	63	63.0	5.138	-0.006	0.017	-0.357	0.048	0.130
Total		**320.29**	**149.84**				**1383.57**					**32.09**
Total Uncertainties					**Uncertainty in total inventory %:**		**37.20**				**Trend uncertainty %:**	**5.67**

Uncertainty estimation of $PM_{2.5}$ emissions 1990 and 2022

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\lvert\frac{D}{\sum C}\right\rvert$	I∙F (Note C)	J∙E∙√2 (Note D)	$K^2 + L^2$
1A1a	PM2.5	16.263	1.071	3	3	4.2	0.002	-0.277	0.014	-0.832	0.059	0.695
1A1b Liquid Fuels	PM2.5	0.203	0.001	3	118	118.0	0.000	-0.004	0.000	-0.428	0.000	0.183
1A1b Gaseous Fuels	PM2.5	0.059	0.017	3	50	50.1	0.000	-0.001	0.000	-0.043	0.001	0.002
1A1b Biomass	PM2.5	0.000	0.000	3	62	62.1	0.000	0.000	0.000	0.000	0.000	0.000
1A1c Liquid Fuels	PM2.5	0.026	0.176	3	84	84.1	0.019	0.002	0.002	0.152	0.010	0.023
1A1c Gaseous Fuels	PM2.5	0.000	0.004	3	50	50.1	0.000	0.000	0.000	0.002	0.000	0.000
1A1c Biomass	PM2.5	0.000	0.001	3	63	63.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2a Solid Fuels	PM2.5	9.202	1.733	3	65	65.1	1.101	-0.142	0.022	-9.260	0.095	85.754
1A2a Gaseous Fuels	PM2.5	0.136	0.016	3	50	50.1	0.000	-0.002	0.000	-0.112	0.001	0.012
1A2a Biomass	PM2.5	0.000	0.000	3	62	62.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Liquid Fuels	PM2.5	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Solid Fuels	PM2.5	0.753	0.008	3	65	65.1	0.000	-0.013	0.000	-0.871	0.000	0.759
1A2c Gaseous Fuels	PM2.5	0.261	0.023	3	50	50.1	0.000	-0.004	0.000	-0.219	0.001	0.048
1A2c Biomass	PM2.5	0.000	0.019	3	62	62.1	0.000	0.000	0.000	0.015	0.001	0.000
1A2d Solid Fuels	PM2.5	0.000	0.014	3	65	65.1	0.000	0.000	0.000	0.012	0.001	0.000
1A2d Gaseous Fuels	PM2.5	0.000	0.004	3	50	50.1	0.000	0.000	0.000	0.003	0.000	0.000
1A2d Biomass	PM2.5	0.000	0.022	3	62	62.1	0.000	0.000	0.000	0.018	0.001	0.000
1A2e Liquid Fuels	PM2.5	0.000	0.001	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Solid Fuels	PM2.5	0.139	0.062	3	65	65.1	0.001	-0.002	0.001	-0.110	0.003	0.012
1A2e Gaseous Fuels	PM2.5	0.000	0.011	3	50	50.1	0.000	0.000	0.000	0.007	0.001	0.000
1A2e Biomass	PM2.5	0.000	0.133	3	62	62.1	0.006	0.002	0.002	0.107	0.007	0.011
1A2f Liquid Fuels	PM2.5	0.000	0.020	3	50	50.1	0.000	0.000	0.000	0.013	0.001	0.000
1A2f Solid Fuels	PM2.5	0.306	0.118	3	65	65.1	0.005	-0.004	0.002	-0.258	0.006	0.067
1A2f Gaseous Fuels	PM2.5	0.000	0.008	3	50	50.1	0.000	0.000	0.000	0.005	0.000	0.000
1A2f Biomass	PM2.5	0.000	0.003	3	62	62.1	0.000	0.000	0.000	0.002	0.000	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I*F (Note C)	J*E*√2 (Note D)	$K^2 + L^2$
1A2gvii	PM2.5	0.000	0.148	3	100	100.0	0.019	0.002	0.002	0.191	0.008	0.036
1A2gviii Liquid Fuels	PM2.5	1.215	0.001	3	50	50.1	0.000	-0.022	0.000	-1.089	0.000	1.185
1A2gviii Solid Fuels	PM2.5	0.928	0.005	3	65	65.1	0.000	-0.017	0.000	-1.077	0.000	1.159
1A2gviii Gaseous Fuels	PM2.5	0.193	0.020	3	50	50.1	0.000	-0.003	0.000	-0.160	0.001	0.026
1A2gviii Biomass	PM2.5	0.000	1.017	3	62	62.1	0.345	0.013	0.013	0.815	0.056	0.667
1A3ai(i)	PM2.5	0.004	0.008	5	20	20.6	0.000	0.000	0.000	0.000	0.001	0.000
1A3aii(i)	PM2.5	0.000	0.001	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
1A3bi	PM2.5	0.284	1.160	3	50	50.1	0.292	0.010	0.015	0.494	0.064	0.248
1A3bii	PM2.5	0.249	0.556	3	50	50.1	0.067	0.003	0.007	0.136	0.030	0.019
1A3biii	PM2.5	1.567	1.082	3	50	50.1	0.255	-0.014	0.014	-0.705	0.059	0.501
1A3biv	PM2.5	0.132	0.012	3	50	50.1	0.000	-0.002	0.000	-0.110	0.001	0.012
1A3bvi	PM2.5	0.374	1.177	3	50	50.1	0.301	0.008	0.015	0.425	0.064	0.185
1A3bvii	PM2.5	0.214	0.530	3	50	50.1	0.061	0.003	0.007	0.150	0.029	0.023
1A3c	PM2.5	0.184	0.138	5	130	130.1	0.028	-0.002	0.002	-0.196	0.013	0.039
1A3di(ii)	PM2.5	0.000	0.008	5	40	40.3	0.000	0.000	0.000	0.004	0.001	0.000
1A3dii	PM2.5	1.530	0.044	5	40	40.3	0.000	-0.027	0.001	-1.075	0.004	1.155
1A4ai Liquid Fuels	PM2.5	0.000	0.003	3	84	84.1	0.000	0.000	0.000	0.003	0.000	0.000
1A4ai Solid Fuels	PM2.5	0.000	0.019	3	65	65.1	0.000	0.000	0.000	0.016	0.001	0.000
1A4ai Gaseous Fuels	PM2.5	0.000	0.017	3	50	50.1	0.000	0.000	0.000	0.011	0.001	0.000
1A4ai Biomass	PM2.5	0.000	0.325	3	63	63.1	0.036	0.004	0.004	0.264	0.018	0.070
1A4aii	PM2.5	0.000	0.044	3	100	100.0	0.002	0.001	0.001	0.057	0.002	0.003
1A4bi Liquid Fuels	PM2.5	0.007	0.002	3	49	49.1	0.000	0.000	0.000	-0.005	0.000	0.000
1A4bi Solid Fuels	PM2.5	13.021	0.758	3	35	35.1	0.061	-0.223	0.010	-7.817	0.042	61.102
1A4bi Gaseous Fuels	PM2.5	0.125	0.163	3	50	50.1	0.006	0.000	0.002	-0.007	0.009	0.000
1A4bi Biomass	PM2.5	17.702	89.848	3	63	63.1	2780.803	0.841	1.161	53.000	4.924	2833.297
1A4ci Liquid Fuels	PM2.5	0.002	0.059	3	84	84.1	0.002	0.001	0.001	0.060	0.003	0.004
1A4ci Solid Fuels	PM2.5	0.070	0.082	3	65	65.1	0.002	0.000	0.001	-0.014	0.004	0.000
1A4ci Gaseous Fuels	PM2.5	0.027	0.003	3	50	50.1	0.000	0.000	0.000	-0.022	0.000	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2+F^2}$	$\frac{(G*D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I∗F (Note C)	J∗E∗$\sqrt{2}$ (Note D)	$K^2 + L^2$
1A4ci Biomass	PM2.5	0.000	0.066	3	63	63.1	0.001	0.001	0.001	0.053	0.004	0.003
1A4cii	PM2.5	0.000	0.058	3	100	100.0	0.003	0.001	0.001	0.075	0.003	0.006
1A5a Liquid Fuels	PM2.5	0.008	0.288	3	84	84.1	0.051	0.004	0.004	0.300	0.016	0.090
1A5a Solid Fuels	PM2.5	1.315	0.000	0	0	0.0	0.000	-0.024	0.000	0.000	0.000	0.000
1A5a Gaseous Fuels	PM2.5	0.000	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
1B1a	PM2.5	0.172	0.108	3	253	253.0	0.065	-0.002	0.001	-0.428	0.006	0.183
1B1b	PM2.5	0.242	0.000	0	0	0.0	0.000	-0.004	0.000	0.000	0.000	0.000
1B2aiv	PM2.5	0.943	0.900	2	60	60.0	0.253	-0.005	0.012	-0.316	0.033	0.101
1B2c	PM2.5	0.489	0.007	2	253	253.0	0.000	-0.009	0.000	-2.196	0.000	4.821
2A1	PM2.5	1.089	0.550	2	63	63.0	0.104	-0.012	0.007	-0.783	0.020	0.614
2A2	PM2.5	1.418	0.018	2	75	75.0	0.000	-0.025	0.000	-1.889	0.001	3.567
2A3	PM2.5	0.146	0.079	5	444	444.0	0.106	-0.002	0.001	-0.714	0.007	0.509
2A5a	PM2.5	0.127	0.502	5	63	63.2	0.087	0.004	0.006	0.265	0.046	0.072
2A5b	PM2.5	0.058	0.128	5	85	85.1	0.010	0.001	0.002	0.052	0.012	0.003
2B10a	PM2.5	0.015	0.001	2	62	62.0	0.000	0.000	0.000	-0.015	0.000	0.000
2C1	PM2.5	2.407	0.314	2	61	61.0	0.032	-0.039	0.004	-2.385	0.011	5.687
2C2	PM2.5	0.085	0.000	0	0	0.0	0.000	-0.002	0.000	0.000	0.000	0.000
2C3	PM2.5	0.067	0.033	5	126	126.1	0.002	-0.001	0.000	-0.097	0.003	0.009
2C5	PM2.5	0.000	0.000	2	118	118.0	0.000	0.000	0.000	0.000	0.000	0.000
2C6	PM2.5	0.000	0.000	2	126	126.0	0.000	0.000	0.000	0.000	0.000	0.000
2C7a	PM2.5	0.010	0.000	0	0	0.0	0.000	0.000	0.000	0.000	0.000	0.000
2D3b	PM2.5	0.041	0.148	2	125	125.0	0.029	0.001	0.002	0.145	0.005	0.021
2D3c	PM2.5	0.008	0.000	2	84	84.0	0.000	0.000	0.000	-0.012	0.000	0.000
2G	PM2.5	0.729	0.813	2	46	46.0	0.121	-0.003	0.010	-0.118	0.030	0.015
2H1	PM2.5	0.228	0.000	2	81	81.0	0.000	-0.004	0.000	-0.331	0.000	0.109
3B1a	PM2.5	0.607	0.215	10	400	400.1	0.640	-0.008	0.003	-3.244	0.039	10.523
3B1b	PM2.5	0.205	0.067	10	400	400.1	0.062	-0.003	0.001	-1.128	0.012	1.273
3B2	PM2.5	0.023	0.017	10	400	400.1	0.004	0.000	0.000	-0.079	0.003	0.006

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2022)	Activity data uncertainty 2022	Emission factor uncertainty 2022	Combined uncertainty 2022	Combined uncertainty as % of total national emissions in year 2022	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		kt	kt	%	%	%	%	%	%	%	%	%
		Input data	Input data	Input data Note A	Input data Note A	$\sqrt{E^2 + F^2}$	$\frac{(G * D)^2}{(\sum D)^2}$	Note B	$\left\|\frac{D}{\sum C}\right\|$	I*F (Note C)	$J*E*\sqrt{2}$ (Note D)	$K^2 + L^2$
3B3	PM2.5	0.076	0.021	10	400	400.1	0.006	-0.001	0.000	-0.435	0.004	0.189
3B4a	PM2.5	0.018	0.005	10	400	400.1	0.000	0.000	0.000	-0.101	0.001	0.010
3B4d	PM2.5	0.002	0.002	10	400	400.1	0.000	0.000	0.000	0.001	0.000	0.000
3B4e	PM2.5	0.046	0.022	10	400	400.1	0.007	-0.001	0.000	-0.216	0.004	0.047
3B4gi	PM2.5	0.154	0.126	10	400	400.1	0.219	-0.001	0.002	-0.458	0.023	0.211
3B4gii	PM2.5	0.140	0.071	2	400	400.0	0.069	-0.002	0.001	-0.638	0.003	0.407
3B4giii	PM2.5	0.000	0.020	2	400	400.0	0.006	0.000	0.000	0.105	0.001	0.011
3B4giv	PM2.5	0.000	0.001	10	400	400.1	0.000	0.000	0.000	0.003	0.000	0.000
3B4h	PM2.5	0.005	0.001	10	400	400.1	0.000	0.000	0.000	-0.034	0.000	0.001
3Dc	PM2.5	0.727	0.675	2	138	138.0	0.752	-0.004	0.009	-0.594	0.025	0.354
3F	PM2.5	0.036	0.032	5	251.2	251.2	0.006	0.000	0.000	-0.058	0.003	0.003
5A	PM2.5	0.000	0.000	20	122	123.6	0.000	0.000	0.000	0.000	0.000	0.000
5C1bi	PM2.5	0.000	0.000	20	628	628.3	0.000	0.000	0.000	0.000	0.000	0.000
5C1bv	PM2.5	0.000	0.000	2	253	253.0	0.000	0.000	0.000	0.000	0.000	0.000
5C2	PM2.5	0.597	0.543	2	83	83.0	0.176	-0.004	0.007	-0.307	0.020	0.095
5E	PM2.5	0.000	0.939	2	65	65.0	0.323	0.012	0.012	0.788	0.034	0.623
Total		**77.41**	**107.46**				2786.55					3016.87
Total Uncertainties					**Uncertainty in total inventory %:**		**52.79**				**Trend uncertainty %:**	**54.93**

Notes are from EMEP/EEA Guidebook 2019.

1.8. General Assessment of Completeness

In the Romanian inventory notation keys are used where appropriate to ensure the transparency and comparability of the submission. Emissions have been estimated by applying emission factors using 2019 EMEP/EEA Guidebook.

Table 1.8. Notation keys used in NFR emission tables – Definition

Notation key	Meaning	Purpose
NO	Not occurring	For activities or processes which do not exist in Romania / for emissions by sources of compounds that do not occur for a particular compound or source category.
NE	Not estimated	Where emission occur, but have not been estimated or reported.
NA	Not applicable	We used for activities which are believed to result in emission which are insignificant to national totals
NR	Not relevant	According to the Emission Reporting Guidelines, NR (not relevant) is introduced to ease the reporting where emissions are not strictly required by the different protocols.
IE	Included elsewhere	For emissions of pollutants which are calculated, but included elsewhere from expected source category in the inventory
C	Confidential	For sources of data of confidential information

1.8.1 Sources reported as “NE“

The Inventory uses NE notation key for categories and pollutants that 2019 EMEP/EEA GB included under the “Not estimated” section of every emission factor table. Emission factors are not available in the methodological guidelines.

Table 1.8.1 Explanation to the Notation key NE year 2022

NFR	**NOx**	**NMVOC**	**SOx**	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	**BC**	**CO**	**Pb**	**Cd**	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Se**	**Zn**	**PCDD/ PCDF**	**PAH**	**HCB**	**PCBs**	**Reason for not estimation**
1A1a				NE																			*Lack of emission factors in EMEP/EEA Guidebook 2019*
1A1b				NE																			*Lack of emission factors in EMEP/EEA Guidebook 2019*
1A3ai(i)				NE			NE	NE		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE			*The values of pollutants due to the aviation activities were taken from the EUROCONTROL values.*
1A3aii(i)				NE			NE	NE		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE			*The values of pollutants due to the aviation activities were taken from the EUROCONTROL values.*
1A3bvi																			NE	NE	NE	NE	*Emissions are not estimated in COPERT.*
1A3bvii										NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	*Emissions are not estimated in COPERT.*
1A3c										NE		NE	NE						NE				*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
1A3di(ii)				NE																			*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2023*
1A3dii				NE																			*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2023*
1A5a				NE																			*Lack of emission factors in EMEP/EEA Guidebook 2019*
1B1a								NE		NE	NE	NE	NE	NE	NE	NE	NE	NE					*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
1B1b																					NE	NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
1B2ai			NE																NE				*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
1B2aiv																			NE				*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
1B2av			NE																NE				*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*

NFR	NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF	PAH	HCB	PCBs	Reason for not estimation
1B2b			NE																NE				*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
1B2c				NE															NE	NE		NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2B1		NE																					*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2B5	NE	NE	NE		NE	NE		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2B10a										NE	NE		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2C1				NE																			*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2C3										NE	NE	NE	NE	NE	NE	NE	NE	NE					*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2C5												NE		NE	NE	NE	NE			NE	NE		*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2C6														NE	NE	NE	NE			NE	NE		*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2C7c	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	*Emissions have not been estimated due to lack of activity data*
2C7d					NE	NE	NE																*Emissions have not been estimated due to lack of activity data*
2D3b																			NE	NE	NE		*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2D3c										NE	NE	NE							NE	NE	NE		*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2D3f					NE																		*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2D3g								NE							NE			NE	NE		NE	NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2D3h					NE																		*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2D3i	NE		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2G																	NE				NE	NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2H1				NE																NE	NE		*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2H2					NE	NE	NE	NE															*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
2I													NE		NE								*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*

NFR	NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF	PAH	HCB	PCBs	Reason for not estimation
2K												NE										NE	*Emissions have not been estimated due to lack of activity data*
3Df																					NE		*Emissions have not been estimated due to lack of activity data*
5A				NE				NE				NE											*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
5B1	NE	NE	NE		NE	NE	NE	NE	NE														*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
5B2	NE	NE	NE		NE	NE	NE	NE	NE	NE	NE	NE		NE				NE	NE	NE	NE	NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
5C1bi				NE										NE	NE		NE	NE				NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
5C1biii				NE	NE	NE											NE	NE					*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
5C1bv								NE															*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
5C2				NE								NE				NE					NE		*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
5D3					NE	NE	NE			NE	NE	NE	NE	NE	NE	NE	NE	NE					*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
5E	NE	NE	NE	NE				NE	NE							NE	NE	NE		NE	NE	NE	*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*

1.8.2 Explanation of the notation key "IE"

Table 1.8.2 Sources included elsewhere IE year 2022

NFR	NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn	PCDD/ PCDF	PAH	HCB	PCBs	Include in NFR code
1A2b	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	1A2a
1A4bii	IE	IE	IE	IE	IE	IE	IE	IE	IE		IE			IE	IE	IE	IE	IE		IE			1A3b
1A4ciii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	1A4cii
1A5b	IE	IE	IE	IE	IE	IE	IE	IE	IE		IE			IE	IE	IE	IE	IE		IE			1A5a
2A1	IE	IE	IE	IE					IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	1A2f
2A2	IE	IE	IE	IE					IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	1A2f
2A3	IE		IE						IE														1A2f
2B10b		IE		IE	IE	IE	IE	IE															2B10a
3B4f	IE	IE		IE	IE	IE	IE																3B4e
3Da3	IE																						3Da2a
5C1bii	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	5C1bi
5C1biv	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	5C1bi
5D1	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	5D3
5D2	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	5D3

2. EXPLANATION OF KEY TRENDS

2.1. Emission trends for Main Pollutants

Table 2.1.1 Total Emission trends (kt) for Main Pollutants, Particulate Matter, BC and CO

Year/Pollutant	NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
1990	470.668	432.853	819.340	320.292	77.412	132.811	286.537	5.763	1208.091
1991	398.660	365.103	700.151	262.469	63.879	108.205	219.265	5.164	955.175
1992	410.392	338.175	697.005	230.135	62.344	100.937	223.692	7.259	817.098
1993	369.611	317.413	699.732	226.840	64.886	105.850	222.050	7.241	758.765
1994	371.456	321.955	665.399	213.033	67.981	107.881	213.795	8.259	761.805
1995	373.771	331.612	696.116	215.854	73.426	114.793	237.118	8.443	750.944
1996	419.457	363.129	698.744	215.859	111.030	153.149	278.721	13.031	1095.157
1997	401.004	361.389	614.077	201.446	130.971	169.404	260.191	15.010	1243.112
1998	352.832	335.759	494.477	196.184	117.685	153.332	221.220	13.692	1179.520
1999	305.437	305.421	474.743	185.235	108.936	141.251	220.931	12.345	1022.859
2000	315.267	322.573	491.792	175.956	106.752	139.683	234.342	12.458	1054.330
2001	328.610	312.081	509.407	170.020	87.220	121.651	211.570	10.655	1029.775
2002	334.818	314.184	509.058	175.982	90.183	124.000	214.164	11.302	1034.411
2003	340.112	335.309	587.876	178.971	106.262	144.461	259.533	12.682	1090.879
2004	342.607	350.464	558.280	187.860	119.355	161.736	289.379	13.777	1193.292
2005	332.751	350.278	603.543	193.797	120.804	158.741	298.889	14.092	1223.661
2006	332.070	332.778	649.104	194.705	115.942	154.720	273.404	13.721	1135.022
2007	312.959	311.467	517.130	196.130	113.963	155.497	296.419	13.667	1115.339
2008	309.302	326.000	522.467	194.734	133.547	172.121	317.333	15.389	1157.736
2009	260.960	300.142	441.949	189.177	125.721	161.074	271.515	14.617	1041.996
2010	248.028	287.280	355.452	172.695	129.082	165.176	288.164	14.925	1045.135
2011	258.734	272.298	327.331	172.140	119.123	156.873	286.001	13.888	1003.377
2012	251.277	266.100	257.465	167.552	120.998	160.597	284.173	14.172	971.093
2013	230.661	259.924	207.991	169.691	113.566	150.532	257.544	13.363	948.663
2014	224.050	260.218	181.148	165.423	113.701	150.801	259.650	13.282	952.334
2015	222.030	257.350	148.968	169.460	108.633	145.115	237.346	12.815	907.295
2016	211.958	244.846	98.135	165.807	108.708	142.924	218.572	13.036	932.270
2017	220.633	247.094	78.443	163.707	109.737	142.528	206.682	13.273	935.666
2018	222.653	241.291	71.017	161.629	107.779	140.808	213.684	13.056	936.057
2019	219.194	245.190	85.957	158.793	108.876	146.437	224.833	13.010	942.175

Year/Pollutant	NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
2020	206.163	253.655	60.958	155.630	107.726	145.109	233.355	12.781	901.463
2021	214.161	251.145	66.344	156.813	113.994	152.318	223.090	13.600	952.990
2022	202.899	235.344	46.596	149.840	107.462	143.134	197.139	12.953	895.665

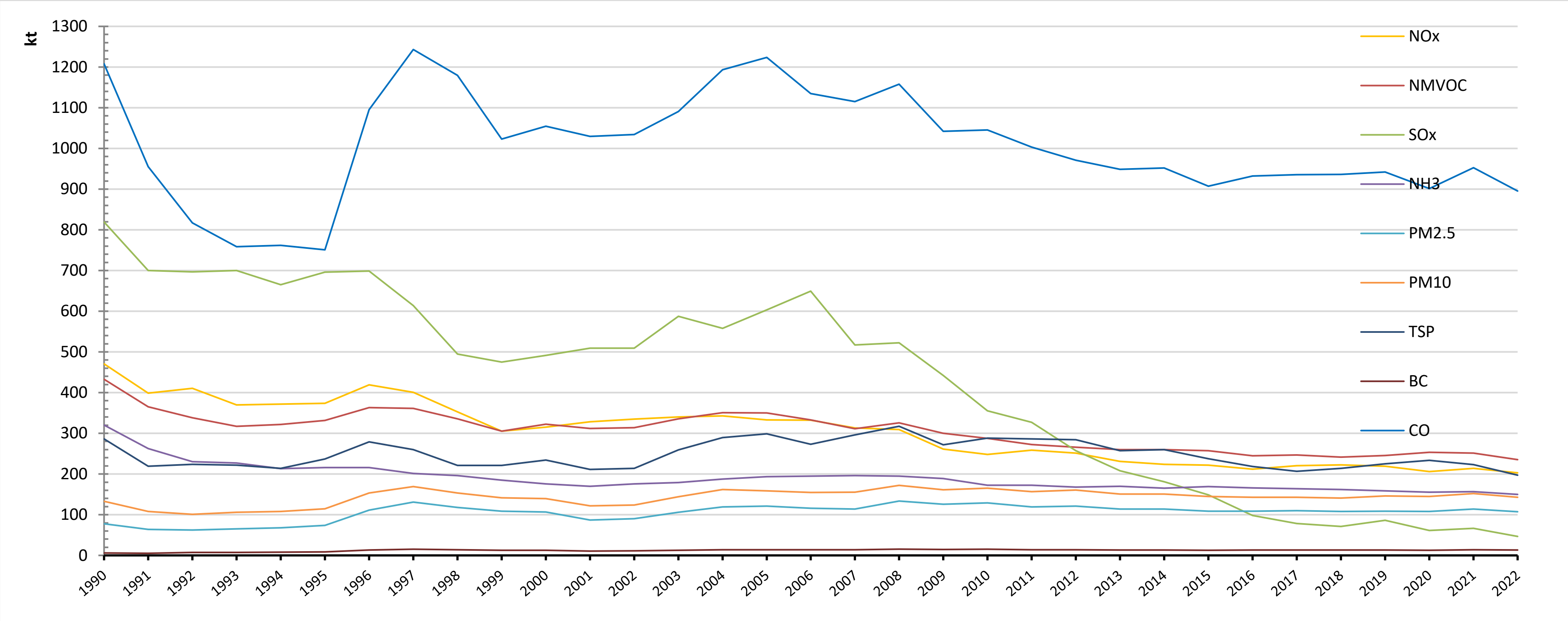


Figure 2.1.1. Total Emission trends (kt) for Main Pollutants, Particulate Matter, BC and CO

The chart shows the total emission trend for main pollutants, particulate matter, BC and CO between 1990-2022.

The most important variation can be noticed for SOx, starting from 819.3 kt/year in 1990, 603.5 kt /year in 2005 ending with 46.6 kt/year in 2022. SOx emissions decreased with 94.3% in 2022, compared to 1990 and with 92.3% in 2022, compared to 2005. Since 2009, SOx emissions have decreased dramatically. This was mainly due to the use of low-sulphur fuels and also the regulatory binding on maximal content of sulphur in fuels in transport diesel/gas oil. Also, many LCPs installed desulphurization equipment in order to achieve compliance with the EU legislation.

The variation NOx emissions are from 470.7 kt/year in 1990, to 332.7 kt/year in 2005 and to 202.9 kt/year in 2022. NOx emissions decreased with 56.9% in 2022, compared to 1990 and with 39% in 2022, compared to 2005, mainly due to the implementation of emissions reduction program in LCP installations as well as the decrease of the liquid fuel consumption.

NMVOC emissions decreased by almost 45,6% in 2022 compared to 1990 and 32.8% in 2022 compared to 2005. NMVOC emissions were 432.85 kt in 1990, 350.3 kt in 2005 and 235.3 kt in 2022.

NH3 emissions decreased from 320.3 kt in 1990 to 193.8kt in 2005 and to 149.8kt in 2022. NH3 emissions had also an overall decrease in the given period. NH3 emissions decreased by almost 53.2% in 2022 compared to 1990 and 22.7% in 2022 compared to 2005.

The evolution of PM2.5 emissions fluctuated from 77.4 kt in 1990 to 120.8 kt in 2005, and 107.5kt in 2022. Compared to 1990, PM2.5 emissions increased in 2005 by 38.8% and compared to 2005, PM2.5 emission decreased in 2022 by 11%.

The residential combustion (NFR 1A4bi) is a key source for PM2,5, contributing to the 2022 national total with 84,5%. The emissions originate mainly from the combustion of biomass (wood) for residential heating.

The trend reflects several issues: the economic growth in Romania in the interval 2002-2008, before the world economic crisis that triggered the decrease of industrial production, the decrease of energy production in fossil fuels power plants and the implementation of emission reduction technologies.

2.2. Emission trends for Heavy Metals

Table 2.2.1 Total Emission trends (t) for Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn

Year/Pollutant (t)	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
1990	728.685	5.024	4.187	72.777	25.139	9.773	113.017	19.673	124.622
1991	459.281	4.025	3.257	46.665	18.913	8.198	87.744	16.334	98.324
1992	323.625	3.483	2.524	34.112	15.458	10.068	70.435	16.697	81.209
1993	341.379	3.617	2.430	36.176	15.756	8.674	72.528	16.447	84.911
1994	359.499	3.699	2.489	37.570	16.744	8.178	63.773	15.204	88.967
1995	355.741	3.909	2.741	36.899	19.063	8.618	63.959	15.697	98.366
1996	344.193	4.618	2.608	35.978	19.656	10.272	69.594	16.003	122.848
1997	348.547	4.792	2.304	35.391	21.730	9.999	75.038	13.291	143.074
1998	265.261	4.113	2.024	26.506	20.087	8.556	54.582	10.510	125.196
1999	144.183	3.653	1.766	15.358	15.114	7.237	45.215	10.626	105.709
2000	50.075	3.377	2.554	5.814	14.735	6.899	34.522	11.731	103.221
2001	51.164	3.027	2.590	6.010	14.599	6.355	42.096	11.364	93.983
2002	57.728	3.039	2.606	6.347	16.873	6.684	33.660	11.695	98.783
2003	62.289	3.433	3.102	6.998	17.902	6.533	31.582	13.861	112.516
2004	65.749	3.551	3.227	6.747	18.399	6.793	27.095	13.130	118.732
2005	72.037	3.710	3.524	6.637	20.198	50.306	25.284	12.542	134.791
2006	71.521	3.734	3.724	7.228	20.096	52.009	23.621	14.495	132.659
2007	69.752	3.730	3.509	7.170	20.224	53.461	19.915	14.674	132.637
2008	62.006	3.916	3.374	6.825	18.572	58.469	18.407	15.157	140.230
2009	41.308	3.425	2.381	5.336	13.843	58.270	15.338	12.859	124.482
2010	48.133	3.604	2.416	5.166	14.298	56.666	14.871	11.976	131.540
2011	48.895	3.543	2.860	5.936	14.267	59.483	16.370	14.485	123.368
2012	44.945	3.481	2.187	5.431	13.709	60.394	14.581	13.275	124.087
2013	41.893	3.183	1.799	4.474	13.198	58.836	13.017	10.138	117.948
2014	42.744	3.183	1.832	4.471	13.253	59.355	11.812	10.277	118.694
2015	45.252	3.122	1.874	4.686	13.991	59.478	11.204	10.555	118.576
2016	44.633	3.166	1.804	4.319	13.907	63.903	9.768	9.374	120.424
2017	45.015	3.219	1.827	4.316	13.797	67.732	11.784	9.454	122.041
2018	46.251	3.220	1.843	4.341	14.225	70.692	11.233	9.305	122.453
2019	46.558	3.163	1.833	4.188	14.550	73.166	11.628	8.661	123.959
2020	41.040	2.899	1.589	3.291	13.404	71.579	10.457	6.188	119.458
2021	45.847	3.135	1.713	3.646	14.643	73.969	11.826	6.815	128.054
2022	40.690	2.967	1.555	3.193	12.977	80.676	11.488	6.391	121.334

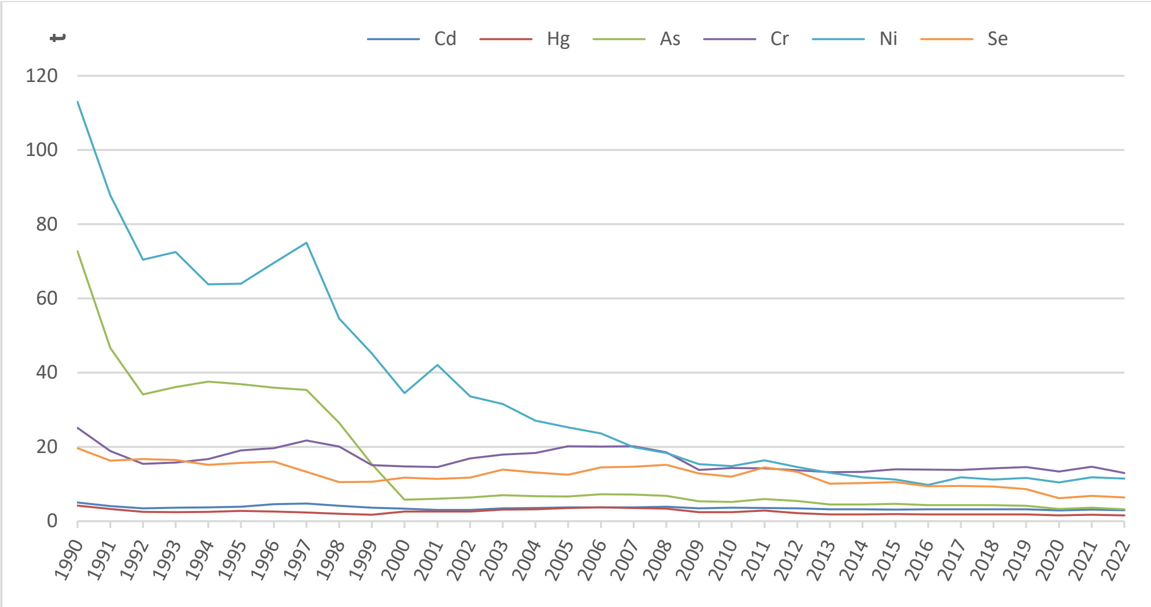


Figure 2.2.1.a Total Emission trends (t) for Cd, Hg, As, Cr, Ni and Se

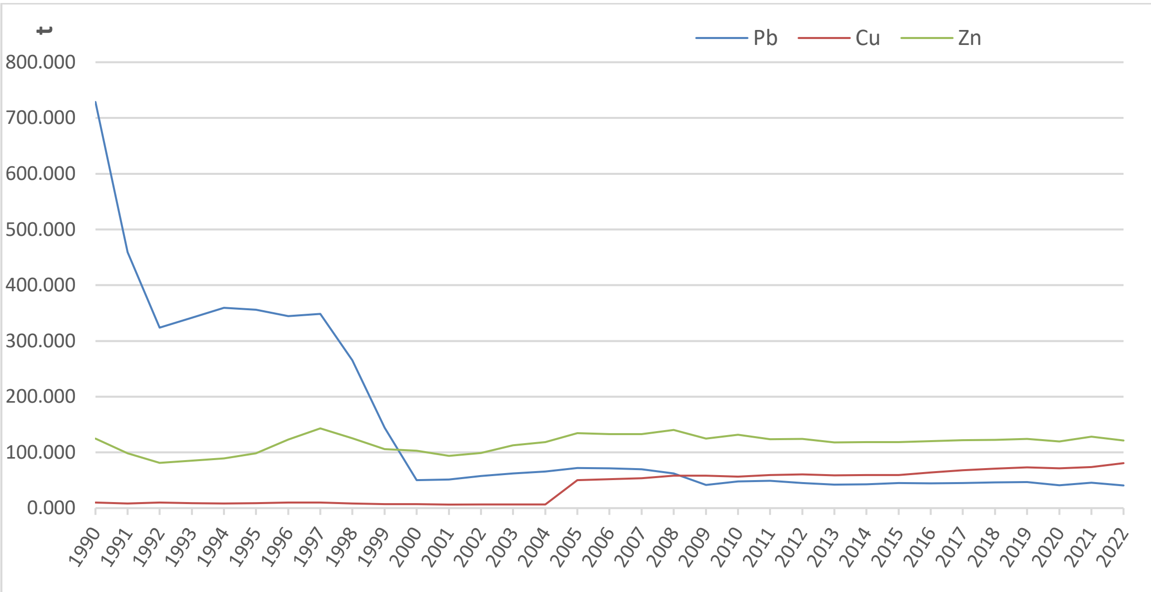


Figure 2.2.1.b Total Emission trends (t) for Pb, Cu and Zn

The graphs describe the total emission trends for heavy metals over the period 1990-2022.

At the beginning of the period analysed, Ni, As and Cr emissions had the highest values according to activity data.

Se, As and Pb emissions decreased severely in the first two years of the period and again between 1997 and 2000. From 2002 Se continued a slight decrease but As has got a plateau until the end of the period.

Cu emissions come mainly from road transport (93.2% of the national total in 2022) due to the increase in road traffic (60% increase in 2022 compared to 2005).

The trends of heavy metals emissions are influenced by the variation in the activity of the Public electricity, NFR 1.A.1.a, Stationary combustion in manufacturing industries and construction (iron and steel, NFR 1.A.2.a), Stationary combustion in manufacturing industries and construction (Non-metallic minerals, NFR 1.A.2.f) and Iron and steel production, NFR 2.C.1.

2.3. Emission trends for POPs

Table 2.3.1 Total Emission trends for PCDD/F (g I-TEQ), total PAHs (t), HCB and PCBs (kg)

Year/Pollutant	PCDD/PCDF (g I-TEG)	total PAHs (t)	HCB (kg)	PCBs (Kg)
1990	265.726	76.502	2.843	61.689
1991	221.017	54.376	2.578	45.430
1992	201.910	43.715	2.697	34.249
1993	204.446	40.389	2.795	30.897
1994	211.087	39.201	2.790	32.143
1995	230.822	45.296	2.923	38.638
1996	268.545	62.453	3.144	35.899
1997	309.917	74.732	3.004	39.788
1998	332.873	66.173	2.699	37.546
1999	567.271	55.922	3.283	26.003
2000	762.488	55.666	3.875	28.115
2001	902.698	45.271	4.174	29.459
2002	831.487	49.465	4.086	34.175
2003	921.017	57.334	4.675	37.050
2004	875.268	65.455	4.508	38.970
2005	756.502	64.992	4.205	39.125
2006	685.640	62.192	4.232	38.386
2007	202.616	61.770	3.985	36.484
2008	208.822	69.684	3.763	30.510
2009	170.188	60.126	3.198	17.437
2010	187.746	63.248	3.204	21.143
2011	179.769	57.410	3.451	20.681
2012	182.539	58.066	3.360	18.192
2013	166.099	55.321	2.867	17.445
2014	170.320	56.881	2.932	17.984
2015	167.406	56.448	3.025	20.250
2016	169.849	56.168	2.948	19.689
2017	177.765	55.238	3.111	18.578
2018	179.705	55.144	3.135	19.203
2019	185.236	55.860	3.125	19.374
2020	183.708	54.938	2.995	17.019
2021	209.528	58.966	3.594	19.791
2022	186.098	53.678	3.134	15.064

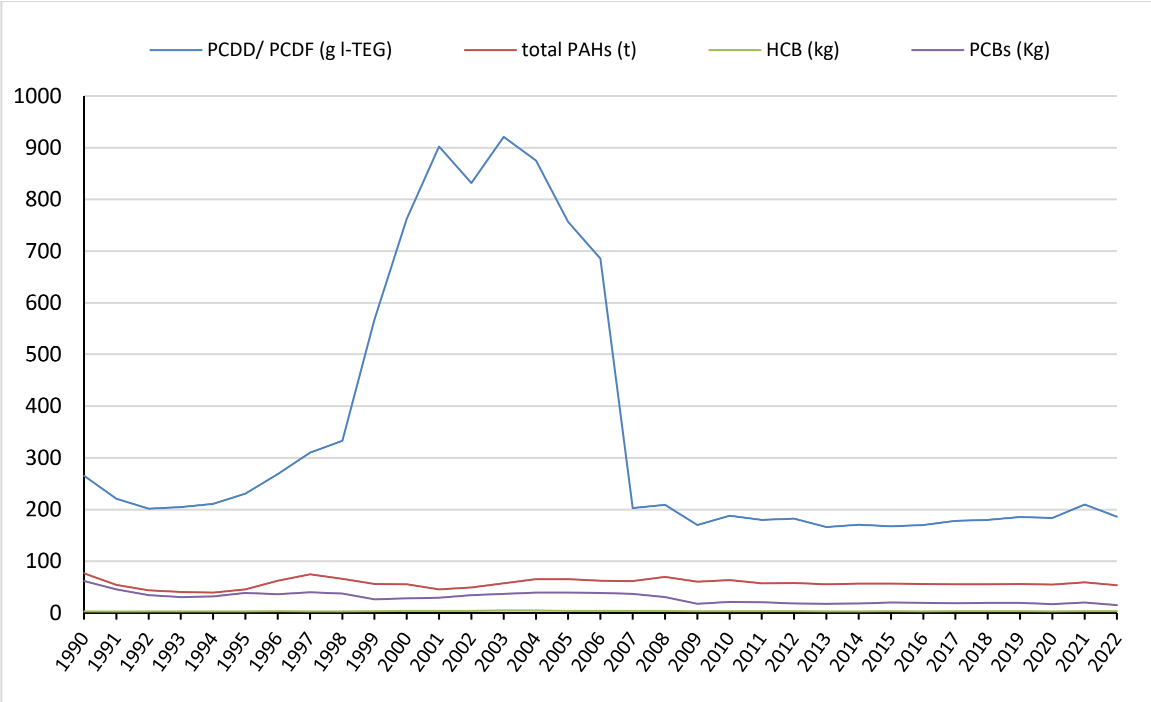


Figure 2.3.1 Total Emission trends for Dioxins (*g I-TEQ*), total PAHs (*t*), HCB and PCBs (*kg*)

The graph provides the total emission trend for POP's in the period 1990-2022.

The most relevant fluctuation was recorded for PCDD/PCDF emission, reaching high values in the period 1999-2006.

In general, the majority of emissions have fluctuated until 2009 and decreased steadily afterwards, in accordance with the activity data.

3. ENERGY (NFR sector 1)

The "ENERGY" sector represents the main source of emissions in Romania. This includes fuel combustion in the energy industry (NFR 1.A.1) and in the manufacturing industry (NFR 1.A.2), transport (NFR 1.A.3), small combustion (NFR 1.A.4), non-road mobile machinery (1A2gvii, 1A4aii, 1A4bii, 1A4cii) and fugitive emissions from fuels (NFR 1.B.1 and NFR 1.B.2).

3.1 Stationary Fuel Combustion and Non-road mobile machineries – Sector overview

This chapter considers emissions originating from stationary fuel combustion activities (NFR 1.A.1, NFR 1.A.2, NFR 1.A.4 and 1A5) and from the non-road mobile machineries (NFR 1.A.2.g.ii, 1.A.4.aii, NFR 1.A.4.bii, NFR 1.A.4.cii and NFR 1.A.5.b).

Table 3.1.1 gives a summary of sources of activity data for stationary combustion categories (including the non-road mobile machineries). The table is relevant for assessing the completion of NFR categories on stationary and non-road mobile machineries.

Table 3.1.1 Reference of activity data for NFR categories 1.A.1, 1.A.2, 1.A.4 and 1.A.5.

NFR	**Activity data source**
1.A.1.a Public Electricity and Heat Production	• LCP operators; • Energy statistics*: Main activity producer plants, (Electricity/CHP/Heat only), Own use in electricity, CHP and heat plants, Autoproducers* - 1990-2016, EUROSTAT complete energy balances, annual data (nrg_110a) - 2017-2022, EUROSTAT ENERGY Questionnaires, National Institute of Statistics
1.A.1.b Petroleum refining	• 1990-2016: EUROSTAT complete energy balances, annual data (nrg_110a*) Consumption of the energy branch/Petroleum refineries* • 2017-2022, EUROSTAT ENERGY Questionnaires, National Institute of Statistics
1A1c Manufacture of Solid fuels and Other Energy Industries	• 1990-2015: EUROSTAT complete energy balances, annual data (nrg_110a): *Consumption of the energy branch/Consumption in Oil and gas extraction, Consumption in Coal Mines, Consumption in Coke Ovens, Consumption in Non-specified (Energy)* • 2016-2022: EUROSTAT ENERGY Questionnaires, National institute of Statistics
1.A.2.a Iron and Steel	• 1990-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Industry/Iron & steel industry;* • 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics
1.A.2.b Non-ferrous Metals	IE – included in NFR 1.A.2.a
1.A.2.c Chemicals	• 1990-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Industry/Chemical and Petrochemical;* • 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics
1.A.2.d Pulp, Paper and Print	• 1992-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Industry/Paper, Pulp and Print;* 1990-1991, included in 1A2gviii; • 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;
1.A.2.e Food Processing, Beverages and Tobacco	• 1990-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Industry/Food and Tobacco;* • 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;
1.A.2.f Non-metallic Minerals	• 1990-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Industry/Non-Metallic Minerals;* • 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;

NFR	Activity data source
	• 2005-2022 clinker production , National Institute of Statistics;
1A2gvii Mobile Combustion in manufacturing industry	• 1992-2016: EUROSTAT complete energy balances, annual data (nrg_110a): Final energy consumption/Industry (all) - gasoline and diesel. 1990-1991: included in NFRs 1A3b; • 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;
1.A.2.gviii Other Stationary Combustion	• 1990-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Industry (*all) minus amount considered at the other specific industries; • 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics
1.A.4.a.i Commercial/ Institutional: stationary	• 1992-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Other Sectors/Services;* 1990-1991: included in NFR 1A4bi; 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;
1.A.4.a.ii Commercial/institutional: Mobile	• 1992-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Other Sectors/Services,* gasoline and diesel; 1990-1991: included in NFRs 1A3b; 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics
1.A.4.b.i Residential: stationary	• 1990-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Other Sectors/Residential;* 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;
1.A.4.b.ii Residential: Household and gardening (mobile)	Included in NFRs 1A3b. Reported separately for years with available data for gasoline and diesel in the statistics EUROSTAT Energy, *Final energy consumption/Other Sectors/Residential;*
1.A.4.c.i Agriculture/ Forestry/Fishing, Stationary	• 1990-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Other Sectors/Agriculture, Forestry;* 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;
1.A.4.c.ii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	• 1992-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Other Sectors/Agriculture & Forestry,* Gasoline and Diesel; 1990-1991: included in NFRs 1A3b; 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;
1.A.4.c.iii National fishing	IE – included in 1.A.4.c.ii Agriculture/Forestry/Fishing: Off-road vehicles and other machinery;
1.A.5.a Other Stationary (including Military)	• 1990-2016: EUROSTAT complete energy balances, annual data (nrg_110a): *Final energy consumption/Other Sectors/Non-specified (Other);* 2017-2022: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;
1.A.5.b Other, Mobile (including military, land based and recreational boats)	IE – included in 1.A.5a

Fuels in the energy balances have been aggregated to categories liquid, solid, gas and biomass according to the following table regarding their relevance for Tier 1 application of emission factors:

Table 3.1.2 Aggregation of fuels on fuel types

Tier 1 Fuel type	Associated fuel types
Hard coal /solid	Coking coal, other bituminous coal, sub-bituminous coal, coke, manufactured 'patent' fuel
Brown coal/solid	Lignite, oil shale, manufactured 'patent' fuel, peat
Gaseous fuels	Natural gas, natural gas liquids, liquefied petroleum gas, refinery gas, gas works gas, coke oven gas, blast furnace gas
Heavy fuel oil/Liquid fuels	Residual fuel oil, refinery feedstock, petroleum coke, orimulsion, bitumen
Light oil/Liquid fuels	Gas oil, kerosene, naphtha, shale oil
Biomass	Wood, charcoal, vegetable (agricultural) waste

(source: Table 3-1 Tier 1 fuel classifications, 2019 EMEP/EEA Guidebook)

Information on condensable component of PM_{10} and $PM_{2.5}$, as provided by the Guidebook 2019:

For NFR 1A1, all tables of emission factors in Guidebook 2019, used in the estimation of TSP, PM_{10} and $PM_{2.5}$, note that "The TSP, PM_{10} and $PM_{2.5}$ emission factors represent filterable PM emissions".

For non-road mobile and machineries (NRMM), NFR 1A2gvii, 1A4aii, 1A4bii and 1A4cii, Notes to the Table 3.1 in the NRMM chapter of Guidebook 2019 mentions that "PM factors represent total PM emissions (filterable and condensable fractions)".

For all industry combustion, NFR 1A2:

- Table 3.2, solid fuels, mentions that "The basis of the TSP, PM_{10} and $PM_{2.5}$ emission factors could not be determined in the reference";
- Table 3.3, gaseous fuels and table 3.4, liquid fuel, mentions that "The TSP, PM_{10} and $PM_{2.5}$ emission factors have been reviewed and it is unclear whether they represent filterable PM or total PM (filterable and condensable) emissions";
- Table 3.5, biomass, mentions that "The TSP, PM_{10} and $PM_{2.5}$ emission factors represent filterable PM".

For 1A4ai, 1A4ci and 1A5a, the Guidebook Tier 1 tables 3.7 to 3.9, used for assessing the emissions from coal, gaseous fuels and liquid fuels, note that "The TSP, PM_{10} and $PM_{2.5}$ emission factors have been reviewed and it is unclear whether they represent filterable PM or total PM (filterable and condensable) emissions". Table 3.10 - Tier 1 emission factors for NFR source category 1.A.4.a/c, 1.A.5.a, using solid biomass: "Emission factors have been recalculated to represent total particles (including condensable component) by assuming condensable represent 12% of the total PM mass for $PM_{2.5}$ (average of automatic and medium sized boilers from Denier van der Gon et al., 2015)."

For NFR 1A4bi, the Guidebook Tier 1 tables 3.3 to 3.5, used for assessing the emissions from coal, gaseous fuels and other liquid fuels, mention that "The TSP, PM_{10} and $PM_{2.5}$ emission factors have been reviewed and it is unclear whether they represent filterable PM or total PM (filterable and condensable) emissions".

For NFR 1A4bi, wood combustion, tables Tier 2, 3.40, 3.43 and 3.44 mention “total particles” for TSP, PM_{10}, $PM_{2.5}$ and BC.

Details on calculations and trends are given in the following sections.

3.2 NFR 1.A.1.a Public electricity and heat production

Activities in this category cover combustion processes from production of electric power and thermal energy in public power and district heating plants, including the own fuel consumption.

NFR 1.A.1.a is key source for SOx (39,76%), NOx (8,70%), Cd (7.92%), Hg (23,90%), As (56,86%), Ni (21,78%), Se (83,99%) and HCB (26,80%).

The share of emissions from Combustion in public electricity and heat production – NFR 1A1a, in the country total, by pollutant, is shown in the table 3.2.1 and figure 3.2.1:

Table 3.2.1. Share of 1A1a emissions in the national total, in 2022

Pollutant	1A1a	National Total	Unit	% 1A1a in national total
NOx	17.659	202.90	kt	8.70%
NMVOC	0.558	235.34	kt	0.24%
SOx	18.527	46.60	kt	39.76%
PM2.5	1.071	107.46	kt	1.00%
PM10	1.462	143.13	kt	1.02%
TSP	1.799	197.14	kt	0.91%
BC	0.032	12.95	kt	0.25%
CO	6.648	895.66	kt	0.74%
Pb	1.985	40.69	t	4.88%
Cd	0.235	2.97	t	7.92%
Hg	0.372	1.55	t	23.90%
As	1.816	3.19	t	56.86%
Cr	1.173	12.98	t	9.04%
Cu	0.330	80.68	t	0.41%
Ni	2.503	11.49	t	21.78%
Se	5.367	6.39	t	83.99%
Zn	3.058	121.33	t	2.52%
PCDD/PCDF	1.700	186.10	g I-TEQ	0.91%
Total PAH	0.019	53.68	t	0.04%
HCB	0.840	3.13	kg	26.80%
PCBs	0.031	15.06	kg	0.21%

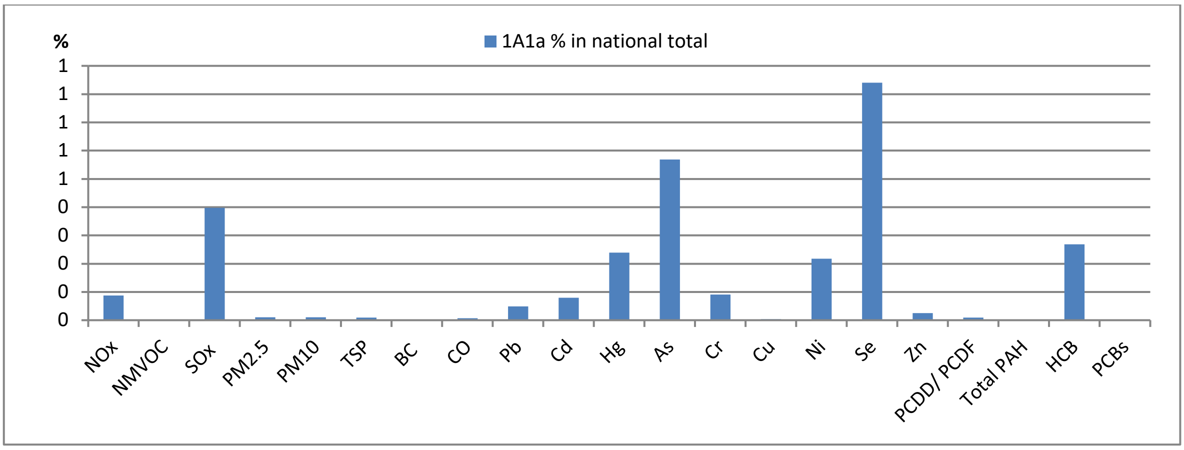


Figure 3.2.1 Share of 1A1a emissions by pollutant in the national total in 2022

The estimation of emissions for the category 1.A.1.a considers the fuel consumption in all power and heat plants (including the ones under 50 MW) as well as the fuel consumption for own use in the electricity, CHP and heat plants, including Autoproducers. Note that, based on information from the N.I.S, the autoproducers are not reported in the national energy balance separately, but included in the Electricity/CHP/Heat only categories, therefore, in order to assure consistency between data sources (Eurostat categories and national statistics categories), the consumption for Autoproducers was also allocated to NFR 1.A.1.a. A major recalculation of the series was done in 2017, following the Review (review ref: RO-1A1a-2017-0001).

Emission Factors

Table 3.2.1. Pollutants and Emission factors for 1A1

NFR	Pollutants Reported	Emission Factor tier and source
1A1a Public Electricity and Heat Production	All NECD/LRTAP pollutants (except NH3)	T2 – EMEP EEA Guidebook 2019 factors for BC, PM10 and PM2.5 T3- plant specific factors for NOx, SOx and TSP T2 – EMEP EEA Guidebook 2019 factor for CO, POPs, NMVOC and heavy metals
1A1b Petroleum refining	All NECD/LRTAP pollutants (except NH3)	T1 – EMEP EEA Guidebook 2019 factors
1A1c Manufacture of Solid fuels and Other Energy Industries	All NECD/LRTAP pollutants	T1&T2 – EMEP EEA Guidebook 2019 factors

CO, NMVOC, Heavy Metals and POPs:

The emissions were calculated for the entire time series 1990-2022 based on the Guidebook 2019 emission factors (NFR 1.A.1.a, Tier 2 Tables 3.10, 3.11, 3.12 and 3.13) applied on fuel consumption from EUROSTAT energy balances, categories *Main activity producer plants (Electricity/CHP/Heat only)* and *Own use in electricity, CHP and heat plants,* including *Autoproducers*.

NOx, SOx and TSP:

Estimation for years 2005-2022 considers the fuel consumption and measured emissions reported by LCPs operators and the data provided in the Eurostat energy balances. The LCP fuel consumption was compared with Eurostat values, categories *Main activity producer* plants (electricity/CHP/Heat only) and Own use in electricity, CHP and heat plants, including Autoproducers. TSP, NOx and SOx emissions were estimated from the difference between fuel data from energy balances and LCP consumption. These emissions were summed up with the LCPs measured values of TSP, NOx and SOx, to get the values reported on NFR 1.A.1.a.
For the years 1990-2004, NOx and SOx were estimated based on the Eurostat Energy data and the Guidebook 2019 Tier 2 emission factors, Tables 3.10, 3.11, 3.12 and 3.13. The TSP emission factors for lignite and heavy fuel oil considered in this estimation are equal to 120 g/GJ for lignite and 40 g/GJ for liquid fuel, based on national data - operators reports for years 2002-2004, averaged and extrapolated back to 1990.

PM_{10}, $PM_{2.5}$ and BC:

PM_{10}, $PM_{2.5}$ and BC were estimated based on TSP measured values. This approach was due to the fact that a. the discrepancy between the measured values of TSP and the Guidebook estimation was too high (the measured values significantly higher than estimated ones) and b. only TSP is currently largely monitored at stack. Therefore, the following method was used:
1st step: for the years when measured TSP values were available (2005-2022), the emissions of TSP, PM_{10}, $PM_{2.5}$ and BC were estimated based on Guidebook 2019 emission factors (NFR 1.A.1.a, Tables 3.10, 3.11, 3.12 and 3.13) for the LCP consumptions of solid, liquid, natural gas and biomass fuel. 2nd: the ratios between the estimates at step 1, PM_{10}/TSP, $PM_{2.5}$/TSP and BC/TSP were calculated. 3rd: These ratios were used as coefficients (multiplying the TSP emissions) to determine the emissions of PM_{10}, $PM_{2.5}$ and BC on the basis of measured TSP.
For the historical years 1990-2004, no measured data are available. For this time series, the following estimations were applied: $PM_{10} = 0.693 * TSP$; $PM_{2.5} = 0.34 * TSP$; $BC = 0.01 * TSP$.
The above coefficients were determined as the average of the BC/TSP, PM25/TSP, PM10/TSP ratios for the time series 2005 - 2016 and were applied back for the 1990-2004 time series. This method assures the consistency of the emissions trend.

Table 3.2.1. Emissions 1990-2022 NFR 1.A.1.a. NOx, SOx, Particulate Matter, Black Carbon and CO

Year/Pollutant (kt)	NOx	NMVOC	SOx	$PM_{2.5}$	PM_{10}	TSP	BC
1990	146.591	2.011	646.896	16.263	33.149	47.833	0.478
1991	128.620	1.792	561.547	14.091	28.721	41.445	0.414
1992	148.505	2.316	589.739	15.215	31.011	44.749	0.447
1993	149.494	2.238	619.814	15.974	32.558	46.981	0.470

Year/Pollutant (kt)	NOx	NMVOC	SOx	$PM_{2.5}$	PM_{10}	TSP	BC
1994	125.651	1.650	582.344	14.620	29.798	42.999	0.430
1995	126.966	1.628	599.838	15.054	30.683	44.276	0.443
1996	130.087	1.712	601.001	15.102	30.781	44.417	0.444
1997	107.990	1.390	504.963	12.640	25.763	37.176	0.372
1998	90.759	1.255	400.701	10.025	20.434	29.486	0.295
1999	86.204	1.103	405.941	10.111	20.608	29.738	0.297
2000	87.407	1.068	427.705	10.643	21.693	31.303	0.313
2001	88.885	1.052	442.864	11.014	22.448	32.393	0.324
2002	86.145	1.009	437.999	11.032	22.485	32.446	0.324
2003	98.511	1.112	508.790	12.581	25.643	37.004	0.370
2004	90.020	0.999	473.535	11.797	24.045	34.697	0.347
2005	99.237	0.902	518.810	12.077	21.634	31.002	0.405
2006	105.170	0.996	565.524	11.536	21.474	30.772	0.345
2007	87.695	0.943	445.804	8.369	15.026	21.617	0.290
2008	86.522	0.895	453.332	6.856	14.400	20.826	0.136
2009	65.563	0.759	396.058	5.739	11.529	16.634	0.138
2010	56.472	0.730	302.129	4.874	9.894	14.140	0.099
2011	61.037	0.835	275.421	5.737	11.737	16.804	0.115
2012	56.508	0.783	214.310	4.573	9.154	13.016	0.094
2013	45.422	0.653	163.532	3.796	7.744	11.003	0.069
2014	44.295	0.649	138.349	3.485	6.601	9.167	0.072
2015	42.404	0.689	109.623	2.903	5.074	6.871	0.068
2016	32.425	0.657	61.271	2.443	3.969	5.219	0.061
2017	33.482	0.716	45.910	2.010	3.193	4.176	0.053
2018	35.667	0.716	39.314	1.793	2.836	3.711	0.048
2019	32.151	0.640	52.251	1.712	2.648	3.427	0.046
2020	22.871	0.569	29.958	1.607	2.341	2.952	0.046
2021	21.938	0.599	30.994	1.316	1.814	2.231	0.039
2022	17.659	0.559	18.527	1.071	1.462	1.800	0.032

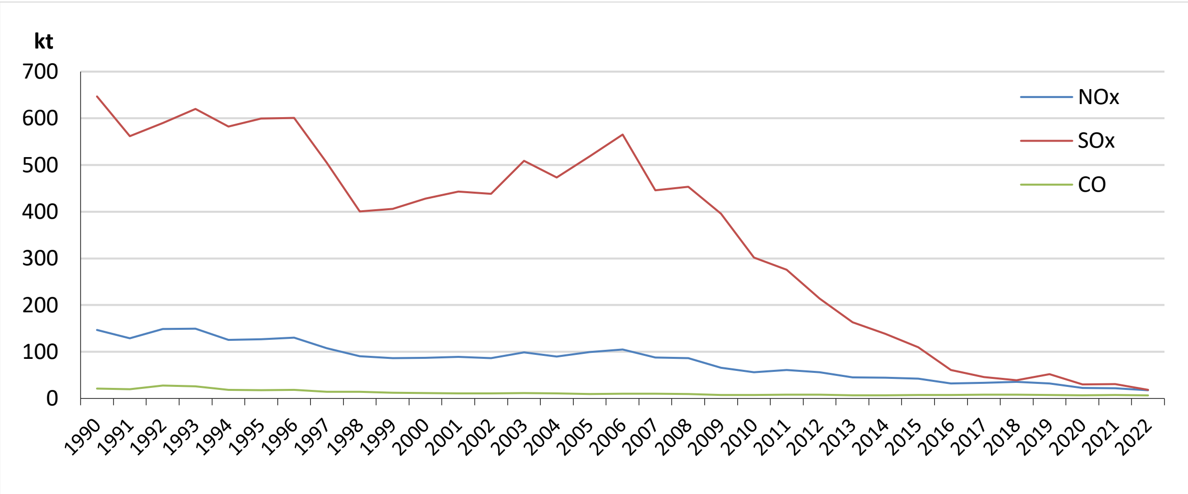


Figure 3.2.1.a Emission Trends (kt) for NFR 1.A.1.a. for NOx, SOx and CO

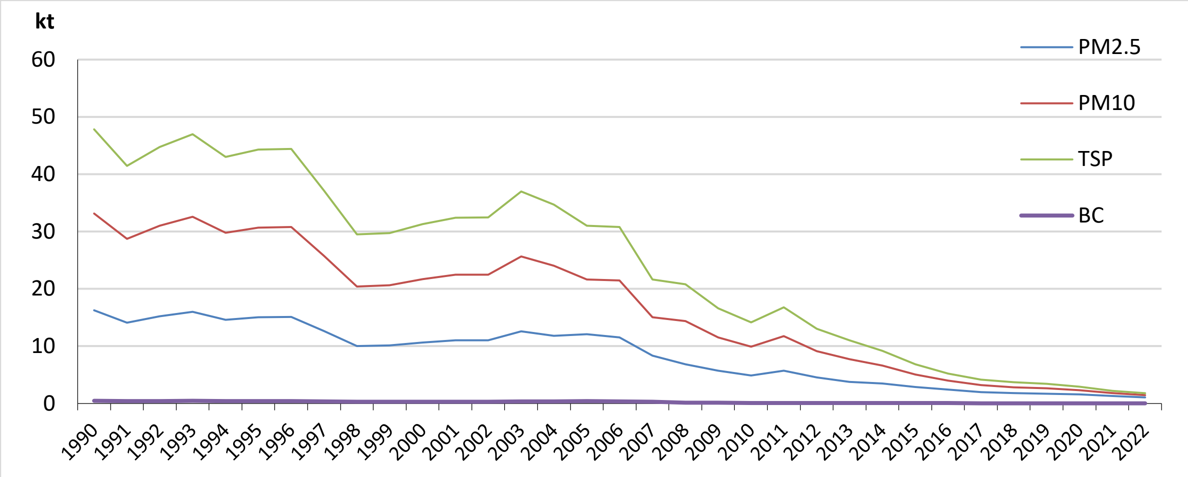


Figure 3.2.1.b. Emission Trends (kt) for NFR 1.A.1.a. for TSP, PM_{10}, $PM_{2.5}$ and BC

Compared to 1990 emissions, there was a significant decrease of emissions in the public power sector. For main pollutants, decreases are as high as 87% for NOx, 97% for SOx and 93% for $PM_{2.5}$. Compared to 2005, the emissions decreased in 2022 with 82% for NOx, 96% for SOx and 91% for $PM_{2.5}$. The decrease is due to implementation of emissions reduction program in LCP installations as well as a general decrease in fuel consumption. Variation of emission values is also determined by the different mixing ratios of solid/liquid/gaseous fuels along the time series, contributing with different emission factors to the estimate of each pollutant.

Emissions of heavy metals followed the same decreasing trend; the heaviest reduction took place before 2005.

Table 3.2.2. Emissions 1990-2022 NFR 1.A.1.a. Heavy Metals

Year/Pollutant (t)	Pb	Cd	Hg	As	Cr	Ni	Se
1990	5.823	0.868	1.022	5.495	3.475	69.219	14.421
1991	5.056	0.730	0.910	4.786	3.023	51.089	12.919
1992	5.454	0.753	1.004	5.125	3.246	43.860	14.014
1993	5.729	0.802	1.038	5.370	3.407	50.139	14.549
1994	5.274	0.722	0.972	4.990	3.160	38.464	14.045
1995	5.434	0.742	0.999	5.138	3.256	39.159	14.487
1996	5.443	0.753	0.995	5.145	3.259	42.948	14.350
1997	4.549	0.649	0.817	4.300	2.722	42.825	11.755
1998	3.609	0.500	0.667	3.427	2.164	28.448	9.575
1999	3.650	0.500	0.674	3.465	2.191	26.621	9.797
2000	3.853	0.515	0.719	3.657	2.316	23.156	10.540
2001	3.981	0.547	0.729	3.772	2.390	29.461	10.669
2002	3.999	0.527	0.741	3.768	2.397	21.634	10.890
2003	4.571	0.593	0.865	4.348	2.755	20.519	12.850
2004	4.294	0.542	0.818	4.070	2.585	13.913	12.193
2005	4.018	0.505	0.772	3.827	2.426	11.672	11.572
2006	4.714	0.584	0.903	4.466	2.840	11.306	13.537
2007	4.658	0.569	0.906	4.443	2.818	7.370	13.700
2008	4.758	0.579	0.925	4.536	2.879	6.385	14.040

Year/Pollutant (t)	Pb	Cd	Hg	As	Cr	Ni	Se
2009	4.136	0.508	0.798	3.936	2.500	7.506	12.099
2010	3.832	0.465	0.741	3.637	2.313	5.334	11.204
2011	4.687	0.567	0.902	4.436	2.826	6.064	13.659
2012	4.281	0.517	0.823	4.046	2.579	5.460	12.439
2013	3.233	0.390	0.622	3.050	1.945	4.097	9.349
2014	3.278	0.393	0.621	3.054	1.960	4.060	9.263
2015	3.335	0.399	0.632	3.105	1.992	3.981	9.408
2016	2.960	0.351	0.562	2.748	1.765	2.771	8.320
2017	3.021	0.361	0.575	2.813	1.803	3.498	8.503
2018	2.948	0.353	0.563	2.752	1.762	3.678	8.328
2019	2.719	0.324	0.516	2.526	1.621	3.063	7.627
2020	1.893	0.225	0.357	1.739	1.120	2.348	5.155
2021	2.120	0.250	0.397	1.937	1.252	0.350	2.361
2022	1.985	0.235	0.372	1.816	1.173	2.503	5.367

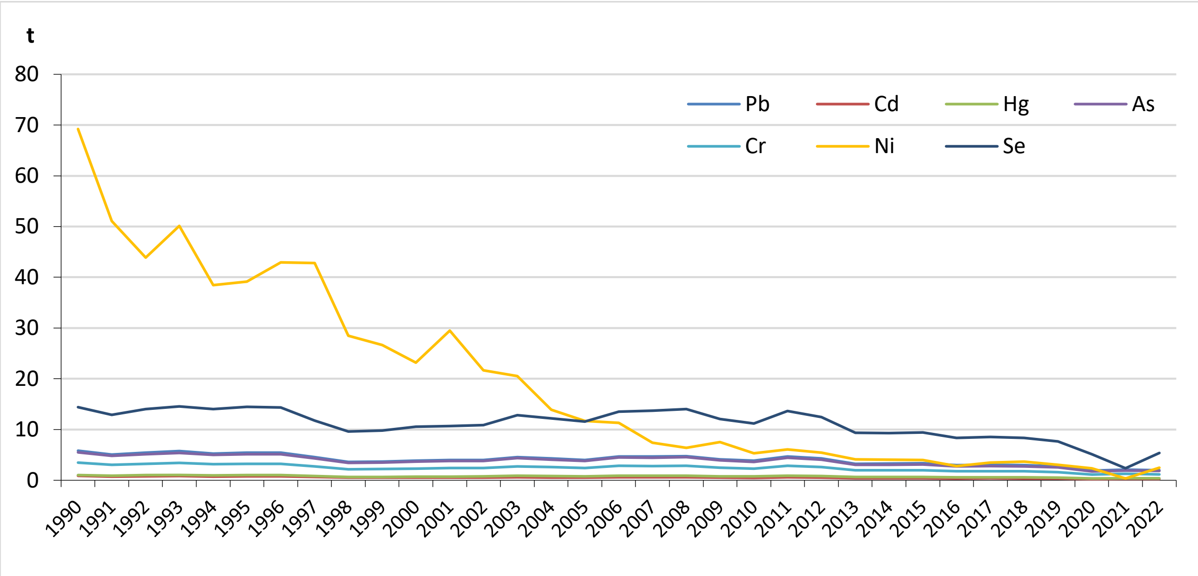


Figure 3.2.2. Emission Trends (t) for NFR 1.A.1.a. for Heavy Metals

Compared to 1990, emissions of heavy metals decreased in 2022 between 63% (Hg) and 96% (Ni).

The table and chart below give the consumption of fuels in power and heat plants for 1990-2022.

Table 3.2.3 Fuel consumption (TJ) 1990-2022, by fuel type, for NFR 1.A.1.a.

Year/Fuel type	Liquid fuels	Solid fuels	Gaseous fuels	Biomass
1990	259680.00	308478.00	376161.00	547.00
1991	189720.00	278288.00	369439.00	772.00
1992	159992.00	303748.00	562945.00	8132.00
1993	184200.00	314526.00	505400.00	8259.00
1994	139063.00	305585.00	339389.00	2699.00
1995	141408.00	315309.00	323274.00	2877.00

Year/Fuel type	Liquid fuels	Solid fuels	Gaseous fuels	Biomass
1996	156419.00	311576.00	344917.00	2700.00
1997	158235.00	253902.00	255451.00	880.00
1998	103606.00	207934.00	276622.00	833.00
1999	96251.00	213231.00	222700.00	593.00
2000	81981.00	230389.00	210910.00	1100.00
2001	106668.00	232146.00	183694.00	611.00
2002	75559.00	238396.00	182287.00	3800.00
2003	69678.00	282280.00	211471.00	899.00
2004	44173.00	268800.00	192325.00	2923.00
2005	35995.00	255427.00	174513.00	1080.00
2006	32748.00	299183.00	182344.00	3731.00
2007	17286.00	303565.00	180602.00	1236.00
2008	13120.00	311315.00	161040.00	1387.00
2009	19163.00	267925.00	126608.00	1417.00
2010	11321.00	248362.00	129687.00	2642.00
2011	12017.00	302833.00	135098.00	4364.00
2012	10662.00	275770.00	130300.00	4663.00
2013	7945.00	207248.00	120611.00	4281.00
2014	7671.00	205244.00	109766.00	7991.00
2015	7210.00	208475.00	122413.00	8477.00
2016	3368.00	184433.00	126235.00	8610.00
2017	6100.48	188431.90	145829.54	8066.54
2018	7003.82	184515.46	149632.86	7170.32
2019	5152.18	169011.45	128805.81	7758.61
2020	4430.94	114103.97	131462.56	7822.37
2021	3897.09	126974.80	131762.80	9607.00
2022	4805.75	118790.06	121821.37	8785.80

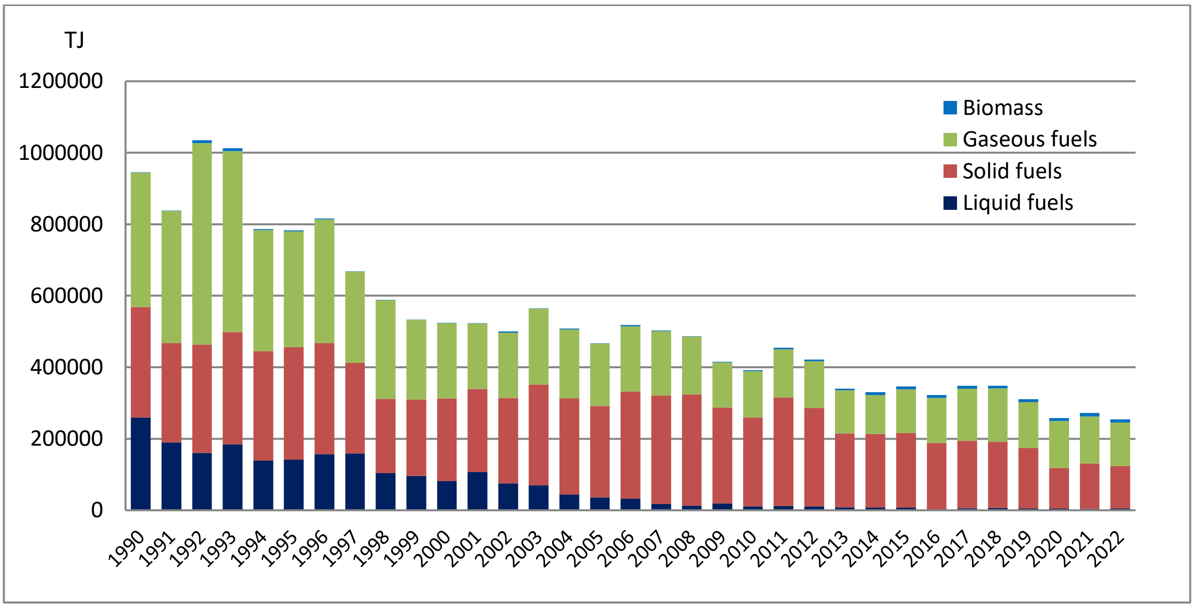


Figure 3.2.3 Fuel consumption [TJ], by fuel type, for NFR 1.A.1.a.

The general decrease in emissions is consistent with the decrease of fuel consumption and technology improvement in power plants.

3.3 NFR 1.A.1.b Petroleum refining

The NFR category 1.A.1.b covers emissions released from combustion processes within refineries. NFR 1.A.1.b is not a key source for any pollutant.

The emissions for years 1990-2022 were calculated by applying Tier 1 emission factors (2019 EMEP/EEA Guidebook 1.A.1.a, Tables 3.4, 3.5 and 3.7) to activity data provided by the EUROSTAT energy balances.

Tables and charts below show the emission trend and fuel consumption for the category NFR 1.A.1.b.

Table 3.3.1. Emissions for NFR 1.A.1.b, 1990-2022

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx (kt)	PM2.5 (kt)	PM_{10} (kt)	CO (kt)	Ni (t)
1990	7.437	0.198	5.226	0.262	0.325	2.763	2.683
1991	5.447	0.138	5.714	0.260	0.328	1.844	2.938
1992	3.603	0.096	2.543	0.128	0.158	1.338	1.306
1993	3.866	0.101	3.256	0.156	0.195	1.385	1.673
1994	5.808	0.144	6.922	0.308	0.390	1.887	3.560
1995	5.746	0.142	6.843	0.304	0.386	1.867	3.519
1996	6.251	0.145	10.109	0.427	0.548	1.778	5.202
1997	5.240	0.126	7.197	0.312	0.398	1.612	3.703
1998	6.362	0.158	7.478	0.333	0.422	2.077	3.845
1999	5.330	0.139	4.606	0.219	0.274	1.898	2.366
2000	5.665	0.151	3.830	0.194	0.240	2.119	1.966
2001	4.880	0.127	4.288	0.203	0.254	1.731	2.203
2002	5.822	0.161	2.531	0.149	0.179	2.312	1.295
2003	4.920	0.135	2.251	0.130	0.157	1.943	1.153
2004	4.900	0.132	2.923	0.154	0.189	1.870	1.499
2005	5.171	0.139	3.378	0.173	0.213	1.946	1.734
2006	4.846	0.126	4.214	0.200	0.250	1.724	2.165
2007	4.696	0.126	3.094	0.158	0.195	1.765	1.588
2008	4.522	0.125	1.955	0.115	0.139	1.797	1.001
2009	3.744	0.102	1.958	0.108	0.131	1.455	1.004
2010	4.195	0.109	3.600	0.172	0.214	1.496	1.850
2011	3.750	0.096	3.562	0.166	0.208	1.305	1.830
2012	3.361	0.088	2.751	0.133	0.165	1.212	1.413
2013	3.531	0.091	3.159	0.149	0.187	1.247	1.623
2014	2.704	0.078	0.279	0.037	0.040	1.159	0.140
2015	2.576	0.074	0.322	0.037	0.041	1.099	0.162
2016	2.775	0.080	0.280	0.038	0.041	1.190	0.140
2017	2.915	0.084	0.281	0.039	0.042	1.252	0.140
2018	2.588	0.076	0.030	0.027	0.027	1.132	0.011
2019	2.146	0.061	0.221	0.029	0.031	0.920	0.110
2020	1.771	0.050	0.362	0.031	0.035	0.742	0.184
2021	1.621	0.046	0.355	0.029	0.033	0.677	0.180
2022	1.667	0.049	0.026	0.017	0.018	0.728	0.011

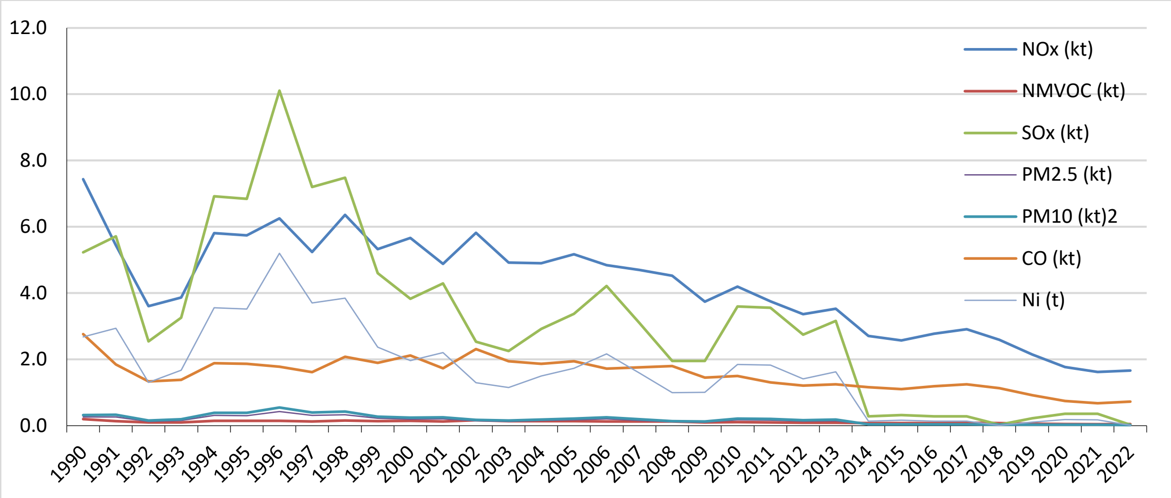


Figure 3.3.1. Emissions for NFR 1.A.1.b, 1990-2022

Emissions trends are consistent with the fuel consumption variation along the time series 1990-2022. The fuel consumption shows a strong variation in first years after 1990 followed by a slight decrease in the following years. Significant is the decrease of the liquid fuel which impacts heavily on emissions reduction. The strong decrease of the liquid fuel in 2014 determines the sharp decrease of emissions in 2014 compared with the previous years.

Table 3.3.2. Fuel consumption trends (TJ), by fuel type, for NFR 1.A.1.b

Year/Fuel type (TJ)	Liquid fuels	Gaseous fuels	Biomass
1990	10520	66776.00	0.00
1991	11520.00	42818.00	0.00
1992	5120.00	32313.00	0.00
1993	6560.00	32977.00	0.00
1994	13960.00	42984.00	0.00
1995	13800.00	42539.00	0.00
1996	20400.00	37683.00	0.00
1997	14520.00	35707.00	0.00
1998	15080.00	47424.00	0.00
1999	9280.00	45076.00	0.00
2000	7709.00	51355.00	0.00
2001	8640.00	41045.00	0.00
2002	5080.00	57305.00	0.00
2003	4520.00	48065.00	0.00
2004	5880.00	45670.00	0.00
2005	6798.00	47257.00	0.00
2006	8489.00	40909.00	0.00
2007	6227.00	42834.00	0.00
2008	3924.00	44552.00	0.00
2009	3936.00	35788.00	0.00
2010	7253.00	35563.00	0.00
2011	7178.00	30683.00	0.00
2012	5542.00	28924.00	0.00

Year/Fuel type (TJ)	Liquid fuels	Gaseous fuels	Biomass
2013	6365.00	29520.00	1.00
2014	547.00	29513.00	2.00
2015	634.00	27932.00	2.00
2016	549.00	30300.00	1.00
2017	548.93	31875.19	1.41
2018	43.80	29010.34	0.47
2019	434.31	23420.80	1.03
2020	721.48	18745.39	1.11
2021	706.65	17086.51	0.38
2022	42.80	18639.60	0.44

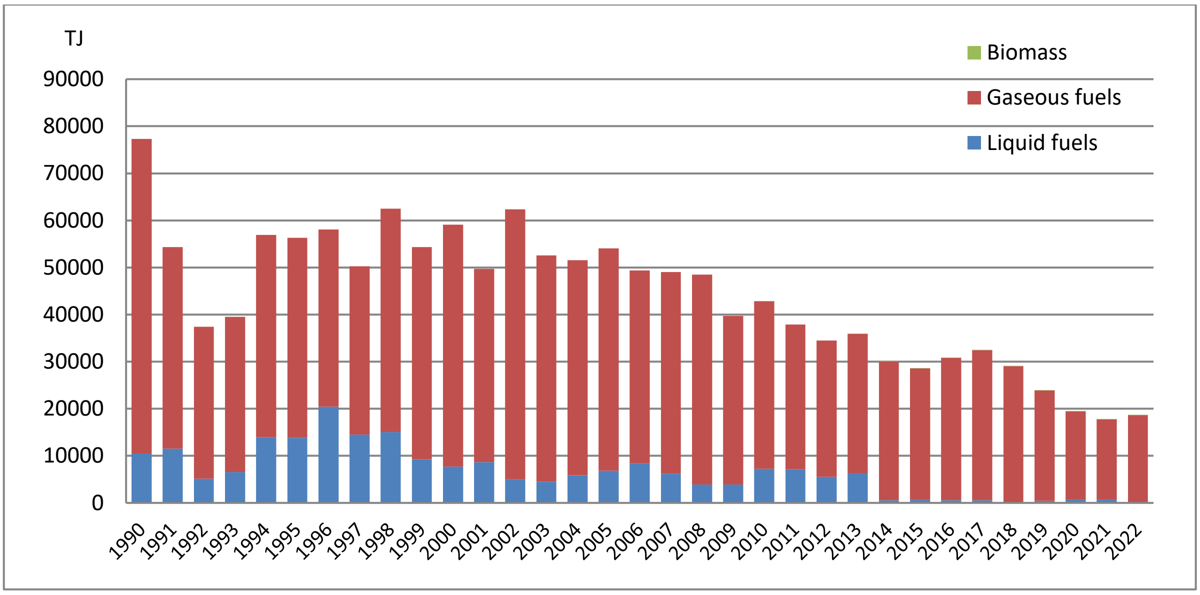


Figure 3.3.2. Fuel consumption [TJ] trends, by fuel type, for NFR 1.A.1.b

3.4 NFR 1.A.1.c Manufacture of solid fuels and other energy industries

This category includes emissions from fuel combustion in the following industries: Oil and gas extraction, Coal Mines, Coke Ovens and other non-specified fuel consumption in energy industries. Activity data are provided by EUROSTAT, in the complete energy balances, annual data - nrg_110a, categories Consumption of the energy branch, for 1990-2016 and in the EUROSTAT Energy questionnaires for 2017-2022. In 2022, relevant values where provided for *Consumption in Oil and gas extraction, Consumption in Coal Mines* and *Not elsewhere specified (Energy)*.

The main fuels are liquid and gaseous types. Tier 1 emissions factors are applied, which, according to the notes to Guidebook emission factors, tables 3-8 and 3-9 - Small combustion chapter, are averages of Tier2 factors. There is not a better national approach than the average.

NFR 1.A.1.c is a key source for Ni, with a contribution of 10.6% in the national total, in 2022.

No recalculations was applied to this category for the current report.

Tables and charts below show the main emissions and fuel consumption time series for the category NFR 1.A.1.c.

Table 3.4.1. Emissions of NOx, NMVOC, SOx CO and PM for NFR 1.A.1.c.

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx(kt)	CO (kt)	$PM_{2.5}$ (kt)	PM_{10} (kt)	TSP (kt)	Ni (t)
1990	0.442	0.029	0.136	0.134	0.026	0.029	0.029	0.181
1991	0.579	0.040	0.199	0.200	0.037	0.041	0.041	0.235
1992	5.650	0.804	2.628	3.245	0.429	0.471	0.482	1.700
1993	6.300	0.873	1.375	2.080	0.280	0.309	0.309	1.807
1994	8.563	1.415	2.447	3.736	0.445	0.488	0.495	2.144
1995	8.501	1.410	3.548	4.796	0.585	0.640	0.656	2.211
1996	6.809	1.266	3.797	4.974	0.586	0.639	0.660	1.634
1997	13.773	2.419	4.437	6.711	0.775	0.847	0.864	3.265
1998	10.712	1.830	4.280	5.941	0.711	0.778	0.796	2.687
1999	7.290	1.022	2.182	2.995	0.399	0.439	0.444	2.120
2000	5.708	1.020	1.635	2.614	0.297	0.324	0.330	1.315
2001	6.214	1.184	1.685	2.866	0.310	0.339	0.345	1.317
2002	8.992	1.429	2.235	3.515	0.431	0.473	0.478	2.325
2003	8.853	2.040	9.771	11.739	1.370	1.489	1.559	1.909
2004	9.844	1.489	4.443	5.661	0.733	0.803	0.823	2.829
2005	9.339	1.301	2.252	3.301	0.443	0.488	0.490	2.686
2006	5.929	0.877	1.320	2.068	0.265	0.292	0.292	1.615
2007	5.962	0.671	1.523	1.946	0.300	0.332	0.332	1.970
2008	6.262	0.758	1.653	2.175	0.319	0.353	0.354	1.990
2009	3.401	0.524	0.789	1.250	0.156	0.172	0.173	0.900
2010	4.060	0.603	0.892	1.408	0.180	0.198	0.198	1.102
2011	3.515	0.525	0.773	1.224	0.155	0.171	0.171	0.949
2012	3.211	0.506	0.673	1.127	0.137	0.151	0.151	0.824
2013	3.239	0.519	0.622	1.095	0.130	0.143	0.143	0.812
2014	3.937	0.596	0.806	1.326	0.166	0.183	0.183	1.046
2015	2.565	0.387	0.530	0.866	0.109	0.120	0.120	0.684
2016	1.875	0.426	0.222	0.692	0.053	0.057	0.057	0.263
2017	3.538	0.470	0.805	1.168	0.162	0.179	0.179	1.050
2018	1.341	0.257	0.209	0.470	0.046	0.050	0.050	0.267
2019	3.532	0.361	0.929	1.122	0.183	0.203	0.203	1.229
2020	3.787	0.363	1.023	1.193	0.200	0.222	0.222	1.355
2021	4.319	0.372	1.218	1.345	0.237	0.275	0.275	1.616
2022	3.350	0.309	0.922	1.052	0.180	0.210	0.210	1.221

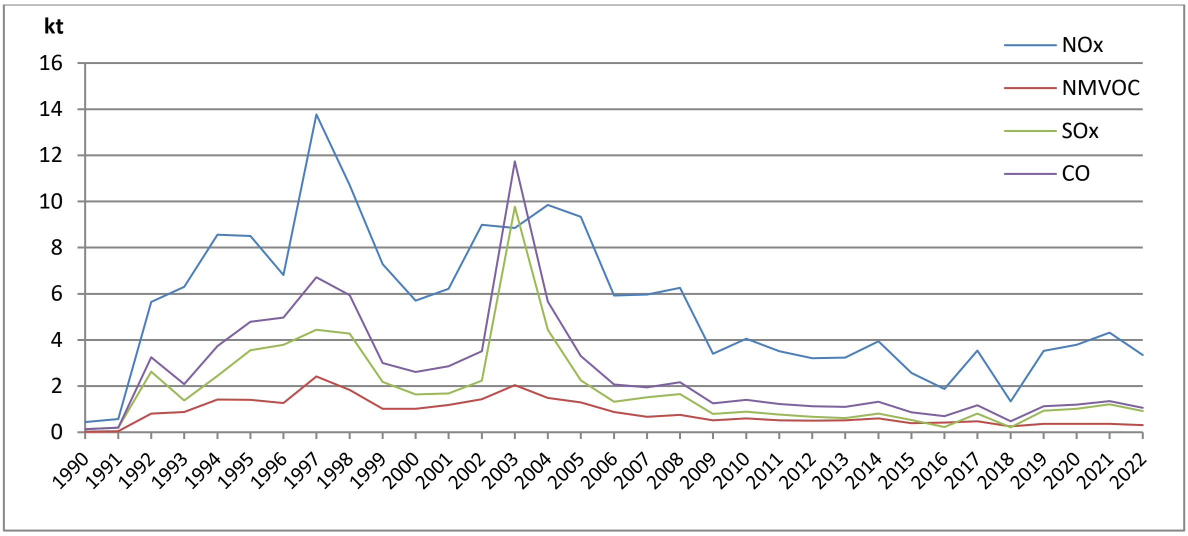


Figure 3.4.1a Emissions (kt) of NOx, NMVOC, SOx and CO for NFR 1.A.1.c.

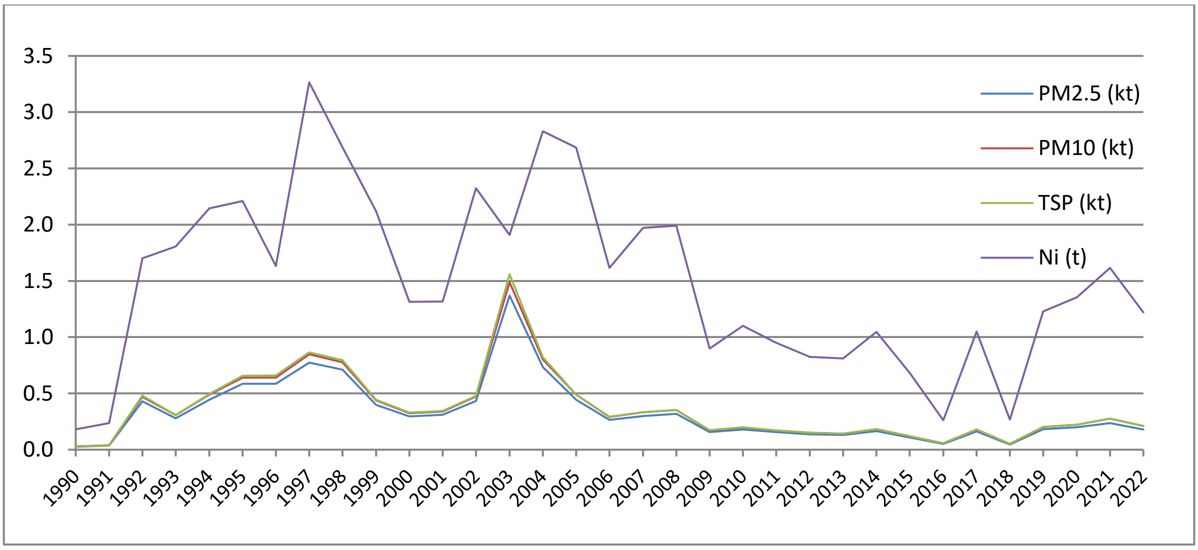


Figure 3.4.1b Emissions (kt) of TSP, PM_{10}, $PM_{2.5}$ for NFR 1.A.1.c.

The emissions peak in 1997 and 2002-2003, corresponding to the variation of coke production in Romania. The rise of emissions in 2020-2021 is due to liquid fuel consumption in energy industries reported under “Not elsewhere specified” category in EUROSTAT data.

Table 3.4.2 Fuel consumption (TJ), by fuel type, for NFR 1.A.1.c

Year/Fuel (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	1446.0	0.0	0.0	0.0
1991	1876.0	27.0	0.0	0.0
1992	13427.0	1613.0	17054.0	0.0
1993	14450.0	0.0	25385.0	0.0
1994	17043.0	972.0	42966.0	0.0
1995	17454.0	2241.0	37464.0	0.0
1996	12749.0	3068.0	32126.0	0.0
1997	25873.0	2328.0	73690.0	0.0

Year/Fuel (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1998	21215.0	2681.0	50760.0	0.0
1999	16884.0	687.0	27087.0	7.0
2000	10437.0	753.0	32203.0	14.0
2001	10447.0	805.0	38856.0	32.0
2002	18535.0	552.0	43545.0	26.0
2003	14225.0	10010.0	37377.0	23.0
2004	22341.0	2762.0	34141.0	16.0
2005	21460.0	250.0	36875.0	6.0
2006	12910.0	106.0	26484.0	2.0
2007	15757.0	38.0	15319.0	2.0
2008	15904.0	173.0	18449.0	0.0
2009	7185.0	123.0	15953.0	8.0
2010	8805.0	62.0	18311.0	1.0
2011	7584.0	59.0	15997.0	0.0
2012	6581.0	52.0	16048.0	2.0
2013	6496.0	0.0	16909.0	1.0
2014	8365.0	9.0	18586.0	1.0
2015	5468.0	9.0	12031.0	1.0
2016	2104.2	15.4	16602.8	1.0
2017	8393.8	8.2	13080.4	1.4
2018	2137.8	1.7	9281.6	0.5
2019	9830.1	0.3	7080.0	4.0
2020	10836.9	0.0	6358.8	0.7
2021	12923.9	0	4921.4	0.6
2022	9769.0	0	4920.6	4.5

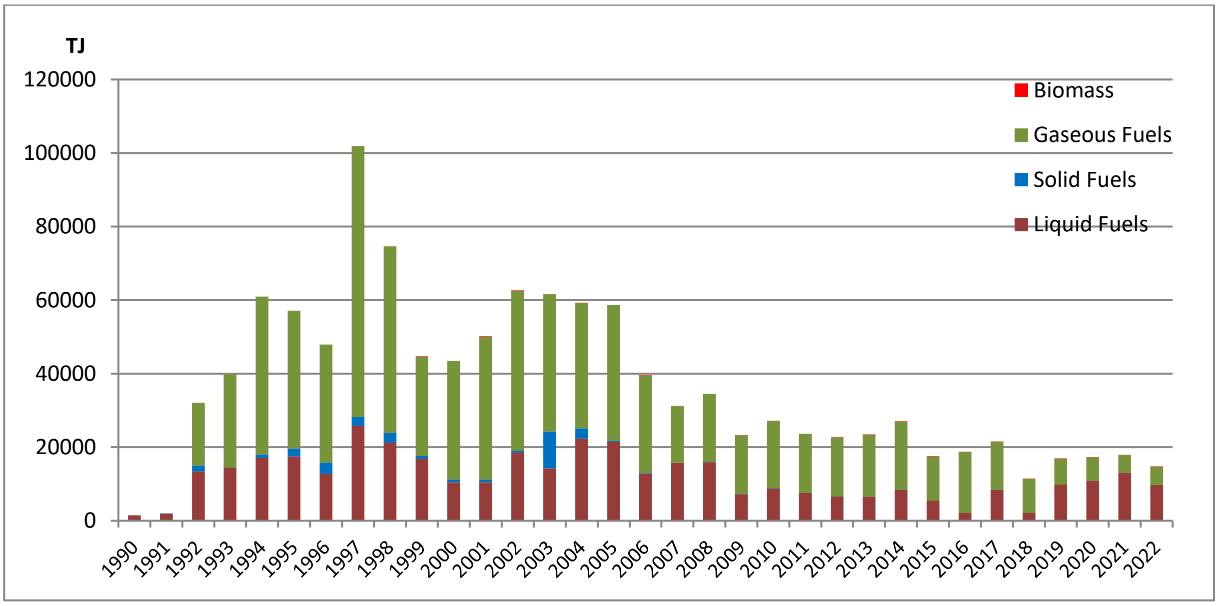


Figure 3.4.2 Fuel consumption [TJ], by fuel type, for NFR 1.A.1.c, 1990-2022

3.5 NFR 1.A.2 Stationary combustion in manufacturing industries and construction

NFR 1A2 refers to emissions from the stationary combustion in manufacturing industries and construction. The sub-sectors cover the combustion installations from the following sources:

- NFR 1.A.2.a Iron and Steel
- NFR 1.A.2.b Non-Ferrous Metals (included in this submission in 1A2a)
- NFR 1.A.2.c Chemicals
- NFR 1.A.2.d Pulp, Paper and Print
- NFR 1.A.2.e Food Processing, Beverages and Tobacco
- NFR 1.A.2.f Non-metallic minerals
- NFR 1.A.2.gviii Other

The NFR category 1A2gvii – Mobile Combustion in manufacturing industries and construction is also described in this section.

In 2022, key sources from NFR 1A2 sector, combustion in industry, are:

- NFR 1A2a – Iron and steel industry, for SOx (31%), Pb (5.3%) and Hg (8.8%).
- NFR 1A2f – Non-metallic minerals, for NOx (5.0%), SOx (7.9%) and Hg (23.1%).

Emission Factors

Table 3.5.1. Pollutants and Emission factors for 1A2

NFR	Pollutants Reported	Emission Factor tier and source
1A2a Iron and Steel	All CLRTAP pollutants	T1 – EMEP EEA guidebook (2019) factors
1A2b Non-ferrous Metals	Included in NFR 1.A.2.a	
1A2c Chemicals	All CLRTAP pollutants	T1 – EMEP EEA guidebook (2019) factors
1A2d Pulp, Paper and Print	All CLRTAP pollutants (from 1992)	T1 – EMEP EEA guidebook (2019) factors
1A2e Food Processing, Beverages and Tobacco	All CLRTAP pollutants	T1 – EMEP EEA guidebook (2019) factors
1A2f Non-metallic Minerals	All CLRTAP pollutants All CLRTAP pollutants (except NH3, PM, TSP, BC) – from 2005	T1 – EMEP EEA guidebook (2019) factors T2 EMEP EEA guidebook (2019) factors
1A2gvii Mobile Combustion in manufacturing industry	All CLRTAP pollutants (except Pb, Hg, As, POPs) (from 1992)	T1 – EMEP EEA guidebook (2019) factors for HM and POPs T2- EMEP EEA guidebook (2019) for gaseous pollutants and PM
1.A.2.gviii Other Stationary Combustion	All CLRTAP pollutants	T1 – EMEP EEA guidebook (2019) factors

Emissions from stationary fuel combustion in industry, for all subcategories, have been estimated based on fuel consumption data from statistics and default Tier 1 emission factors (2019 EMEP/EEA Guidebook, NFR 1.A.2, Tables 3.2 to 3.5). The statistics relate to EUROSTAT complete energy balances, annual data (nrg_110a), category Final energy consumption/ Industry and, for the last year, Eurostat ENERGY questionnaires provided by the Romanian National Institute of Statistics. Details are given in the *Table 3.1.1 Reference of activity data for NFR categories 1.A.1, 1.A.2, 1.A.4 and 1.A.5.* The emissions from NFR 1A2b – Combustion in non-ferrous metals industry, are included at *NFR 1A2a* – Iron and Steel*.* The reason is that the fuel consumption for this category is not recorded separately in the available energy statistics.

The shares of emissions from combustion in industry – NFR 1A2, in the country total, by pollutant, is shown in the table 3.5.1 and figure 3.5.1:

Table 3.5.1. Share of emissions from 1A2a in the national total

Pollutant	1A2	National Total	Unit	1A2 in national total %
NOx	24.50	202.90	kt	12.08
NMVOC	7.48	235.34	kt	3.18
SOx	19.02	46.60	kt	40.83
NH_3	0.01	149.84	kt	0.01
$PM_{2.5}$	3.39	107.46	kt	3.15
PM_{10}	3.57	143.13	kt	2.50
TSP	3.76	197.14	kt	1.91
BC	0.57	12.95	kt	4.43
CO	46.39	895.66	kt	5.18
Pb	3.33	40.69	t	8.18
Cd	0.20	2.97	t	6.86
Hg	0.55	1.55	t	35.30
As	0.27	3.19	t	8.48
Cr	0.75	12.98	t	5.76
Cu	1.45	80.68	t	1.80
Ni	0.62	11.49	t	5.42
Se	0.22	6.39	t	3.52
Zn	11.43	121.33	t	9.42
PCDD/PCDF	4.58	186.10	g I-TEQ	2.46
Total PAH	2.97	53.68	t	5.53
HCB	0.09	3.13	kg	2.75
PCBs	3.78	15.06	kg	25.09

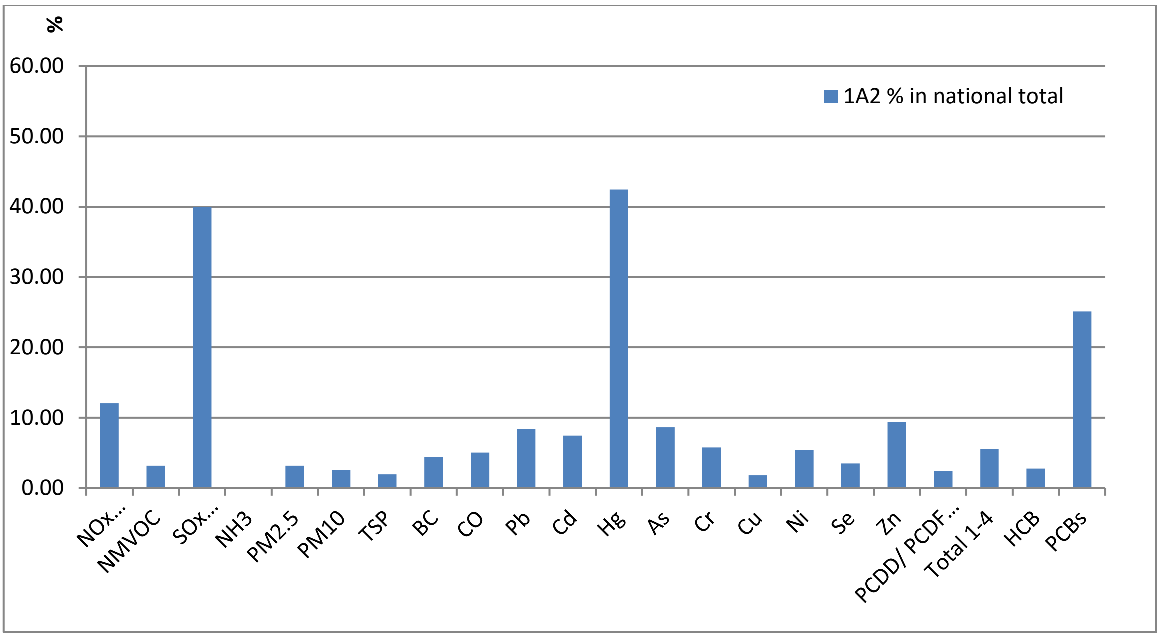


Figure 3.5.1 Share of 1A2 emissions by pollutant in the national total (%) 2022

The following table and chart give details on the shares of fuel consumption by fuel type and subcategory within NFR 1A2 (Fig. 3.5.2), which is relevant for the contribution of the specific industries to sector emissions.

Table 3.5.2. 1A2 Fuel consumption [TJ] by NFR and fuel type, 2022

NFR	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1A2a	NA	16042.714	19930.836	2.169
1A2c	9.498	70.584	30018.886	135.542
1A2d	NA	133.032	5281.726	160.095
1A2e	25.852	575.592	14428.753	950.257
1A2f	9129.136	18155.715	9902.046	199.972
1A2gvii	15696.458	NA	NA	NA
1A2gviii	55.893	49.824	25685.360	7267.190

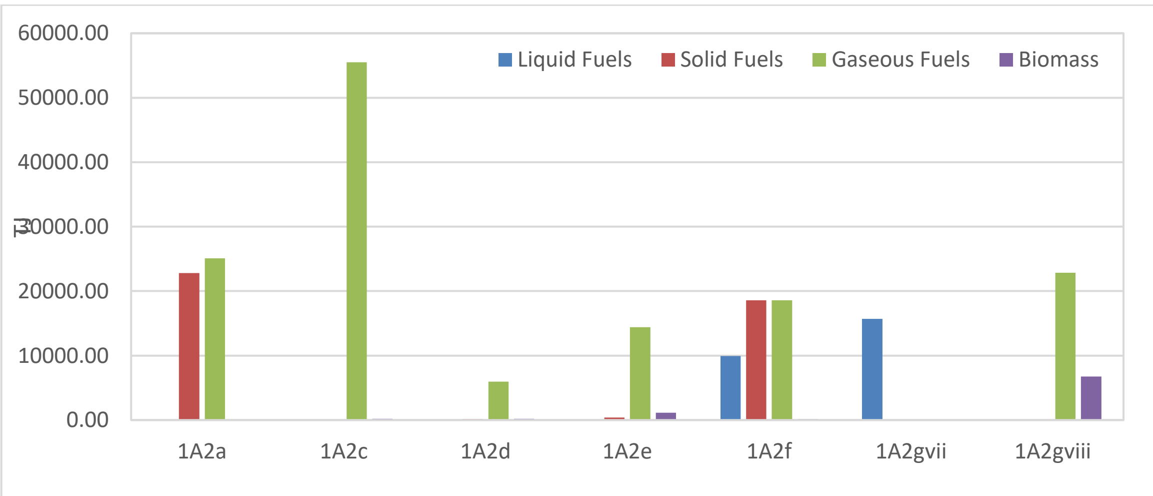


Figure 3.5.2 NFR 1A2 – Fuel consumption [TJ] by fuel type and subcategory, 2022

Time-series trends of emissions and fuel consumption for 1A2 sector and sub-sectors

The trend of fuel consumption in industry (total 1A2), by fuel type, since 1990, is given in the table and chart below:

Table 3.5.3. Trend of fuel consumption, by fuel type, from 1990, for 1A2 sector

Year/Fuel type (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	67735	97919	755418	0
1991	73563	79864	519760	1309
1992	53436	62877	163792	1746
1993	36664	54803	169943	1562
1994	63982	59011	306076	8220
1995	58831	72953	356497	9380
1996	85093	63204	327341	9627
1997	68260	70530	261111	12653
1998	60237	62813	188591	9250
1999	48153	42565	181322	9359
2000	56292	43593	187127	10929
2001	62919	45704	202384	9649
2002	57578	54388	220431	13582
2003	38597	57230	223446	19922
2004	46034	66708	198031	11019
2005	44037	68766	195765	10280
2006	42194	66866	178879	12253
2007	40095	56356	176298	14782
2008	32645	54594	185266	8719
2009	18682	35295	134664	8877
2010	14199	39826	138183	10551
2011	21466	35296	143721	8823
2012	25453	33618	128954	10968
2013	21235	30995	121826	11520
2014	23340	29511	124541	10989
2015	27200	34137	114089	10285
2016	26890	33465	105198	12332
2017	27014	28571	120365	12041
2018	26166	31432	126000	10039
2019	27801	32121	128848	9831
2020	27294	35086	128721	8292
2021	25766	42024	142452	8384
2022	24917	35027	105248	8715

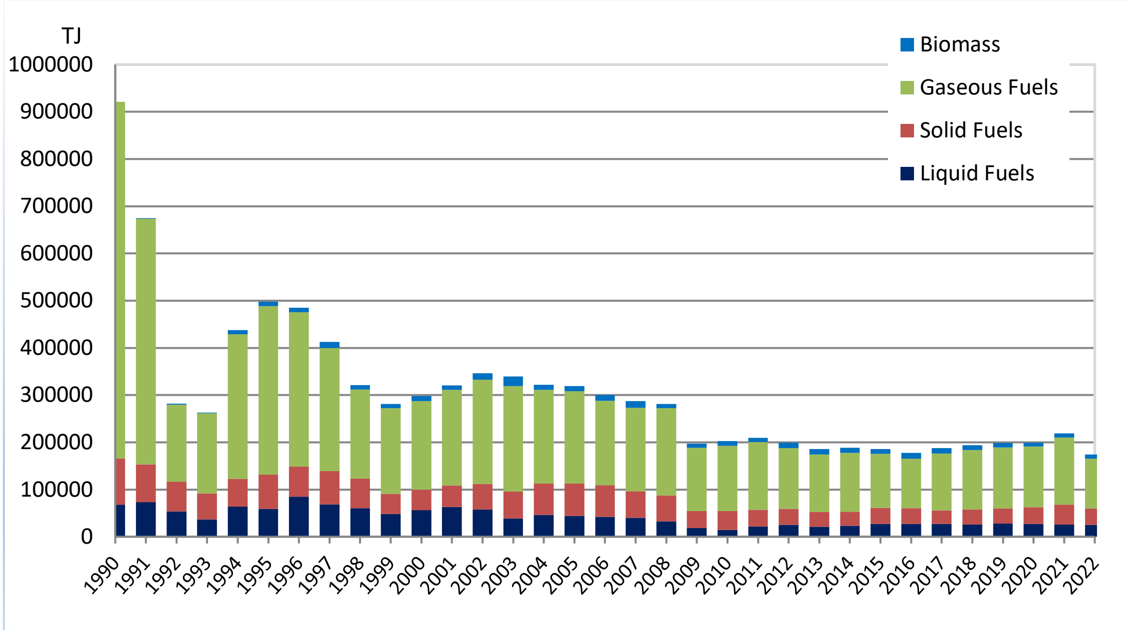


Figure 3.5.3 Fuel consumption (TJ) in industry (NFR 1A2), by fuel type 1990-2022

Total fuel consumption in industry decreased from 1990 to 2022 with about 81.12% (total energy). The highest decrease was recorded in gaseous fuel consumption, determined mostly by the decrease of production in the iron and steel industry.

The emissions from combustion in industry follow the variation of fuel combustion. The following section gives the emissions by NFR for the relevant pollutants, from 1990 to 2022, in tables and charts. For 1990 and 1991 emissions from NFR 1A2d and NFR 1A2gvii are included in 1A2gviii.

Table 3.5.4 NOx emissions for 1A2 sector by NFR, 1990-2022 (kt)

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
1990	27.603	25.976	IE	0.223	0.491	IE	50.925
1991	22.793	14.912	IE	0.022	0.127	IE	52.281
1992	15.853	4.305	0.175	1.090	7.762	18.890	7.452
1993	17.396	5.742	0.106	1.238	6.257	8.910	3.884
1994	19.457	13.267	1.175	4.700	6.220	17.144	9.865
1995	20.988	15.192	2.013	5.514	6.976	14.117	9.866
1996	19.855	15.069	2.019	5.384	8.039	27.215	10.120
1997	20.098	11.539	1.611	4.602	6.597	19.030	9.827
1998	19.449	5.822	1.628	1.653	7.021	17.939	7.812
1999	14.651	5.670	1.395	2.313	5.691	13.504	8.747
2000	14.396	8.778	1.247	2.148	10.238	16.398	4.839
2001	12.987	12.087	1.314	2.189	11.966	19.199	4.439
2002	13.872	10.431	1.372	1.707	11.481	19.968	4.731
2003	14.280	9.758	1.765	1.685	6.873	14.799	4.337
2004	16.812	7.641	1.058	1.833	10.408	12.441	4.904
2005	18.296	7.653	0.907	2.452	9.817	12.896	3.028
2006	18.826	6.987	0.739	1.657	10.652	12.913	4.046
2007	12.762	6.025	0.852	1.535	11.124	18.365	4.188
2008	11.116	7.024	0.238	1.445	10.899	12.124	5.211

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
2009	7.081	5.801	0.178	1.338	8.259	6.499	2.426
2010	7.354	5.560	0.347	1.475	7.416	5.662	2.702
2011	6.933	6.082	0.091	1.600	8.390	6.552	2.868
2012	5.542	5.256	0.127	1.787	8.703	6.882	2.596
2013	5.836	4.287	0.136	1.218	7.557	5.731	2.632
2014	5.749	4.131	0.170	1.235	8.219	5.297	2.586
2015	6.600	3.417	0.216	1.177	9.245	5.697	2.367
2016	6.470	2.670	0.239	1.294	8.967	5.012	2.472
2017	5.785	3.289	0.362	1.440	9.404	4.605	2.478
2018	5.660	3.471	0.242	1.144	10.228	4.236	2.591
2019	5.634	3.837	0.324	1.255	10.799	3.939	2.690
2020	5.240	3.750	0.307	1.206	11.133	3.690	2.474
2021	5.805	4.157	0.484	1.237	11.406	3.823	2.351
2022	4.250	2.251	0.428	1.267	10.178	3.529	2.599

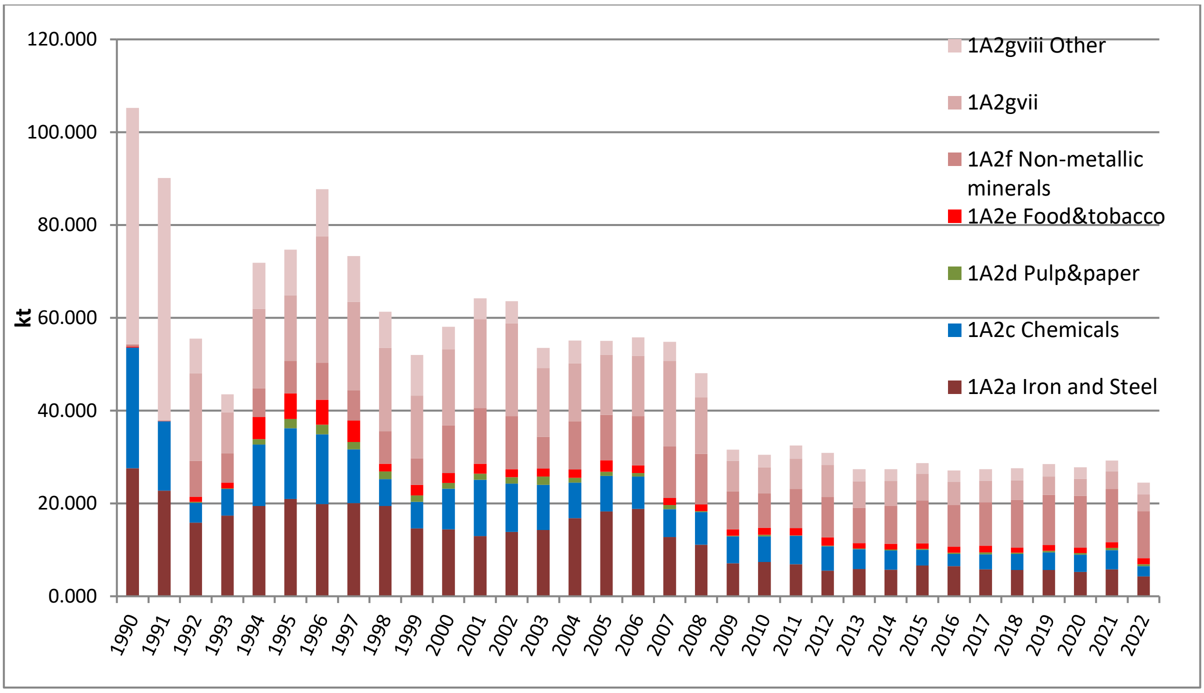


Figure 3.5.4 NOx emissions (kt) for 1A2 sector by NFR, 1990-2022

Table 3.5.5 NMVOC (kt) emissions for 1A2 sector by NFR, 1990-2022

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
1990	11.564	8.318	IE	0.115	0.252	IE	7.960
1991	9.578	4.639	IE	0.012	0.065	IE	6.984
1992	6.254	1.411	0.022	0.290	1.119	10.430	1.435
1993	6.170	1.279	0.006	0.310	0.909	3.708	1.175
1994	6.887	2.744	0.059	1.191	0.953	3.673	3.940
1995	7.929	4.103	0.937	1.339	1.007	1.841	3.184
1996	7.143	3.564	0.916	1.274	1.101	9.393	3.224
1997	7.805	2.345	0.942	1.008	1.000	6.524	4.017
1998	6.966	1.510	0.918	0.468	0.891	9.571	2.801

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
1999	4.733	1.406	0.854	0.628	0.800	5.976	3.157
2000	4.615	2.075	1.186	0.582	1.032	7.402	2.902
2001	4.442	2.675	1.091	0.623	1.254	6.267	2.557
2002	5.026	2.967	1.823	0.453	1.255	13.591	3.262
2003	5.448	3.167	3.029	0.537	0.799	6.948	3.728
2004	6.360	2.388	1.323	0.650	1.089	5.854	2.728
2005	6.626	2.300	1.304	0.817	0.671	7.913	2.190
2006	6.556	1.949	1.283	0.615	0.658	5.515	2.984
2007	5.541	1.944	1.085	0.615	0.552	4.966	3.685
2008	4.949	2.318	0.210	0.505	0.441	2.829	2.938
2009	2.882	1.943	0.161	0.676	0.401	2.041	2.274
2010	3.362	1.921	0.150	0.741	0.412	1.420	2.690
2011	3.141	2.083	0.054	0.687	0.441	1.065	2.282
2012	2.426	1.835	0.074	0.825	0.475	0.946	2.601
2013	2.531	1.540	0.065	0.698	0.454	0.933	2.665
2014	2.484	1.478	0.070	0.766	0.443	0.878	2.771
2015	2.882	1.259	0.091	0.742	0.454	0.986	2.630
2016	2.876	0.951	0.094	0.630	0.475	0.852	3.266
2017	2.497	1.106	0.157	0.794	0.520	0.825	3.027
2018	2.461	1.167	0.102	0.667	0.589	0.694	3.130
2019	2.496	1.232	0.129	0.719	0.525	0.744	3.082
2020	2.316	1.179	0.152	0.648	0.530	0.732	2.612
2021	2.604	1.337	0.205	0.699	0.586	0.844	2.558
2022	1.884	0.738	0.181	0.669	0.481	0.752	2.777

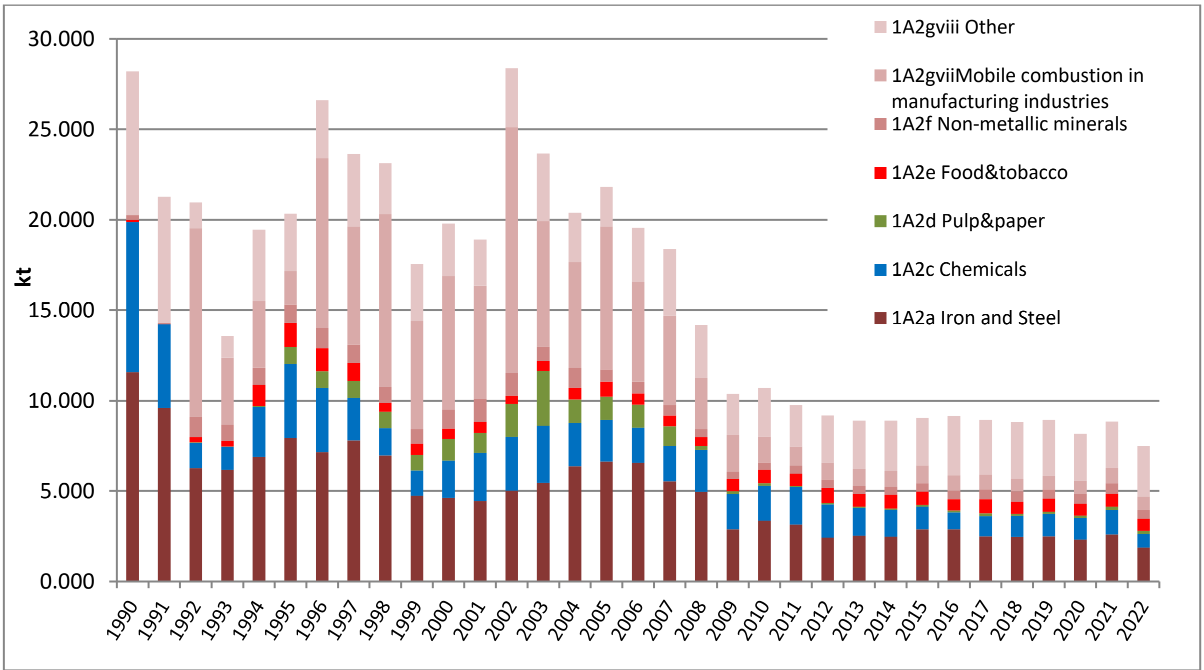


Figure 3.5.5 NMVOC emissions (kt) for 1A2 sector by NFR, 1990-2022

Table 3.5.6 $PM_{2.5}$ (kt) emissions for 1A2 sector by NFR, 1990-2022

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
1990	9.337	1.014	IE	0.139	0.306	IE	2.336
1991	7.792	0.164	IE	0.014	0.079	IE	2.636
1992	5.962	0.683	0.006	0.144	0.390	1.332	0.504
1993	5.706	0.387	0.004	0.124	0.253	0.612	0.280
1994	6.271	0.332	0.046	0.293	0.228	1.131	1.414
1995	7.089	0.925	0.404	0.362	0.293	0.915	1.204
1996	6.139	0.920	0.388	0.347	0.380	1.843	1.210
1997	7.373	0.617	0.398	0.320	0.248	1.288	1.479
1998	6.392	0.620	0.405	0.139	0.301	1.260	1.060
1999	4.131	0.670	0.372	0.195	0.219	1.251	1.119
2000	4.052	0.912	0.519	0.186	0.423	1.444	1.043
2001	4.031	1.222	0.475	0.123	0.543	1.583	0.878
2002	4.762	1.230	0.807	0.113	0.442	1.672	1.243
2003	5.248	1.085	1.363	0.128	0.292	1.160	1.435
2004	6.250	0.994	0.586	0.178	0.530	0.944	0.966
2005	6.593	0.975	0.566	0.145	0.062	0.965	0.765
2006	6.523	0.860	0.563	0.178	0.050	0.891	1.047
2007	5.327	0.688	0.472	0.152	0.051	1.150	1.450
2008	4.847	0.747	0.072	0.101	0.068	0.726	1.010
2009	2.796	0.722	0.056	0.198	0.064	0.395	0.813
2010	3.354	0.727	0.025	0.248	0.057	0.346	1.014
2011	3.076	0.735	0.014	0.205	0.055	0.399	0.831
2012	2.219	0.724	0.019	0.317	0.105	0.414	0.999
2013	2.267	0.593	0.013	0.276	0.097	0.336	1.018
2014	2.174	0.532	0.011	0.289	0.089	0.300	1.063
2015	2.657	0.515	0.015	0.271	0.090	0.320	1.014
2016	2.761	0.268	0.015	0.217	0.098	0.277	1.324
2017	2.249	0.275	0.034	0.278	0.100	0.246	1.190
2018	2.195	0.305	0.026	0.198	0.098	0.219	1.227
2019	2.316	0.251	0.031	0.207	0.098	0.195	1.189
2020	2.137	0.069	0.050	0.182	0.136	0.170	0.983
2021	2.485	0.076	0.045	0.207	0.155	0.168	0.968
2022	1.748	0.050	0.041	0.207	0.148	0.148	1.044

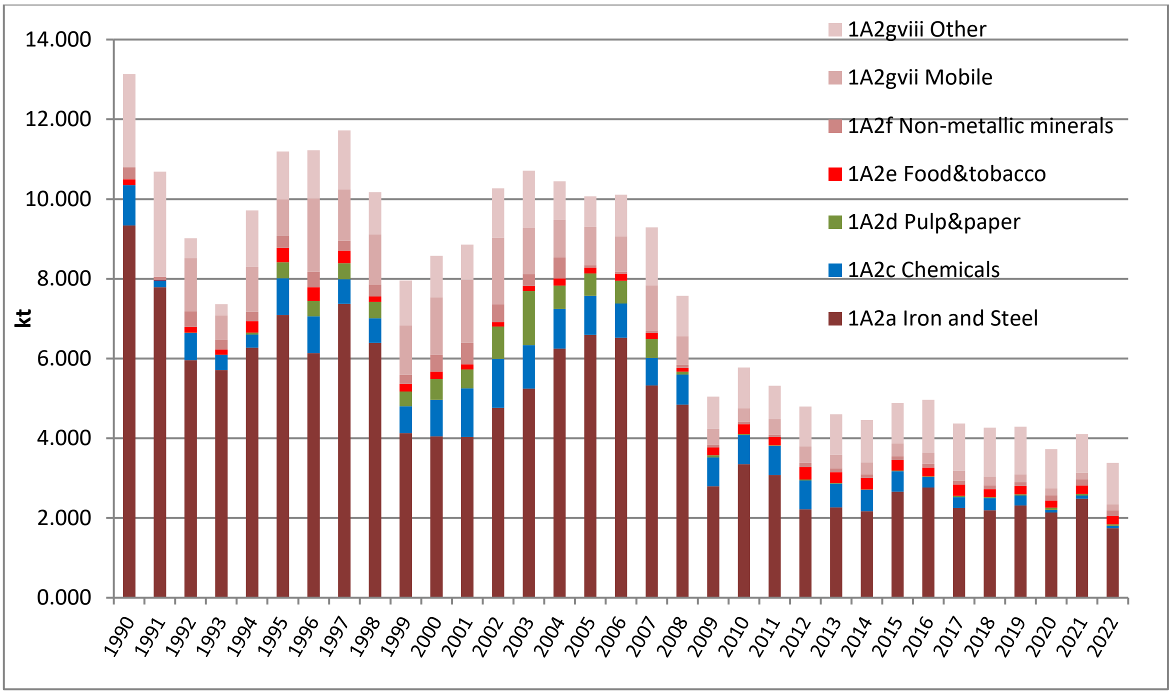


Figure 3.5.6 $PM_{2.5}$ emissions (kt) for 1A2 sector by NFR, 1990-2022

Table 3.5.7 SOx emissions for 1A2 sector by NFR, 1990-2022

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
1990	76.798	6.499	IE	1.162	2.552	IE	10.752
1991	64.099	0.178	IE	0.117	0.662	IE	10.641
1992	48.676	4.741	0.012	0.838	1.554	1.275	2.132
1993	46.131	1.989	0.009	0.563	0.931	0.585	0.969
1994	50.592	0.585	0.107	1.123	0.754	1.077	2.175
1995	57.525	5.643	0.313	1.361	1.117	0.871	1.936
1996	49.512	5.053	0.173	1.185	1.626	1.759	1.901
1997	60.193	2.421	0.132	0.854	0.866	1.229	1.303
1998	51.874	4.063	0.138	0.301	1.032	1.206	0.976
1999	33.099	4.858	0.129	0.226	0.752	0.720	1.012
2000	32.456	6.430	0.194	0.356	1.365	0.880	0.442
2001	32.556	8.496	0.122	0.231	1.560	1.013	0.354
2002	38.677	9.163	0.126	0.219	1.360	1.179	1.225
2003	42.867	8.230	0.165	0.171	1.040	0.856	0.360
2004	51.030	7.586	0.085	0.225	2.258	0.747	0.525
2005	53.643	7.417	0.065	0.149	2.406	0.833	0.177
2006	52.869	6.432	0.056	0.129	2.724	0.839	0.354
2007	43.961	5.232	0.063	0.104	3.014	1.280	0.283
2008	40.085	5.695	0.007	0.047	3.167	0.894	0.314
2009	22.968	5.585	0.006	0.085	2.416	0.527	0.100
2010	27.788	5.556	0.005	0.466	2.097	0.476	0.125
2011	25.467	5.559	0.002	0.280	2.233	0.567	0.142
2012	18.325	5.577	0.005	0.823	2.597	0.627	0.155
2013	18.706	4.473	0.004	0.878	2.182	0.559	0.129
2014	17.934	3.968	0.004	0.741	2.350	0.551	0.132

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
2015	21.934	3.848	0.012	0.664	2.655	0.647	0.132
2016	22.833	1.832	0.028	0.647	2.586	0.619	0.152
2017	18.50	1.828	0.079	0.646	2.675	0.624	0.129
2018	18.117	2.100	0.101	0.282	3.005	0.006	0.141
2019	19.143	1.601	0.132	0.273	3.245	0.006	0.146
2020	17.665	0.056	0.179	0.314	3.702	0.007	0.117
2021	20.561	0.098	0.133	0.354	3.969	0.007	0.110
2022	14.452	0.086	0.125	0.539	3.669	0.007	0.145

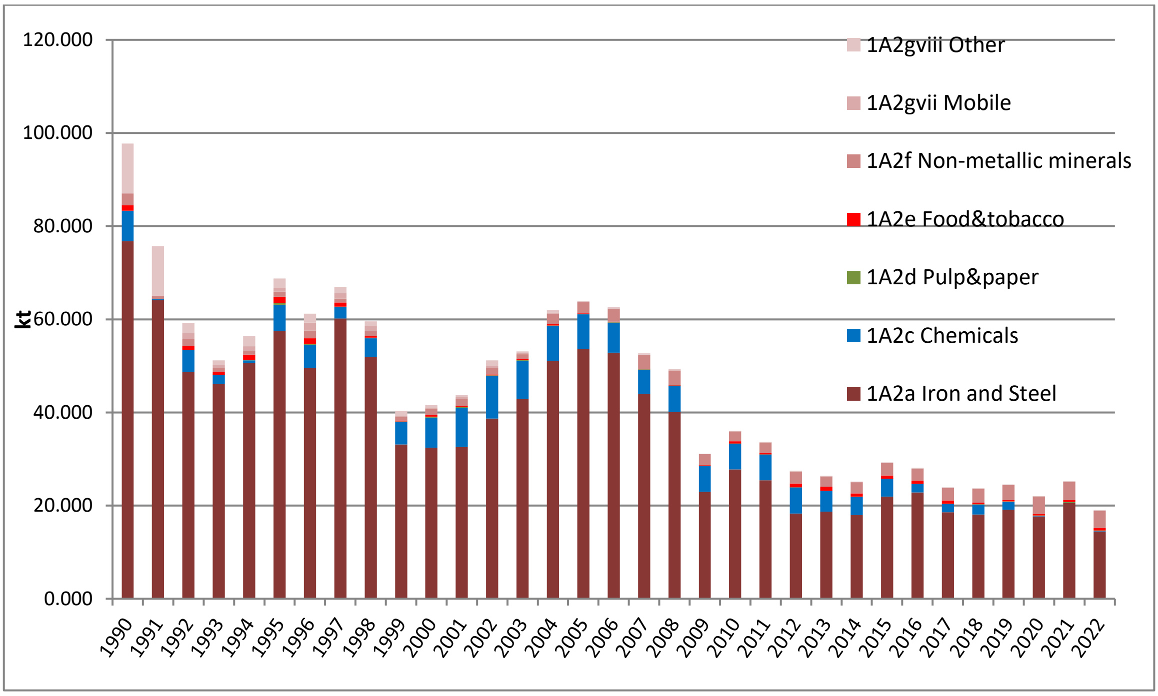


Figure 3.5.7 SOx emissions (kt) for 1A2 sector by NFR, 1990-2022

Table 3.5.8 Pb (t) emissions for 1A2 sector by NFR, 1990-2022

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gviii
1990	11.419	0.938	IE	0.173	0.380	1.159
1991	9.531	0.009	IE	0.017	0.098	1.093
1992	7.215	0.703	0.000	0.122	0.163	0.274
1993	6.812	0.267	0.000	0.081	0.082	0.147
1994	7.471	0.010	0.000	0.155	0.059	0.441
1995	8.517	0.789	0.089	0.186	0.103	8.517
1996	7.318	0.682	0.067	0.160	0.166	7.318
1997	8.917	0.296	0.071	0.113	0.072	8.917
1998	7.661	0.582	0.070	0.047	0.085	7.661
1999	4.867	0.693	0.067	0.038	0.060	4.867
2000	4.771	0.907	0.108	0.056	0.090	4.771
2001	4.799	1.187	0.089	0.035	0.107	4.799
2002	5.715	1.325	0.154	0.032	0.080	5.715
2003	6.345	1.208	0.260	0.031	0.084	6.345
2004	7.550	1.109	0.110	0.046	0.221	7.550
2005	7.924	1.080	0.107	0.030	0.602	7.924

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gviii
2006	7.799	0.929	0.107	0.034	0.691	7.799
2007	6.534	0.767	0.089	0.031	0.768	6.534
2008	5.961	0.837	0.014	0.015	0.796	5.961
2009	3.407	0.822	0.010	0.039	0.607	3.407
2010	4.135	0.822	0.004	0.096	0.535	4.135
2011	3.789	0.822	0.003	0.062	0.574	3.789
2012	2.726	0.826	0.004	0.150	0.633	2.726
2013	2.782	0.666	0.003	0.158	0.539	2.782
2014	2.667	0.591	0.002	0.143	0.577	2.667
2015	3.262	0.574	0.004	0.131	0.651	3.262
2016	3.396	0.275	0.006	0.116	0.630	3.396
2017	2.758	0.272	0.015	0.127	0.654	2.758
2018	2.695	0.311	0.017	0.069	0.715	0.236
2019	2.848	0.235	0.021	0.069	0.777	0.230
2020	2.628	0.007	0.031	0.070	0.860	0.188
2021	3.059	0.013	0.024	0.079	0.911	0.185
2022	2.150	0.013	0.022	0.103	0.837	0.203

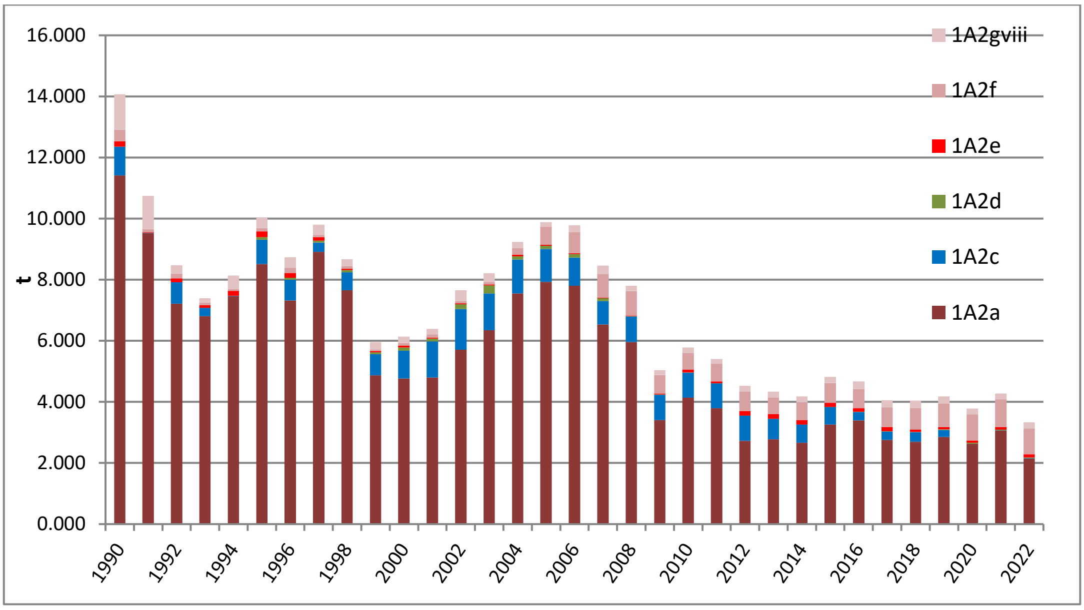


Figure 3.5.8 Pb emissions (t) for 1A2 sector by NFR, 1990-2022

Table 3.5.9 Hg (t) emissions for 1A2 sector by NFR, 1990-2022

Year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gviii
1990	0.767	0.236	IE	0.010	0.022	0.208
1991	0.638	0.109	IE	0.001	0.006	0.167
1992	0.457	0.059	0.000	0.010	0.027	0.036
1993	0.436	0.037	0.000	0.008	0.021	0.027
1994	0.480	0.058	0.000	0.028	0.021	0.053
1995	0.551	0.125	0.007	0.032	0.023	0.551
1996	0.480	0.104	0.005	0.028	0.027	0.480
1997	0.567	0.056	0.005	0.019	0.022	0.567
1998	0.492	0.056	0.004	0.008	0.019	0.492
1999	0.318	0.061	0.004	0.008	0.018	0.318

Year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gviii
2000	0.311	0.085	0.006	0.009	0.020	0.311
2001	0.310	0.109	0.005	0.012	0.022	0.310
2002	0.363	0.125	0.006	0.008	0.024	0.363
2003	0.401	0.126	0.009	0.009	0.017	0.401
2004	0.474	0.103	0.004	0.010	0.027	0.474
2005	0.495	0.100	0.005	0.015	0.307	0.495
2006	0.488	0.084	0.004	0.008	0.351	0.488
2007	0.413	0.078	0.004	0.009	0.385	0.413
2008	0.375	0.090	0.002	0.008	0.388	0.375
2009	0.215	0.081	0.001	0.008	0.293	0.215
2010	0.258	0.080	0.003	0.012	0.262	0.258
2011	0.238	0.083	0.001	0.010	0.288	0.238
2012	0.175	0.078	0.001	0.015	0.297	0.175
2013	0.180	0.064	0.001	0.014	0.256	0.180
2014	0.174	0.059	0.001	0.014	0.276	0.174
2015	0.209	0.053	0.002	0.013	0.312	0.209
2016	0.215	0.033	0.002	0.013	0.299	0.215
2017	0.178	0.036	0.003	0.014	0.313	0.178
2018	0.175	0.040	0.002	0.010	0.336	0.018
2019	0.182	0.038	0.003	0.011	0.365	0.019
2020	0.168	0.026	0.004	0.011	0.383	0.017
2021	0.193	0.030	0.004	0.011	0.397	0.185
2022	0.138	0.017	0.004	0.013	0.359	0.018

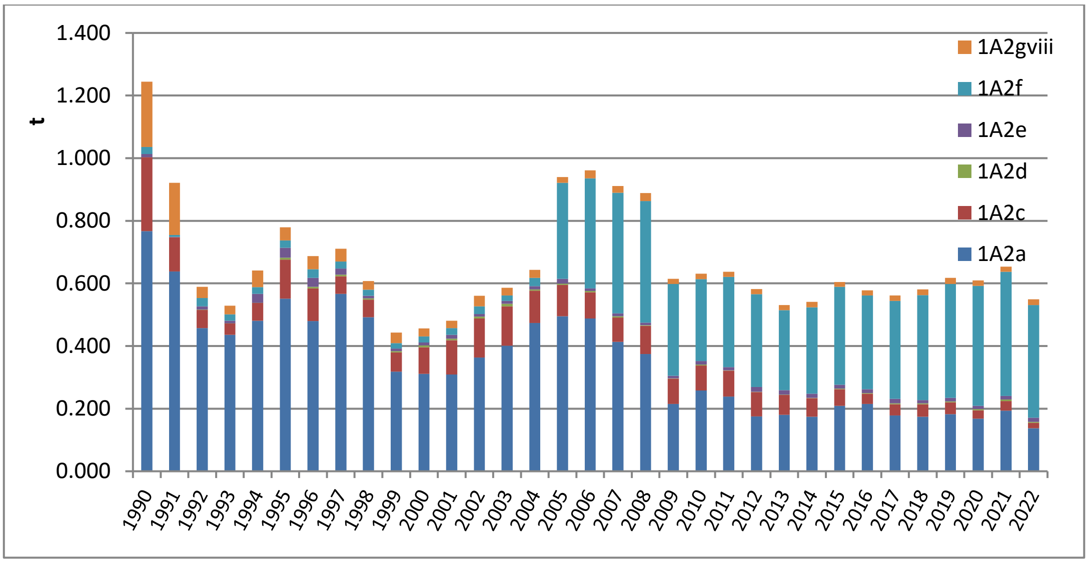


Figure 3.5.9 Hg emissions (t) for 1A2 sector by NFR, 1990-2022

Table 3.5.10 PCBs (kg) emissions for 1A2 sector by NFR, 1990-2021

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gviii
1990	14.484	1.185	IE	0.219	0.482	1.460
1991	12.090	0.008	IE	0.022	0.125	1.332
1992	9.148	0.875	0.000	0.149	0.197	0.321
1993	8.636	0.326	IE	0.094	0.101	0.158
1994	9.470	0.001	IE	0.175	0.072	0.314

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gviii
1995	0.551	0.125	0.007	0.032	0.023	0.551
1996	0.480	0.104	0.005	0.028	0.027	0.480
1997	0.567	0.056	0.005	0.019	0.022	0.567
1998	0.492	0.056	0.004	0.008	0.019	0.492
1999	0.318	0.061	0.004	0.008	0.018	0.318
2000	0.311	0.085	0.006	0.009	0.020	0.311
2001	0.310	0.109	0.005	0.012	0.022	0.310
2002	0.363	0.125	0.006	0.008	0.024	0.363
2003	0.401	0.126	0.009	0.009	0.017	0.401
2004	0.474	0.103	0.004	0.010	0.277	0.474
2005	0.495	0.100	0.005	0.015	0.633	0.495
2006	0.488	0.084	0.004	0.008	0.727	0.488
2007	0.413	0.078	0.004	0.009	0.808	0.413
2008	0.375	0.090	0.002	0.008	0.840	0.375
2009	0.215	0.081	0.001	0.008	0.639	0.215
2010	0.258	0.080	0.003	0.012	0.560	0.258
2011	0.238	0.083	0.001	0.010	0.599	0.238
2012	0.175	0.078	0.001	0.015	0.669	0.175
2013	0.180	0.064	0.001	0.014	0.566	0.180
2014	0.174	0.059	0.001	0.014	0.608	0.174
2015	0.209	0.053	0.002	0.013	0.688	0.209
2016	0.215	0.033	0.002	0.013	0.666	0.215
2017	0.178	0.036	0.003	0.014	0.691	0.178
2018	3.418	0.389	0.019	0.049	0.766	0.005
2019	3.613	0.292	0.024	0.047	0.831	0.007
2020	3.333	0.001	0.033	0.055	0.929	0.004
2021	3.880	0.010	0.024	0.062	0.990	0.003
2022	2.727	0.012	0.023	0.098	0.911	0.009

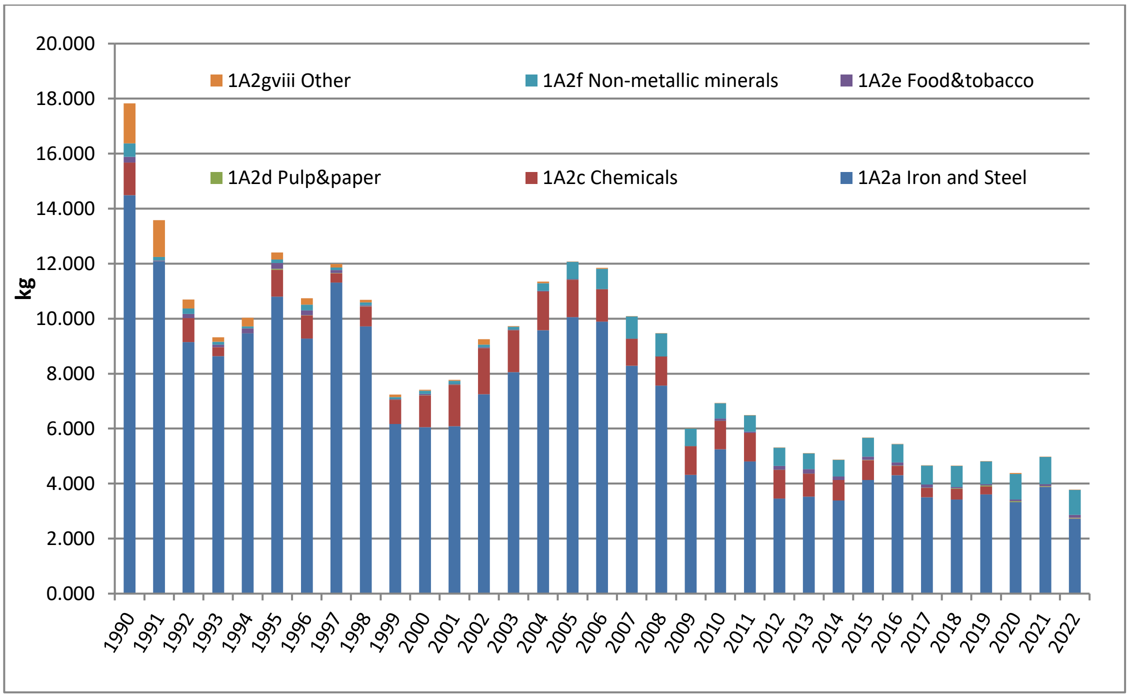


Figure 3.5.10 PCBs emissions (kg) for 1A2 sector by NFR, 1990 -2022

The next subchapters give details on NFR categories which are key sources in 2022.

3.5.1 NFR 1.A.2.a Iron and steel. Stationary combustion.

Emissions from fuel combustion in iron and steel industry have been estimated based on fuel consumption data from the EUROSTAT complete energy balances, annual data (nrg_110a), category *Final energy consumption/Industry/Iron & steel industry* and default Tier 1 emission factors (2019 EMEP/EEA Guidebook, NFR 1.A.2, Tables 3.2-3.5). Emissions from fuel combustion in iron and steel industry have been estimated based on fuel consumption data from the EUROSTAT complete energy balances, annual data (nrg_110a), category *Final energy consumption/Industry/Iron & steel industry* and default Tier 1 emission factors (2019 EMEP/EEA Guidebook, NFR 1.A.2, Tables 3.2-3.5). This category also includes the emissions for NFR 1A2b Non-ferrous metals, because, in EUROSTAT Energy statistics, the specific activity data for Romania are included in fuel consumption for Iron and steel. NFR 1A2a was a key source for emissions of SOx (31%), Pb (5.3%) and Hg (8.8%) in 2022.
The following tables and charts show the trend of emissions and fuel consumption for NFR 1.A.2.a Iron and steel.

Table 3.5.1.1 Emissions of gaseous pollutants, particulate matter, BC, CO (kt), PCDD, PAH and PCBs NFR 1A2a, 1990-2022

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx (kt)	TSP (kt)	BC (kt)	CO (kt)	PCDD (g)	PAH (t)	PCBs (kg)
1990	27.60	11.56	76.80	10.70	0.59	84.36	17.39	12.49	14,48
1991	22.79	9.58	64.10	8.93	0.50	70.33	14.51	10.43	12,09
1992	15.85	6.25	48.68	6.82	0.43	52.13	10.97	7.98	9,15
1993	17.40	6.17	46.13	6.52	0.44	49.68	10.37	7.61	8,64
1994	19.46	6.89	50.59	7.16	0.49	54.64	11.38	8.35	9,47
1995	20.99	7.93	57.53	0.01	7.09	7.66	12.97	10.80	10,80
1996	19.86	7.14	49.51	0.01	6.14	6.63	11.15	9.27	9,27
1997	20.10	7.81	60.19	0.00	7.37	7.97	13.56	11.31	11,31
1998	19.45	6.97	51.87	0.00	6.39	6.91	11.65	9.72	9,72
1999	14.65	4.73	33.10	0.00	4.13	4.46	7.41	6.17	6,17
2000	14.40	4.62	32.46	0.00	4.05	4.37	7.27	6.05	6,05
2001	12.99	4.44	32.56	0.00	4.03	4.35	7.30	6.09	6,09
2002	13.87	5.03	38.68	0.00	4.76	5.15	8.69	7.25	7,25
2003	14.28	5.45	42.87	0.00	5.25	5.68	9.64	8.05	8,05
2004	16.81	6.36	51.03	0.00	6.25	6.76	11.47	9.58	9,58
2005	18.30	6.63	53.64	0.00	6.59	7.13	12.04	10.05	10,05
2006	18.83	6.56	52.87	0.00	6.52	7.05	11.85	9.89	9,89
2007	12.76	5.54	43.96	0.00	5.33	5.77	9.93	8.29	8,29
2008	11.12	4.95	40.09	0.00	4.85	5.25	9.05	7.56	7,56
2009	7.08	2.88	22.97	0.00	2.80	3.03	5.18	4.32	4,32
2010	7.35	3.36	27.79	0.00	3.35	3.63	6.28	5.25	5,25
2011	6.93	3.14	25.47	0.00	3.08	3.33	5.75	4.81	4,81
2012	5.54	2.43	18.33	0.00	2.22	2.40	4.14	3.46	3,46
2013	5.84	2.53	18.71	0.00	2.27	2.45	4.23	3.53	3,53

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx (kt)	TSP (kt)	BC (kt)	CO (kt)	PCDD (g)	PAH (t)	PCBs (kg)
2014	5.75	2.48	17.93	0.00	2.17	2.35	4.06	3.38	3,38
2015	6.60	2.88	21.93	0.00	2.66	2.88	4.96	4.14	4,14
2016	6.47	2.88	22.83	0.00	2.76	2.99	5.16	4.31	4,31
2017	5.79	2.50	18.55	0.00	2.25	2.43	4.19	3.50	3,50
2018	5.66	2.46	18.12	2.52	0.14	19.57	4.10	2.95	3,42
2019	5.63	2.50	19.14	2.66	0.15	20.55	4.33	3.12	3,61
2020	5.24	2.32	17.66	2.45	0.14	18.98	3.99	2.87	3.33
2021	5.80	2.60	20.56	2.85	0.15	21.98	4.64	3.35	3.88
2022	4.25	1.88	14.45	2.01	0.11	15.51	3.27	2.35	2.73

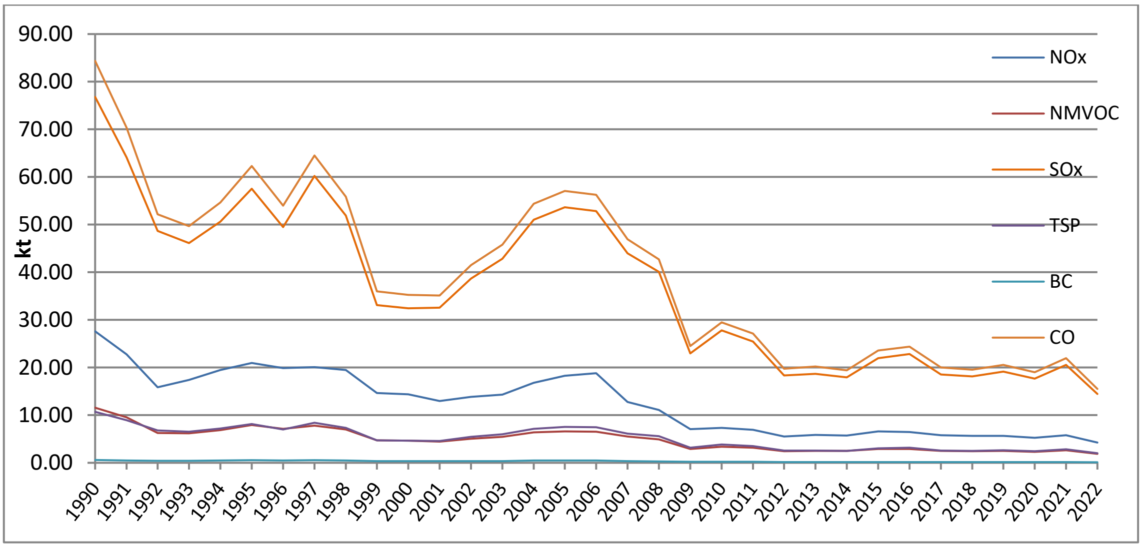


Figure 3.5.1.1 Emissions of NOx, SOx, NMVOC, NH_3, TSP, BC and CO (kt) for NFR 1A2a, 1990-2022

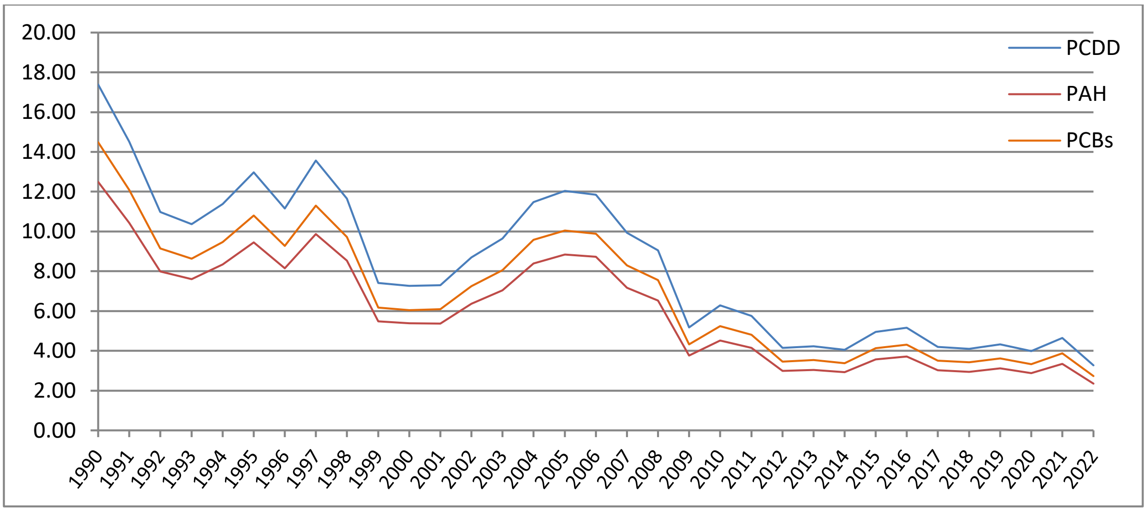


Figure 3.5.1.2 Emissions of PCDD/PCDF (g), PAH (t) and PCBs (kg) for NFR 1A2a, 1990-2022

Emissions of pollutants follow the activity data trend, with peaks in 1990, 1997 and 2005-2006 and then constantly decreasing for the entire time series.

Table 3.5.1.2. Emissions of Heavy Metals (t) for NFR 1.A.2.a.

Year/Pollutant	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
1990	11.419	0.154	0.767	0.358	1.152	1.491	1.110	0.163	17.167
1991	9.531	0.128	0.638	0.299	0.962	1.245	0.926	0.136	14.332
1992	7.215	0.099	0.457	0.221	0.731	0.944	0.701	0.101	10.995
1993	6.812	0.093	0.436	0.210	0.691	0.892	0.662	0.096	10.488
1994	7.471	0.103	0.480	0.230	0.759	0.978	0.726	0.106	11.539
1995	8.517	0.117	0.551	0.263	0.865	1.114	0.827	0.120	13.065
1996	7.318	0.101	0.480	0.227	0.744	0.958	0.711	0.104	11.296
1997	8.917	0.121	0.567	0.274	0.902	1.166	0.866	0.125	13.574
1998	7.661	0.103	0.492	0.236	0.774	1.002	0.744	0.108	11.719
1999	4.867	0.066	0.318	0.151	0.493	0.637	0.473	0.070	7.547
2000	4.771	0.064	0.311	0.148	0.483	0.625	0.463	0.068	7.400
2001	4.799	0.065	0.310	0.148	0.485	0.628	0.466	0.068	7.381
2002	5.715	0.077	0.363	0.175	0.578	0.748	0.555	0.080	8.743
2003	6.345	0.085	0.401	0.194	0.641	0.830	0.616	0.089	9.647
2004	7.550	0.101	0.474	0.231	0.762	0.987	0.733	0.105	11.486
2005	7.924	0.107	0.495	0.242	0.801	1.037	0.769	0.110	12.106
2006	7.799	0.105	0.488	0.238	0.788	1.021	0.757	0.109	11.967
2007	6.534	0.088	0.413	0.200	0.659	0.854	0.635	0.091	9.821
2008	5.961	0.080	0.375	0.182	0.601	0.779	0.579	0.083	8.942
2009	3.407	0.046	0.215	0.104	0.344	0.445	0.331	0.047	5.148
2010	4.135	0.056	0.258	0.126	0.417	0.540	0.401	0.057	6.192
2011	3.789	0.051	0.238	0.116	0.382	0.495	0.368	0.052	5.677
2012	2.726	0.037	0.175	0.084	0.275	0.356	0.265	0.038	4.089
2013	2.782	0.037	0.180	0.086	0.281	0.363	0.270	0.039	4.176
2014	2.667	0.036	0.174	0.083	0.269	0.348	0.259	0.038	4.004
2015	3.262	0.044	0.209	0.100	0.329	0.426	0.317	0.046	4.897
2016	3.396	0.046	0.215	0.104	0.343	0.444	0.330	0.047	5.093
2017	2.758	0.037	0.178	0.085	0.278	0.360	0.268	0.039	4.142
2018	2.695	0.036	0.175	0.083	0.272	0.352	0.262	0.038	4.044
2019	2.848	0.038	0.182	0.088	0.287	0.372	0.277	0.040	4.269
2020	2.628	0.035	0.168	0.081	0.265	0.343	0.255	0.037	3.940
2021	3.059	0.041	0.193	0.093	0.308	0.399	0.297	0.042	4.584
2022	2.150	0.029	0.138	0.066	0.217	0.281	0.209	0.030	3.224

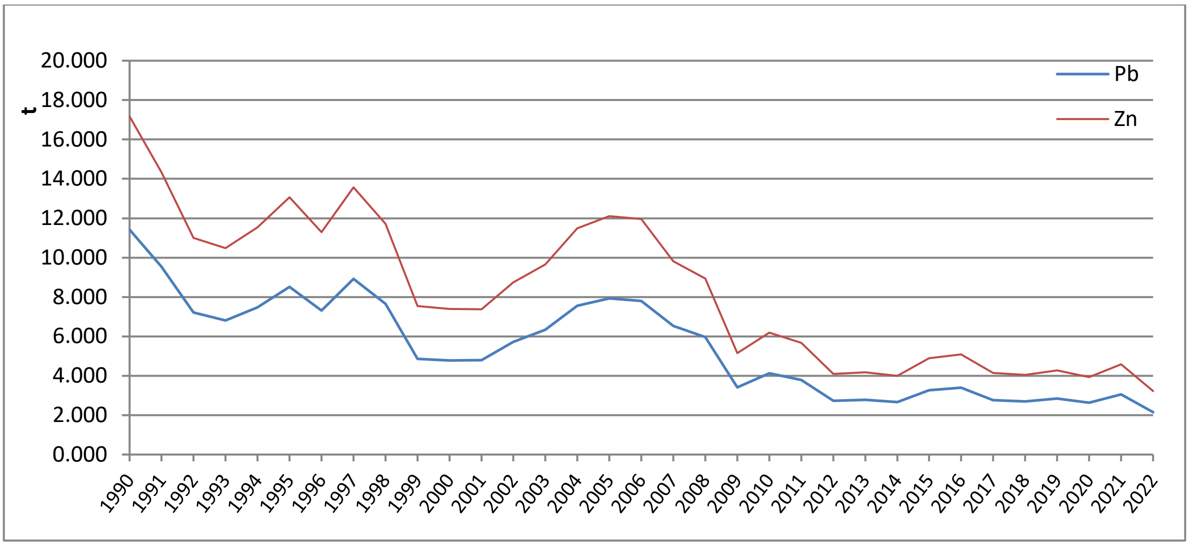


Figure 3.5.1.2.a Emissions of Pb and Zn (t) for NFR 1.A.2.a, 1990-2022

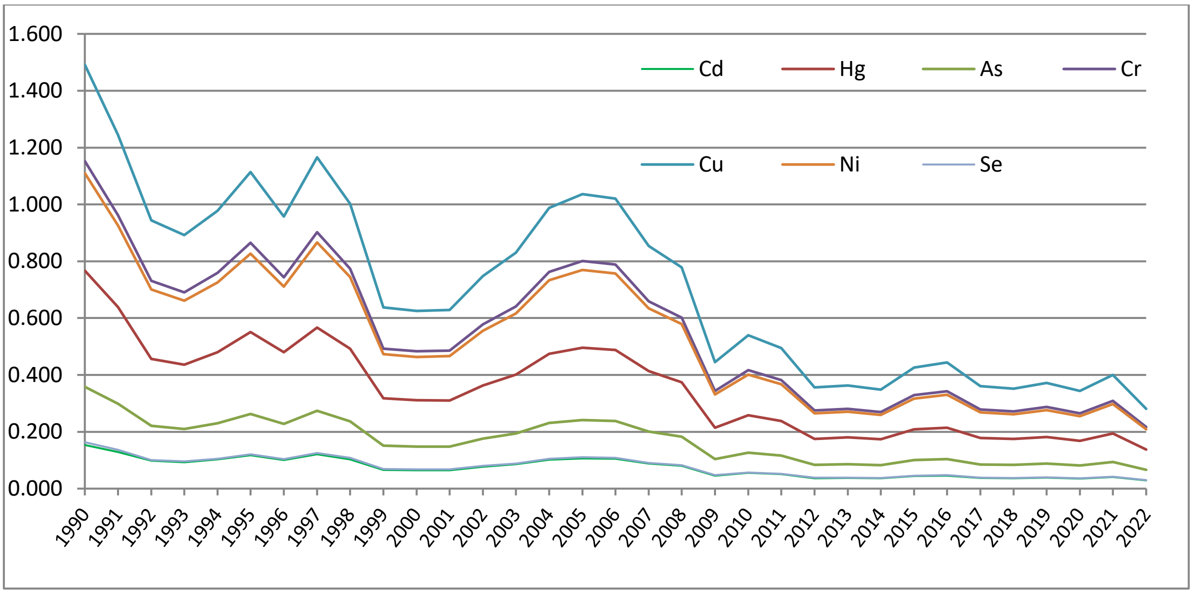


Figure 3.5.1.2.b Emissions of As, Cd, Cr, Cu, Hg, Ni and Se (t) for NFR 1.A.2.a, 1990-2022

All heavy metals emissions showed important decreases in 2022 compared to 1990 emissions, around 80% for Zn and Hg.

The iron and steel industry used mostly gaseous and solid fuels. The fuel consumption decreased from 1990 toward 2000, followed by a slight increase in the interval 2004-2006, a severe decrease to 2009 and a steadier variation afterwards. Total fuel consumption trend in the iron and steel industry is consistent with the production evolution. The amounts are given in the table and figure 3.5.1.3.

Table 3.5.1.3 Fuel consumption (TJ) by fuel type, for NFR 1.A.2.a.

Year/Fuel (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	NA	85202	173824	0
1991	NA	71116	141743	10
1992	4403	53810	57750	123
1993	7787	50802	62192	111
1994	8643	55706	72557	184
1995	6520	63507	89689	213
1996	7400	54558	89216	205
1997	5920	66515	74939	88
1998	8040	57163	73445	2
1999	8160	36308	56522	15
2000	8240	35592	54197	6
2001	6320	35807	47979	3
2002	5840	42634	47272	24
2003	4840	47341	48734	6
2004	6240	56335	52222	0
2005	8417	59126	50668	0
2006	9937	58188	49469	9
2007	1006	48755	51498	6
2008	480	44482	42891	0
2009	1554	25420	25481	0
2010	34	30854	27012	0
2011	34	28275	27346	2
2012	69	20338	26867	0
2013	79	20758	29794	1
2014	NA	19903	31160	1
2015	172	24339	31094	2
2016	172	25341	27002	1
2017	164	20581	28925	0
2018	23	20108	29323	0.18
2019	0.09	21250	26458	0.09
2020	0.23	19609	24961	0.85
2021	NA	22827	25079	1.85
2022	NA	16042	19930	2.17

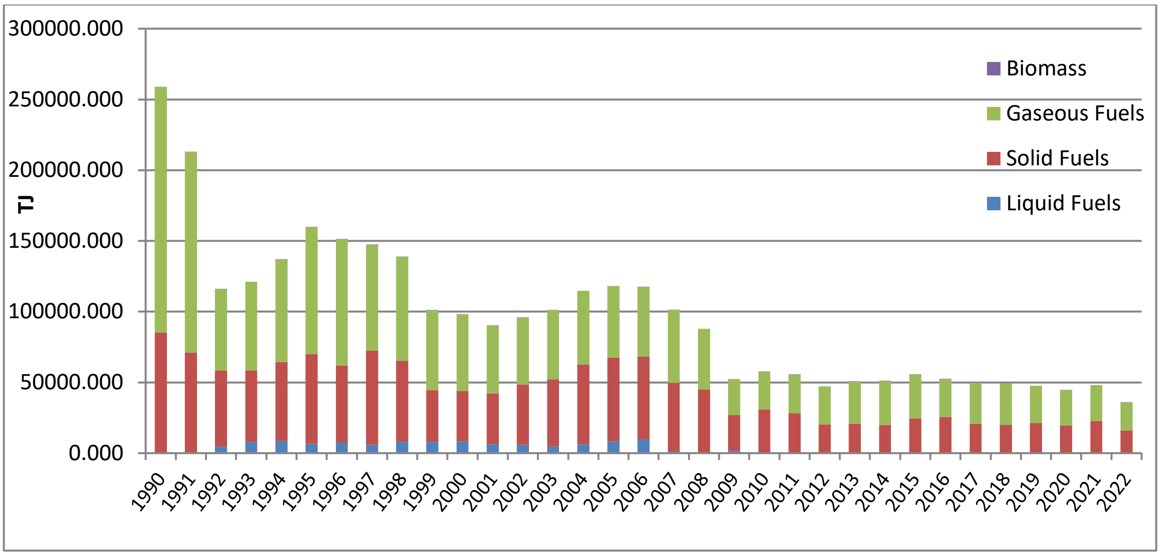


Figure 3.5.1.3 Fuel consumption (TJ), by fuel type, for NFR 1.A.2.a, 1990-2022

Recalculations and improvements:

Moving to a higher level of approach requires both production data regarding the intermediate products in the cast iron/steel production chain and the specific fuel consumption for each process. Data on production, on different stages, can be identified in the national statistical data, but specific consumptions, on the types of processes in the production stages, are not available for now. We initiated steps to identify and collect the necessary additional information.

3.5.2 NFR 1.A.2.f. Non-metallic minerals. Stationary combustion.

Stationary combustion in the non-metallic minerals industry was a key source of NOx (5%), SOx (7.9%) and Hg (23.1%) pollutants in 2022.

Emissions from fuel combustion in non-metallic minerals industry have been estimated for 1990-2004 period, based on fuel consumption data from the EUROSTAT complete energy balances, annual data (nrg_110a), category Final energy consumption/Industry/Non-Metallic Minerals and default Tier 1 emission factors (2019 EMEP/EEA Guidebook, chapter 1.A.2, Tables 3.2-3.5).

The emissions for years 2005-2022 were calculated by applying Tier 2 emission factors (2019 EMEP/EEA Guidebook, chapter 1.A.2, Table 3-24 Tier 2 emission factors for source category 1.A.2.f.i, Cement production) to clinker production, provided by NIS and Tier 1 emission factors (2019 EMEP/EEA Guidebook, chapter 1.A.2, Tables 3.2-3.5), to difference between the total consumption fuel data from the EUROSTAT complete energy balances and the consumption fuel used for produced clinker. For gaseous fuel, the difference between the total gaseous fuel reported to Eurostat and the consumption reported by operators for the production of clinker was taken into account. For the other fuels, the difference was estimated at 11% of the total consumption of liquid fuel, 6% of the total consumption of solid fuel and 10% of the total consumption of biomass fuel, data reported to EUROSTAT.

Table 3.5.2.1 Fuel consumption, by fuel type, for 1A2f sector, 1990-2022

Year/Fuel (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	0	2836	0	0
1991	0	735	0	0
1992	10412	1158	29712	242
1993	7960	597	27918	51
1994	7520	421	30861	61
1995	8960	750	30318	64
1996	10832	1217	30624	58
1997	8040	518	32147	45
1998	10000	605	23994	119
1999	7395	431	24582	39
2000	16283	648	23885	59
2001	19392	697	25114	431
2002	17432	576	32906	39
2003	10200	607	20683	48
2004	16488	1630	22468	50
2005	12712	1444	22277	515
2006	8268	1478	21814	364
2007	7434	1770	15957	783
2008	8528	3806	10244	1193
2009	4678	3685	9477	1611
2010	2636	2389	10446	2000
2011	7074	656	11897	1889
2012	10122	6264	10347	2456
2013	8452	4351	10000	3056
2014	11129	4423	10200	1990
2015	12982	4801	10296	1617
2016	13021	5375	10943	1875
2017	13018	5224	12558	2016
2018	12692	8610	17048	91
2019	13597	8694	13878	101
2020	12933	14925	13355	114
2021	9914	18604	14515	143
2022	9129	18156	9902	200

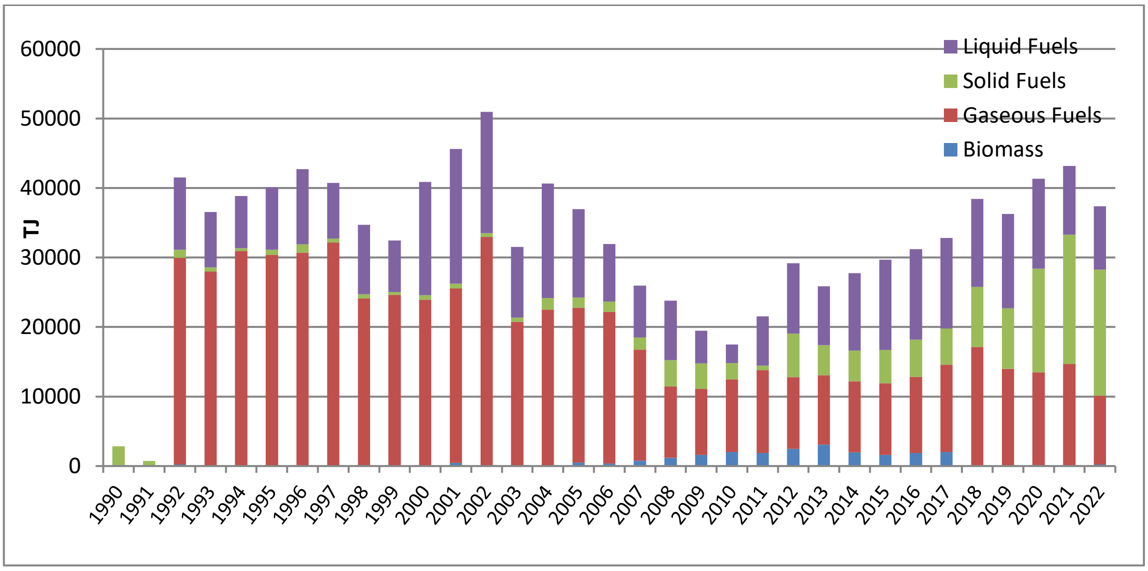


Figure 3.5.2.1 Fuel consumption (TJ), by fuel type, for NFR 1.A.2.f, 1990-2022

Table 3.5.2.2 Clinker production 2005-2022 (kt)

Year	Clinker production kt
2005	6006.96
2006	6916.22
2007	7670.40
2008	7780.028
2009	5841.148
2010	5201.629
2011	5751.215
2012	5873.601
2013	5061.67
2014	5466.54
2015	6203.413
2016	5932.979
2017	6189.799
2018	6586.702
2019	7208.688
2020	7541.962
2021	7765.020
2022	7045.637

Table 3.5.2.3 Emission for NOx, SOx, CO, PCBs, cement production - 2005-2022

Year/Pollutant	NOx kt	SOx kt	CO kt	PCBs kg	Pb t	Hg t
2005	7.455	2.247	8.740	0.619	0.589	0.294
2006	8.583	2.587	10.063	0.712	0.678	0.339
2007	9.519	2.869	11.160	0.790	0.752	0.376
2008	9.655	2.910	11.320	0.801	0.762	0.381
2009	7.249	2.185	8.499	0.602	0.572	0.286
2010	6.455	1.945	7.568	0.536	0.510	0.255
2011	7.137	2.151	8.368	0.592	0.564	0.282
2012	7.289	2.197	8.546	0.605	0.576	0.288
2013	6.282	1.893	7.365	0.521	0.496	0.248
2014	6.784	2.044	7.954	0.563	0.536	0.268
2015	7.698	2.320	9.026	0.639	0.608	0.304
2016	7.363	2.219	8.632	0.611	0.581	0.291
2017	7.682	2.315	9.006	0.638	0.607	0.303
2018	8.174	2.463	9.584	0.678	0.645	0.323
2019	8.946	2.696	10.489	0.742	0.706	0.353
2020	9.360	2.821	10.974	0.777	0.739	0.370
2021	9.636	2.904	11.298	0.800	0.761	0.380
2022	8.744	2.635	10.251	0.726	0.690	0.345

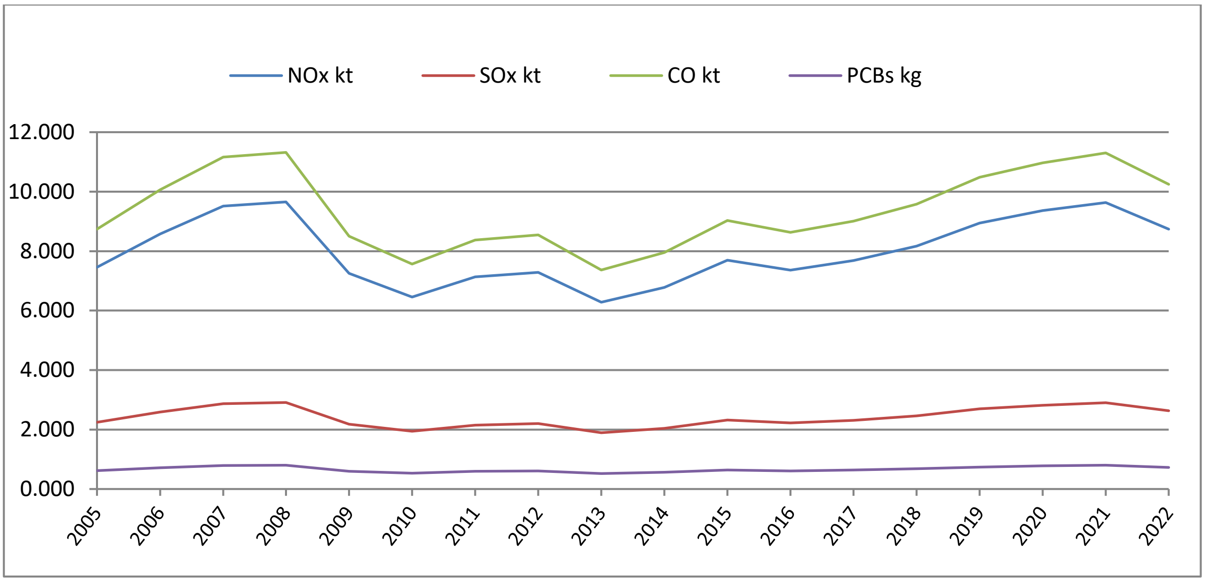


Figure 3.5.2.2 NOx, SOx, CO and PCBs emissions from cement production, 2005-2022

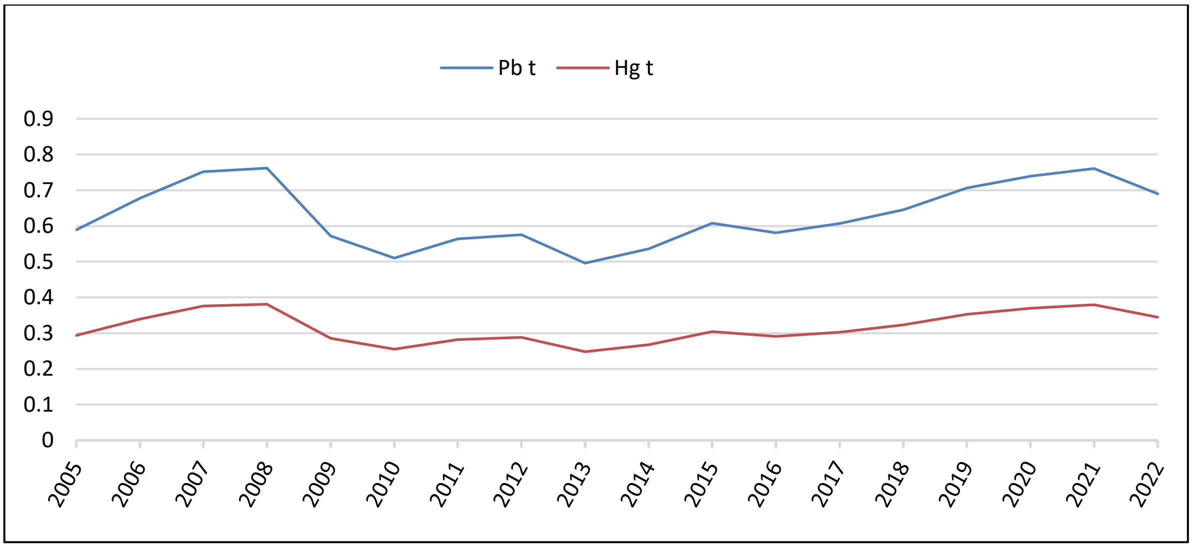


Figure 3.5.2.3 Hg and Pb emissions trend (t) from cement production, 2005-2022

Table 3.5.2.4 Fuel consumption, by fuel type, for 1A2 sector without consumption for cement production, 2005-2022

Year/Fuel (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
2005	1398.32	86.64	21976.00	51.50
2006	909.48	88.68	21415.00	36.40
2007	817.74	106.20	15685.10	78.30
2008	938.08	228.36	9639.18	119.30
2009	514.58	221.10	9374.58	161.10
2010	289.96	143.34	10392.74	200.00
2011	778.14	39.36	11214.38	188.90
2012	1113.42	375.84	10213.19	245.60
2013	929.72	261.06	9809.91	305.60
2014	1224.19	265.38	10049.87	199.00

Year/Fuel (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
2015	1428.02	288.06	10135.95	161.70
2016	1432.31	322.50	10769.15	187.50
2017	1431.94	313.46	12376.60	201.59
2018	1396.17	516.58	16865.53	9.06
2019	1495.67	521.66	13449.47	10.07
2020	1422.59	895.49	12000.36	11.42
2021	1090.50	1116.26	13737.91	14.29
2022	1004.21	1089.34	9853.30	19.99

Table 3.5.2.5 Emissions for NOx, SOx, PM2.5, CO, Pb, Hg and PCBs from 1.A.2 combustion in industry, Tier 1, period 2005-2022

Year/Pollutant	NOx kt	SOx kt	PM2.5 kt	CO kt	Pb t	Hg t	PCBs kg
2005	2.363	0.159	0.062	0.840	0.013	0.013	0.015
2006	2.070	0.137	0.050	0.784	0.013	0.012	0.015
2007	1.606	0.145	0.051	0.652	0.017	0.009	0.018
2008	1.245	0.257	0.068	0.622	0.034	0.007	0.039
2009	1.011	0.231	0.064	0.603	0.034	0.007	0.038
2010	0.961	0.152	0.057	0.568	0.025	0.007	0.024
2011	1.253	0.082	0.055	0.521	0.011	0.007	0.007
2012	1.414	0.400	0.105	0.860	0.057	0.009	0.064
2013	1.276	0.289	0.097	0.763	0.043	0.008	0.044
2014	1.436	0.305	0.089	0.733	0.041	0.008	0.045
2015	1.547	0.335	0.090	0.749	0.043	0.008	0.049
2016	1.605	0.367	0.098	0.814	0.049	0.009	0.055
2017	1.723	0.360	0.100	0.860	0.048	0.009	0.053
2018	2.054	0.542	0.098	1.067	0.070	0.013	0.088
2019	1.854	0.549	0.098	0.980	0.070	0.012	0.089
2020	1.774	0.881	0.136	1.282	0.121	0.014	0.152
2021	1.770	1.065	0.155	1.518	0.150	0.016	0.190
2022	1.435	1.034	0.148	1.378	0.147	0.014	0.185

Table 3.5.2.6 Emissions for NOx, SOx, PM2.5, CO, Pb, Hg and PCBs from 1A2f sector, 1990-2022

Year/Pollutant	NOx kt	SOx kt	PM2.5 kt	CO kt	Pb t	Hg t	PCBs kg
1990	0.491	2.552	0.306	2.640	0.380	0.022	0.482
1991	0.127	0.662	0.079	0.684	0.098	0.006	0.125
1992	7.762	1.554	0.390	2.765	0.163	0.027	0.197
1993	6.257	0.931	0.253	1.920	0.082	0.021	0.101
1994	6.220	0.754	0.228	1.818	0.059	0.021	0.072
1995	6.976	1.117	0.293	2.205	0.103	0.023	0.128
1996	8.039	1.626	0.380	2.769	0.166	0.027	0.207
1997	6.597	0.866	0.248	1.971	0.072	0.022	0.088
1998	7.021	1.032	0.301	1.987	0.085	0.019	0.103
1999	5.691	0.752	0.219	1.624	0.060	0.018	0.073
2000	10.238	1.365	0.423	2.404	0.090	0.020	0.110
2001	11.966	1.560	0.543	2.903	0.107	0.022	0.119
2002	11.481	1.360	0.442	2.663	0.080	0.024	0.098

Year/Pollutant	NOx kt	SOx kt	PM2.5 kt	CO kt	Pb t	Hg t	PCBs kg
2003	6.873	1.040	0.292	1.865	0.084	0.017	0.103
2004	10.408	2.258	0.530	3.286	0.221	0.027	0.277
2005	9.818	2.406	0.062	9.580	0.602	0.307	0.633
2006	10.653	2.724	0.050	10.847	0.691	0.351	0.727
2007	11.125	3.014	0.051	11.813	0.768	0.385	0.808
2008	10.900	3.167	0.068	11.942	0.796	0.388	0.840
2009	8.259	2.416	0.064	9.102	0.607	0.293	0.639
2010	7.416	2.097	0.057	8.136	0.535	0.262	0.560
2011	8.390	2.233	0.055	8.889	0.574	0.288	0.599
2012	8.703	2.597	0.105	9.406	0.633	0.297	0.669
2013	7.557	2.182	0.097	8.128	0.539	0.256	0.566
2014	8.220	2.350	0.089	8.687	0.577	0.276	0.608
2015	9.246	2.655	0.090	9.775	0.651	0.312	0.688
2016	8.967	2.586	0.098	9.446	0.630	0.299	0.666
2017	9.405	2.675	0.100	9.866	0.654	0.313	0.691
2018	10.229	3.005	0.098	10.651	0.715	0.336	0.766
2019	10.800	3.245	0.098	11.469	0.777	0.365	0.831
2020	11.133	3.702	0.136	12.256	0.860	0.383	0.929
2021	11.407	3.969	0.155	12.816	0.911	0.397	0.990
2022	10.178	3.669	0.148	11.629	0.837	0.359	0.911

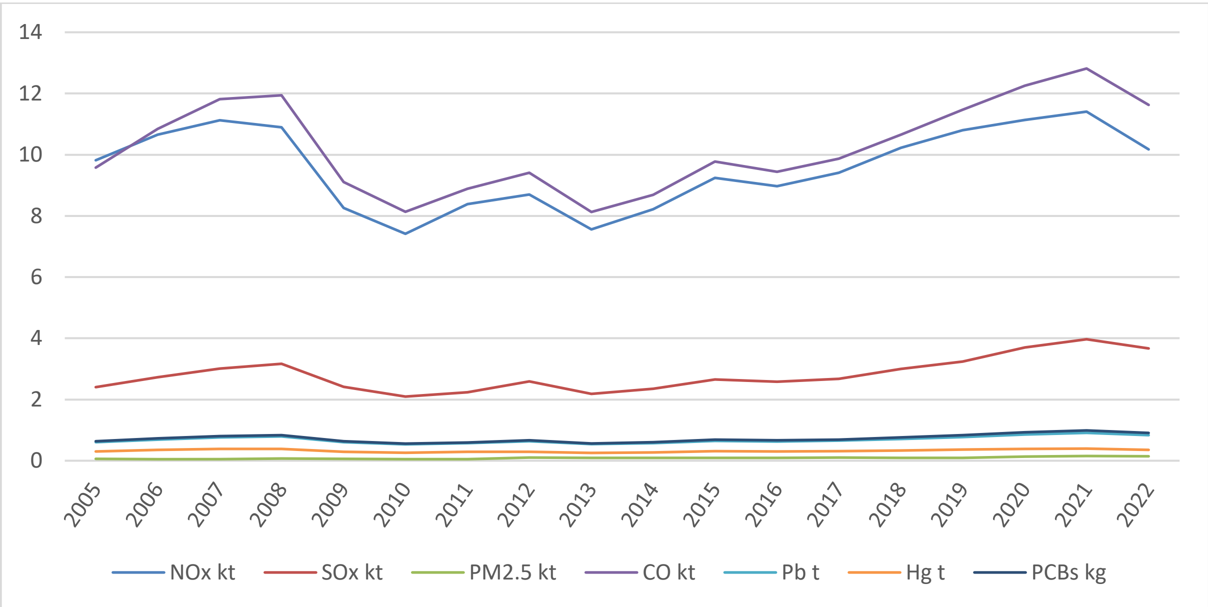


Figure 3.5.2.4 NOx, SOx, PM2.5, CO, PB, Hg, PCBs emissions trend for 1A2f sector

There were no recalculations and improvements for this category.

3.5.3 NFR 1.A.2.g.viii Stationary combustion in manufacturing industries and construction: Other

This category includes the emissions from stationary combustion in industries not included in the preceding 1A2 categories. Emissions have been estimated by applying Tier 1 emission factors (2019 EMEP/EEA Guidebook, NFR 1.A.2, Tables 3.2-3.5) to fuel consumption data from the EUROSTAT annual energy balances, category Final energy consumption/Industry, for the following industries: Construction, Machinery, Mining and Quarrying, Non-specified (Industry), Textile and Leather, Transport Equipment, Wood and Wood Products. In 2022 NFR 1A2gviii was not a key source for any pollutants. The following tables and charts show the trend of emissions of main pollutants and fuel consumption for NFR1.A.2.viii – Stationary combustion in other manufacturing industries and construction.

Table 3.5.3.1. Emissions trend (kt) for NFR 1.A.2.g.viii, Other industries, 1990-2022

Year/Pollutant(kt)	NOx	NMVOC	SOx	$PM_{2.5}$	PM_{10}	CO
1990	50.925	7.960	10.752	2.336	2.413	19.167
1991	52.281	6.984	10.641	2.636	2.710	18.007
1992	7.452	1.435	2.132	0.504	0.523	3.789
1993	3.884	1.175	0.969	0.280	0.291	2.468
1994	9.865	3.940	2.175	1.414	1.452	8.135
1995	9.866	3.184	1.936	1.204	1.235	6.682
1996	10.120	3.224	1.901	1.210	1.240	6.703
1997	9.827	4.017	1.303	1.479	1.511	7.639
1998	7.812	2.801	0.976	1.060	1.082	5.360
1999	8.747	3.157	1.012	1.119	1.142	5.892
2000	4.839	2.902	0.442	1.043	1.065	5.222
2001	4.439	2.557	0.354	0.878	0.896	4.518
2002	4.731	3.262	1.225	1.243	1.276	6.551
2003	4.337	3.728	0.360	1.435	1.465	6.750
2004	4.904	2.728	0.525	0.966	0.987	4.959
2005	3.028	2.190	0.177	0.765	0.780	3.826
2006	4.046	2.984	0.354	1.047	1.069	5.310
2007	4.188	3.685	0.283	1.450	1.480	6.656
2008	5.211	2.938	0.314	1.010	1.030	5.115
2009	2.426	2.274	0.100	0.813	0.830	3.967
2010	2.702	2.690	0.125	1.014	1.035	4.765
2011	2.868	2.282	0.142	0.831	0.848	4.007
2012	2.596	2.601	0.155	0.999	1.020	4.655
2013	2.632	2.665	0.129	1.018	1.039	4.741
2014	2.586	2.771	0.132	1.063	1.086	4.941
2015	2.367	2.630	0.132	1.014	1.036	4.706
2016	2.472	3.266	0.152	1.324	1.352	5.931
2017	2.478	3.027	0.129	1.190	1.215	5.437
2018	2.591	3.130	0.141	1.227	1.253	5.621
2019	2.690	3.082	0.146	1.189	1.215	5.513
2020	2.474	2.612	0.117	0.983	1.004	4.630
2021	2.351	2.558	0.110	0.968	0.988	4.540
2022	2.599	2.777	0.145	1.044	1.066	4.937

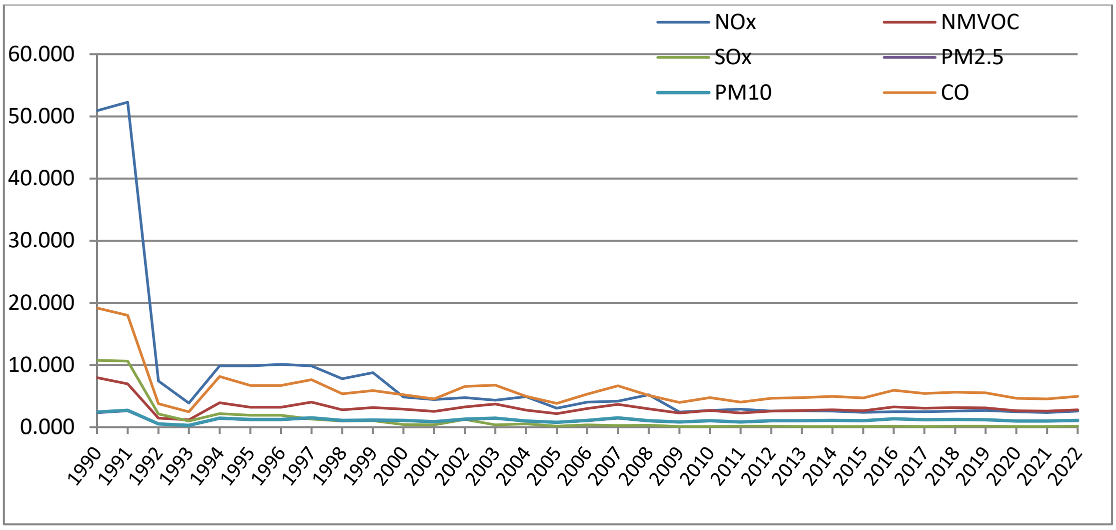


Figure 3.5.3.1 Emission trends (kt) for NFR 1.A.2.g.viii, Other industries, 1990-2022

The sharp decrease of emissions in 1990-1991 is consistent with the decrease of fuel consumption, reported by the national statistics to EUROSTAT Energy database, as consumption in the *Non-specified industry*, mainly as natural gas and fuel oil, as revealed by the table and chart below. The data for 1990-1991, emissions and fuel consumption, include the NFR 1A2d Pulp, Paper and Print.

Table 3.5.3.2 Fuel consumption, by fuel type, for NFR 1.A.2.g.viii, Other industries, 1990-2022

Year/Fuel (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	60763	8590	246860	0
1991	73563	7835	176630	1289
1992	8508	1889	36410	724
1993	2082	932	34902	790
1994	8395	1845	62026	7131
1995	10908	1477	47314	5641
1996	11247	1419	48492	5672
1997	9738	799	53267	8259
1998	8881	524	35772	5699
1999	9049	543	46803	6021
2000	3086	223	35312	6643
2001	2566	165	34947	5582
2002	2120	1131	37375	7494
2003	1883	159	33284	9671
2004	3243	314	35677	5996
2005	1061	59	27139	5113
2006	1214	217	37234	6927
2007	2170	59	29323	9837
2008	3286	69	39524	6470
2009	93	19	25165	5637
2010	458	11	24666	7033
2011	1056	15	24466	5638

Year/Fuel (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
2012	608	40	22293	6897
2013	529	12	23198	7057
2014	329	21	23516	7400
2015	203	33	21816	7068
2016	209	29	20462	9292
2017	86	20	22577	8346
2018	87	29	23771	8595
2019	101	36	25350	8312
2020	140	22	23985	6851
2021	82	18	22845	6764
2022	56	50	25685	7267

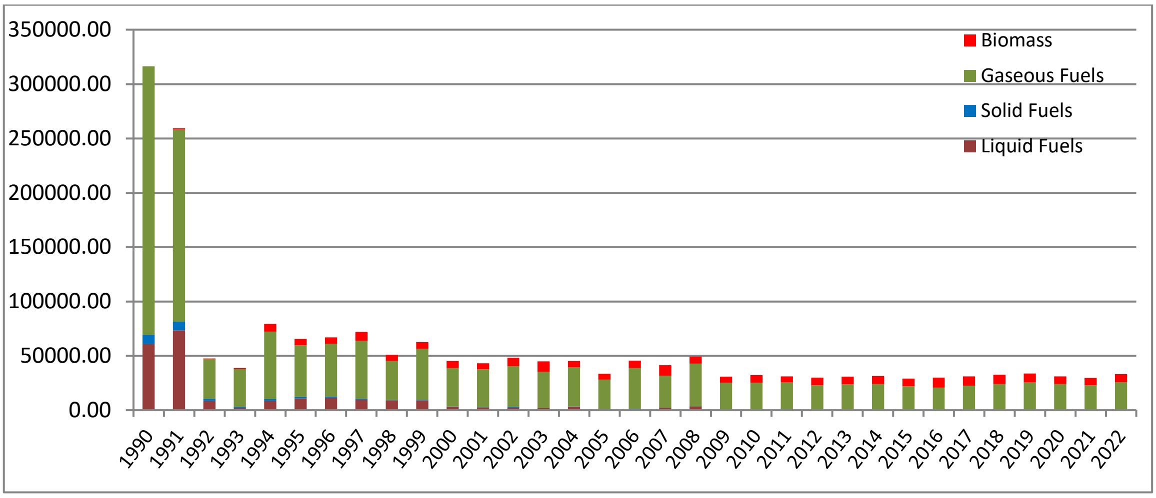


Figure 3.5.3.2 Fuel consumption [TJ], by fuel type, for NFR 1.A.2.g.viii, Other industries, 1990-2022

Recalculations and improvements:

- There were no recalculations and improvements for this category.

3.6 NFR 1.A.2.g.vii Mobile Combustion in manufacturing industries and construction

Category NFR 1A2gvii covers emissions from combustion of fuels in non-road mobile machinery sources, in manufacturing industries and construction. The activity data are provided by Eurostat statistics, energy balances (nrg_110a) before 2017, and Eurostat ENERGY questionnaires, for 2017 – 2022. The activity data are given by the consumption of diesel and gasoline in all industries, category *Final energy consumption/Industry (all).* Activity data and emissions for 1990-1992 are included in NFR 1A3 (separate data in the Energy statistics not available).

The category 1A2gvii-*Mobile combustion in manufacturing industries and construction* is not a key source for any pollutant in 2022.

The estimation includes Tier 2 emissions of NOx, NMVOC, NH3, CO, PM2.5, PM10, TSP and BC and Tier 1 emissions of Cd, Cr, Cu, Ni, Se, Zn and PAHs. Note that for heavy metals and

PAHs the Guidebook provides only Tier 1 emission factors. SOx was estimated based on sulphur content in fuels. National values for sulphur content in diesel are available starting 1999. For the other years, the sulphur content was taken as equal to the maximum value in the legislation in force at that time. For gasoline, which has a lower contribution, sulphur content was taken from Table 3-14 G2019, NFR 1A3b.

The emission factors for Tier 2 calculation are given by Table 3-2 – *Tier 2 emission factors for off-road machinery,* 1.A.2.g.vii, Guidebook 2019, chapter "Non road mobile machinery" (NRMM). There are no relevant national data on split of the fuel consumption by engine age and technologies, therefore, the alternative approach provided by the Guidebook 2019, data derived from Winther (2016) and Winther & Nielsen (2006) was applied. The data used for splitting the fuel for Tier 2 estimation are given in the following Guidebook tables: Table 3-3 *Split (%) of total fuel consumption per engine age, for diesel-fuelled non-road machinery* and Table 3-4 *Share of total fuel consumption per engine age (irrespective of inventory year) for gasoline-fuelled two-stroke and four-stroke non-road machinery* and tables from the electronic NRMM annex *1.A.4 Non road mobile machinery Annex 2019.xlsx*: Table 3-7, *Split of the total fuel consumption into engine technology layers for each inventory year*, diesel, Table 3-8, *Split of the total fuel consumption into engine technology layers for each inventory year,* gasoline two-stroke technology and Table 3-9, *Split of the total fuel consumption into engine technology layers*, *for each inventory year*, gasoline four-stroke technology. The Tier2 Guidebook tables for splitting fuel on engine age and technology provide data for diesel starting 1999 and for gasoline starting 2007. Therefore, Tier 2 method was applied for diesel and gasoline according to these intervals.

For splitting gasoline consumption in 2022 between two-stroke and four-stroke machinery, the percentage split (20/80) is used (expert judgement).

The following table and chart provide the time trend of emissions:

Table 3.6.1. Emission Trend (kt) of NOx and NMVOC and CO for NFR 1.A.2.g.vii

Year/Pollutant (kt)	NOx	NMVOC	CO
1992	18.89	10.43	54.216
1993	8.91	3.708	18.712
1994	17.144	3.673	16.408
1995	14.117	1.841	6.814
1996	27.215	9.393	46.218
1997	19.03	6.524	32.066
1998	17.939	9.571	49.597
1999	13.504	5.976	28.291
2000	16.398	7.402	35.584
2001	19.199	6.267	28.51
2002	19.968	13.591	70.113
2003	14.799	6.948	34.535
2004	12.441	5.854	29.34

Year/Pollutant (kt)	NOx	NMVOC	CO
2005	12.896	7.913	41.146
2006	12.913	5.515	27.878
2007	18.365	4.966	45.415
2008	12.124	2.829	25.652
2009	6.499	2.041	23.302
2010	5.662	1.42	17.216
2011	6.552	1.065	11.572
2012	6.882	0.946	8.761
2013	5.731	0.933	10.728
2014	5.297	0.878	10.633
2015	5.697	0.986	12.518
2016	5.012	0.852	10.81
2017	4.605	0.825	11.165
2018	4.236	0.694	8.939
2019	3.939	0.744	10.669
2020	3.690	0.732	10.857
2021	3.823	0.845	13.162
2022	3.529	0.752	11.432

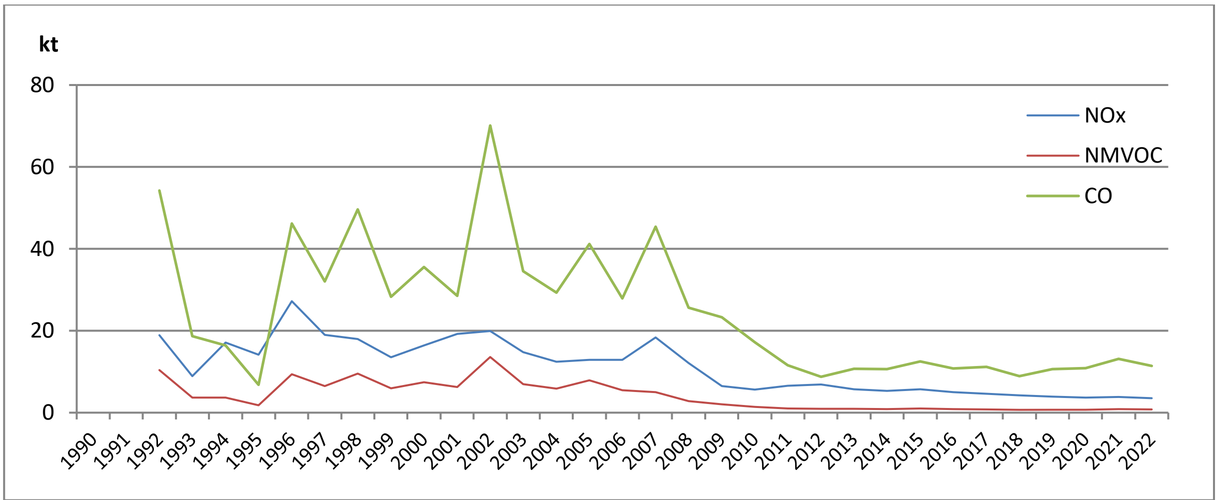


Figure 3.6.1 Emissions of NOx, NMVOC and CO for NFR 1.A.2.gvii

Emission trends follow the fuel consumption variation. Most of the fuel is diesel, gasoline quantities are much lower, in the range of 1 to 15% along the time series.

Table 3.6.2 Fuel consumption (TJ) for NFR 1.A.2.gvii

Year/Fuel (TJ)	Diesel fuel	Gasoline	Total liquid fuel
1992	24151.00	3009.00	27160.00
1993	11455.00	989.00	12444.00
1994	22223.00	674.00	22897.00
1995	18361.00	135.00	18496.00
1996	35091.00	2335.00	37426.00
1997	24539.00	1617.00	26156.00
1998	22953.00	2739.00	25692.00

Year/Fuel (TJ)	Diesel fuel	Gasoline	Total liquid fuel
1999	13899.00	1438.00	15337.00
2000	16902.00	1841.00	18743.00
2001	20206.00	1347.00	21553.00
2002	21195.00	3952.00	25147.00
2003	16388.00	1842.00	18230.00
2004	14331.00	1572.00	15903.00
2005	15443.00	2308.00	17751.00
2006	16386.00	1481.00	17867.00
2007	24925.00	2316.00	27241.00
2008	17760.00	1267.00	19027.00
2009	9996.00	1220.00	11216.00
2010	9266.00	872.00	10138.00
2011	11540.00	522.00	12062.00
2012	12984.00	350.00	13334.00
2013	11415.00	480.00	11895.00
2014	11243.00	479.00	11722.00
2015	13196.00	567.00	13763.00
2016	12688.00	480.00	13168.00
2017	12684.56	484.37	13168.93
2018	12731.70	366.96	13098.65
2019	13172.40	458.70	13631.22
2020	13491.59	466.47	13958.06
2021	15148.82	571.99	15720.82
2022	15213.40	483.06	15696.46

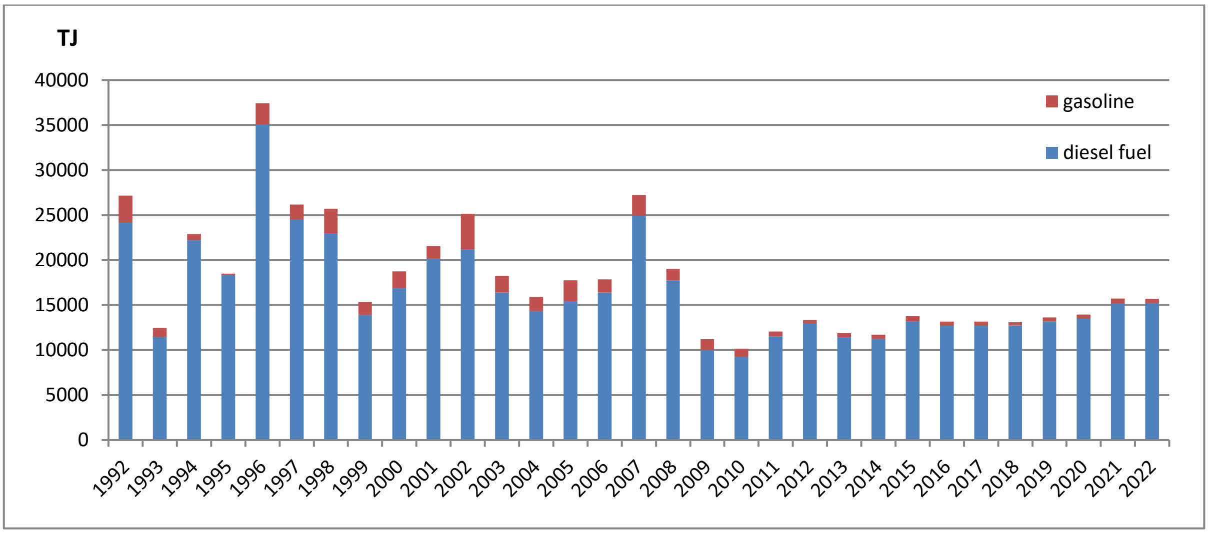


Figure 3.6.2 Fuel consumption (TJ) for NFR 1.A.2.gvii

Recalculations and improvements:

No recalculation was performed on the 1990-2021 time series compared to 2023 submission.

3.7 NFR 1.A.4. Small combustion

NFR categories from section 1.A.4 include emissions from fuel combustion in small facilities, in commercial or institutional buildings, for space and water heating in households as well as fuel combustion in agriculture, forestry and fishing industries. Emissions from mobile sources related to this sector are also included in this section. Small combustion for district heating is reported under NFR 1.A.1, while small combustion in industry is reported under NFR 1.A.2. All emission factors are taken from Guidebook 2019, except for 1A4ai, gaseous fuels, where recalculation was performed, and applying Tier 2 emission factors from Guidebook 2023.
A summary of activities covered by NFR 1.A.4 is given bellow.

Table 3.7.1 Source description for 1.A.4 sector

NFR	NFR name	Source description
1A4ai	Commercial/institutional	Fuel combustion in commercial and institutional buildings (stationary), except combustion of diesel and gasoline, which is allocated to 1A4aii
1A4aii	Mobile Combustion in Commercial/institutional	Diesel and gasoline consumption in commercial/institutional sector
1A4bi	Residential	Fuel combustion in households (such as heating and water warming), except combustion of diesel and gasoline, which is allocated to 1A4bii
1A4bii	Residential: Household and gardening (mobile)	Combustion of diesel and gasoline in residential sector. Not available separately for all years. IE means included in NFR 1A3b.
1A4ci	Agriculture/Forestry/Fishing: Stationary	Stationary fuel combustion in agriculture, forestry, and fishing industries (such as farms)
1A4cii	Agriculture/Forestry/Fishing: Off-road vehicles and other machinery	Combustion of diesel and gasoline in Agriculture/Forestry/Fishing, in off-road vehicles and machineries used in farms and in forestry works. It also includes the National fishing (1A4ciii)
1A5a	Other stationary (including military)	Fuel combustion in small facilities in other sectors than those reported under 1A4
1A5b	Other, Mobile (including military, land based and recreational boats)	Included in 1A5a

Emission factors references:

NFR	Reported pollutants	Emission Factors tier and source
1A4ai	All CLRTAP pollutants	EMEP EEA guidebook (2019) factors, small combustion/commercial, institutional T2 factors for biomass and wood combustion (tables 3.46) T2 factors for gaseous fuels (Table 3-26 Guidebook 2023) T2 - average of EFs for all technologies for liquid fuels T1 factors for solid fuels (table 3.7)
1A4aii	 All CLRTAP pollutants (except SOx, heavy metals and POPs) Cd, Cr, Cu, Ni, Se, Zn and PAHs SOx	EMEP EEA guidebook (2019) factors, non-road mobile machineries T2 for 1999-2022, T1 for 1992-1998 T1 for 1992-2022 T2 - based on sulphur content in fuels
1A4bi	All CLRTAP pollutants	EMEP EEA guidebook (2019) factors, small combustion/residential T1 –factors for solid fuels (table 3.3) T2 – factors for biomass and wood combustion (tables 3.40, 3.43, 3.44) T2 - EMEP EEA guidebook (2019) factors for liquid fuels (average of Tier 2

NFR	Reported pollutants	Emission Factors tier and source
		tables 3.17-3.18) T2 - EMEP EEA guidebook (2019) factors for gaseous fuels (average of Tier 2 tables 3.13-3.16)
1A4bii	Included in 1A3b (2021)	T1- EMEP EEA guidebook (2019) factors, for years with non-zero activity data in Energy statistics
1A4ci	All CLRTAP pollutants	EMEP EEA guidebook (2019) factors, small combustion/commercial, institutional T2 – factors for biomass and wood combustion (tables 3.46) T2 - average of EFs for all technologies for gaseous fuels T2 - average of EFs for all technologies for liquid fuels T1 – factors for solid fuels (table 3.7)
1A4cii	 All CLRTAP pollutants (except SOx, heavy metals and POPs) Cd, Cr, Cu, Ni, Se, Zn and PAHs SOx	EMEP EEA guidebook (2019) factors, non-road mobile machineries T2 for 1999-2022, T1 for 1992-1998 T1 for 1992-2022 T2 - based on sulphur content in fuels
1A4ciii	Included in 1A4cii	
1A5a	All CLRTAP pollutants (except NH3)	Same as for 1A4ai
1A5b	Included in NFR 1A5a	

The share of emissions from small combustion sources (including the non-road mobile and machineries) in the country total, by pollutant, is provided in Figure 3.7.1 and Table 3.7.2:

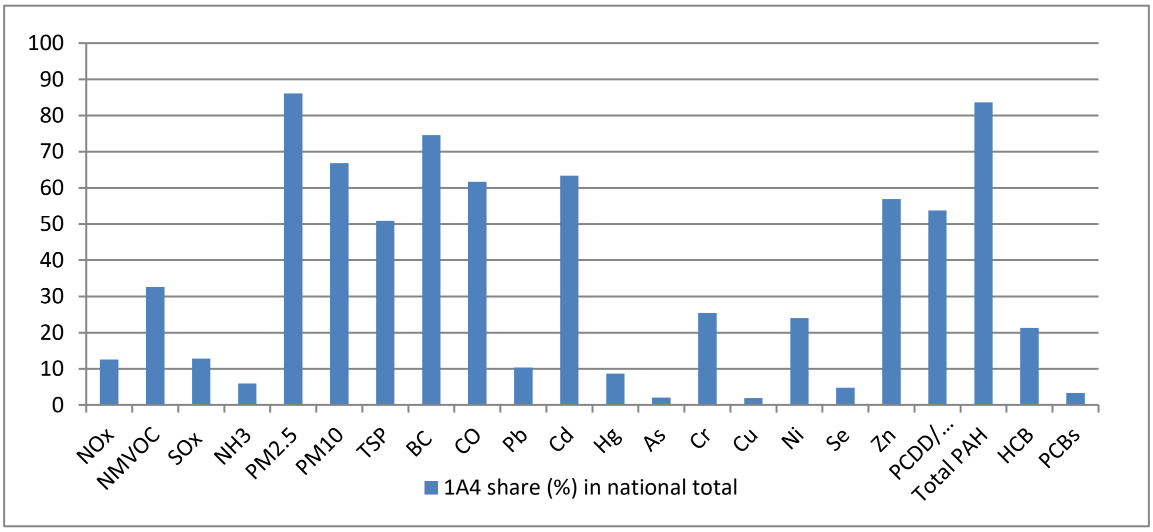


Figure 3.7.1 Share of small combustion emissions, including non-road, in the 2022 national total

Table 3.7.2 Share of emissions from small combustion, including non-road, in the national total, by pollutant

Pollutant	1A4-1A5 (sum, kt)	National total (kt)	Unit	% in national total
NOx	25.50	202.90	kt	12.57%
NMVOC	76.62	235.34	kt	32.56%
SOx	5.97	46.60	kt	12.80%
NH_3	8.93	149.84	kt	5.96%
$PM_{2.5}$	91.73	107.46	kt	85.36%

Pollutant	1A4-1A5 (sum, kt)	National total (kt)	Unit	% in national total
PM_{10}	94.22	143.13	kt	65.82%
TSP	99.12	197.14	kt	50.28%
BC	9.66	12.95	kt	74.54%
CO	552.51	895.66	kt	61.69%
Pb	4.10	40.69	t	10.08%
Cd	1.73	2.97	t	58.35%
Hg	0.11	1.55	t	7.25%
As	0.06	3.19	t	2.02%
Cr	3.29	12.98	t	25.35%
Cu	1.52	80.68	t	1.89%
Ni	2.75	11.49	t	23.96%
Se	0.30	6.39	t	4.76%
Zn	69.06	121.33	t	56.92%
PCDD	100.07	186.10	g I-TEQ	53.77%
Total PAH	44.87	53.68	t	83.59%
HCB	0.67	3.13	t	21.30%
PCBs	0.49	15.06	t	3.25%

3.8 NFR 1.A.4.a.i Commercial/Institutional

Emissions were estimated based on activity data from EUROSTAT energy balances, category *Final energy consumption/Other Sectors/Service*.

The diesel and gasoline consumption for this category are not included in 1A4ai but allocated to 1A4aii – Mobile machineries. For 1990, fuel consumption and emissions are included in 1A4bi. The emission factors are Tier 1 for solid fuels (Guidebook 2019, Small combustion, Tables 3.7), Tier 2 for biomass (Guidebook 2019 Small combustion, Table 3-46), Tier 2 for gaseous fuels (Guidebook 2023, Small combustion, Table 3-26) and Tier2, average on all technologies, for liquid fuels.

Improvement and recalculations:

Emissions from gaseous fuels were recalculated, improving the estimation from Tier 1 to Tier 2 emission factors (Guidebook 2023), for the entire time series.

NFR 1.A.4.ai is not a key source for any pollutant.
The following tables and charts show the trend of emissions and fuel consumption:

Table 3.8.1. Emissions (kt) of gaseous pollutants, PM and BC for NFR 1.A.4.a.i

Year/Pollutant (kt)	NOx	NMVOC	SOx	PM2.5	BC	CO
1990	IE	IE	IE	**IE**	IE	IE
1991	0.638	1.094	0.077	0.691	0.180	3.051
1992	1.0936	0.149	0.029	0.097	0.024	0.734
1993	0.861	0.278	0.033	0.177	0.045	0.995
1994	1.036	0.274	0.036	0.175	0.044	1.040

Year/Pollutant (kt)	NOx	NMVOC	SOx	PM2.5	BC	CO
1995	1.179	0.257	0.038	0.166	0.042	1.043
1996	1.404	0.499	0.056	0.319	0.081	1.744
1997	1.031	0.349	0.040	0.223	0.057	1.233
1998	1.718	0.213	0.104	0.143	0.039	1.061
1999	1.424	0.364	0.162	0.241	0.059	1.467
2000	0.899	0.128	0.157	0.092	0.020	0.711
2001	2.172	0.891	0.350	0.584	0.143	3.206
2002	0.940	1.013	0.238	0.650	0.165	3.048
2003	2.122	0.983	0.213	0.632	0.160	3.308
2004	2.819	0.814	0.168	0.525	0.134	3.034
2005	3.377	1.228	0.150	0.784	0.200	4.275
2006	6.046	1.188	0.393	0.778	0.200	5.014
2007	4.221	0.967	0.192	0.625	0.157	3.884
2008	3.069	0.884	0.127	0.567	0.144	3.281
2009	3.590	0.804	0.195	0.521	0.136	3.186
2010	3.465	0.831	0.152	0.536	0.136	3.261
2011	2.944	0.492	0.201	0.325	0.087	2.174
2012	2.710	0.438	0.113	0.286	0.072	1.995
2013	2.800	0.392	0.133	0.258	0.066	1.900
2014	2.742	0.357	0.308	0.248	0.057	1.953
2015	2.869	0.732	0.316	0.483	0.118	2.971
2016	2.959	0.858	0.322	0.562	0.138	3.330
2017	3.290	0.714	0.239	0.468	0.115	2.998
2018	3.298	0.683	0.236	0.448	0.110	2.915
2019	3.267	0.679	0.223	0.445	0.109	2.892
2020	3.036	0.568	0.185	0.373	0.092	2.503
2021	3.055	0.634	0.201	0.415	0.103	2.678
2022	3.140	0.547	0.250	0.363	0.088	2.516

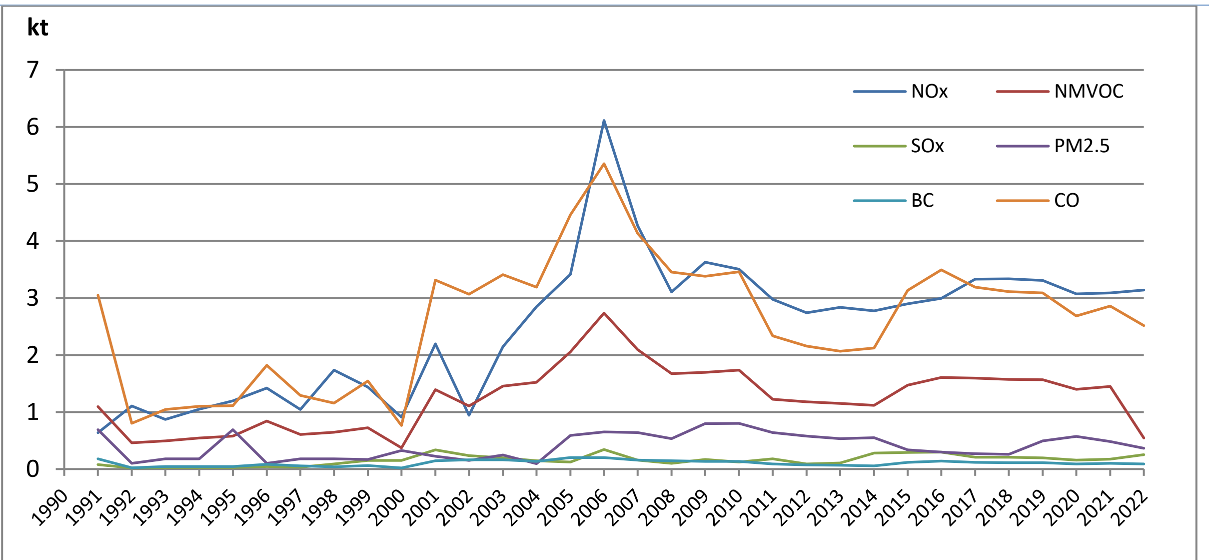


Figure 3.8.1 Emissions (kt) of NOx, NMVOC, SOx, PM_{10}, BC and CO for NFR 1.A.4.a.i

Trend of emissions follows the variation of fuel consumption, which peaks during 2000-2006, in line with development of services in Romania, then decreases due to economic crises and slightly increases again in 2015. The decrease of certain pollutants in 2022 compared to 2021 is due to the decrease of biomass consumption.

Table 3.8.2 Fuel consumption trends (TJ) by fuel type, for NFR 1.A.4.a.i

Year/Fuel type	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1990	IE	IE	IE	IE
1991	IE	IE	IE	7013.00
1992	0.00	0.00	13828.00	924.00
1993	0.00	0.00	9606.00	1757.00
1994	0.00	0.00	12046.00	1726.00
1995	0.00	0.00	14139.00	1618.00
1996	0.00	0.00	15282.00	3165.00
1997	0.00	0.00	11368.00	2208.00
1998	680.00	0.00	19148.00	1237.00
1999	160.00	120.00	15791.00	2210.00
2000	83.00	150.00	10743.00	702.00
2001	0.00	308.00	22188.00	5486.00
2002	80.00	184.00	4162.00	6367.00
2003	83.00	129.00	20732.00	6167.00
2004	215.00	57.00	31237.00	5084.00
2005	0.00	16.00	36529.00	7779.00
2006	1228.00	122.00	68368.00	7231.00
2007	80.00	58.00	49825.00	6039.00
2008	40.00	16.00	34887.00	5575.00
2009	840.00	8.00	39474.00	4950.00
2010	204.00	23.00	40087.00	5192.00
2011	1043.00	31.00	32228.00	2930.00
2012	243.00	17.00	32710.00	2694.00
2013	400.00	27.00	33668.00	2367.00
2014	206.00	261.00	33540.00	2037.00
2015	86.00	253.00	32774.00	4462.00
2016	43.00	254.00	33176.00	5272.00
2017	47.01	156.55	39017.22	4394.40
2018	72.83	152.25	39293.05	4191.31
2019	24.17	142.86	39104.26	4180.61
2020	71.64	104.95	36696.65	3488.70
2021	167.72	109.94	36028.50	3897.14
2022	177.32	171.33	37760.54	3296.28

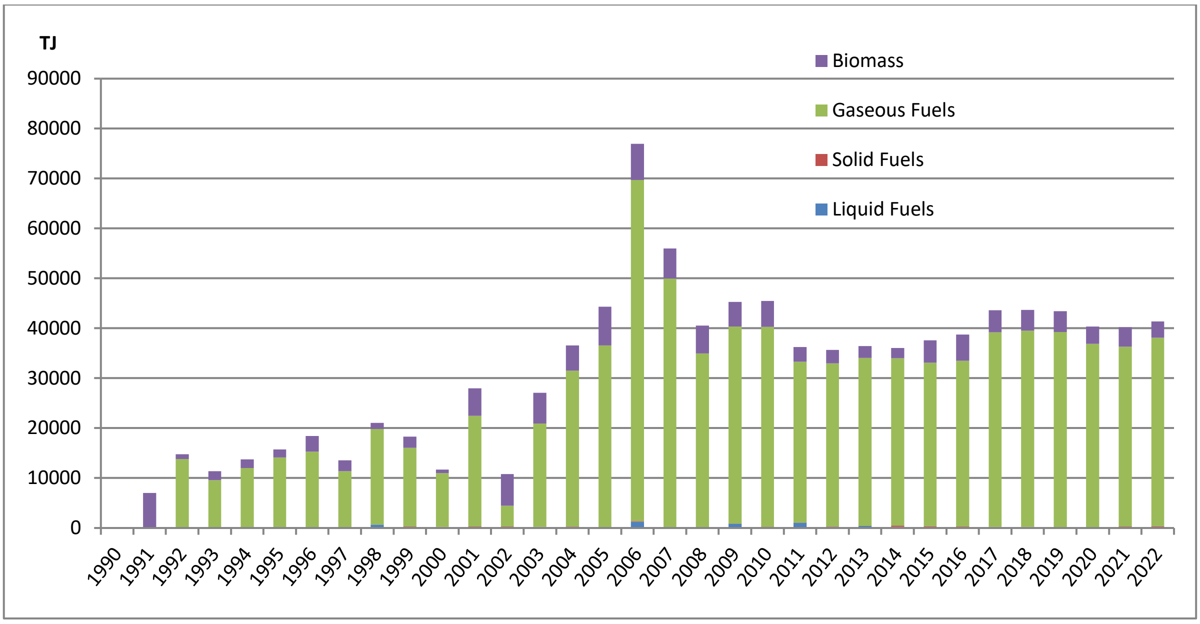


Figure 3.8.2 Fuel consumption (TJ), by fuel type, for NFR 1.A.4.a.i

3.8.1 NFR 1A4aii – Non- road mobile combustion in Commercial/Institutional

This NFR covers the emissions from non-road mobile machineries used in commercial and institutional activities. The estimation is based on diesel and gasoline fuel consumption, provided in the EUROSTAT energy balances, category Final energy consumption/Other Sectors/Services, in nrg EUROSTAT files (1990-2016) or in the EUROSTAT ENERGY Questionnaires, provided by the National Institute of Statistics (2017-2022). Data for 1991-1992 are included in NFRs 1A3b.

The estimation for 2022 includes Tier 2 emissions of NOx, NMVOC, NH_3, CO, $PM_{2.5}$, PM_{10}, TSP and BC and Tier 1 emissions of Cd, Cr, Cu, Ni, Se, Zn and PAHs. Note that for heavy metals and PAHs the Guidebook provides only Tier 1 emission factors. SOx was estimated based on sulphur content in fuels. National values for sulphur content in diesel are available starting 1999. For the other years, the sulphur content was taken as equal to the maximum value in the legislation in force at that time. For gasoline, which has a lower contribution, sulphur content was taken from Table 3-14 Guidebook 2019, NFR 1A3b.

NFR 1A4aii was not a key category for any pollutant in 2022.

The emission factors for Tier 2 calculation are given by Table 3-2 – *Tier 2 emission factors for off-road machinery,* Guidebook 2019, chapter "Non road mobile machinery" (NRMM). There are no relevant national data on split of the fuel consumption by engine age and technologies, therefore, the alternative approach provided by the Guidebook 2019, data derived from Winther (2016) and Winther & Nielsen (2006) was applied. The data used for splitting the fuel for Tier 2 estimation are given in the following Guidebook tables: Table 3-3

Split (%) of total fuel consumption per engine age, for diesel-fuelled non-road machinery and Table 3-4 *Share of total fuel consumption per engine age (irrespective of inventory year) for gasoline-fuelled two-stroke and four-stroke non-road machinery* and tables from the electronic NRMM annex *1.A.4 Non road mobile machinery Annex 2019.xlsx*: Table 3-7, *Split of the total fuel consumption into engine technology layers for each inventory year*, diesel, Table 3-8, *Split of the total fuel consumption into engine technology layers for each inventory year,* gasoline two-stroke technology and Table 3-9, *Split of the total fuel consumption into engine technology layers*, *for each inventory year*, gasoline four-stroke technology. The Tier2 Guidebook tables for splitting fuel on engine age and technology provide data starting 1999 for diesel and starting 2007 for gasoline. Therefore, Tier 2 method was applied for diesel and gasoline according to these intervals. For the earlier years, Tier 1 method was applied.

For splitting gasoline consumption in 2022 between two-stroke and four-stroke machinery, the percentage split (20/80) is used (expert judgement).

The following tables and charts show the trend of emissions and fuel consumption for NFR 1A4aii, Mobile (off-road) Combustion in Commercial/Institutional.

Table 3.8.1.1. Emissions (kt) of NOx, NMVOC and CO from NFR 1.A.4.a.ii

Year/Pollutant (kt)	NOx	NMVOC	CO
1992	0.061	1.524	8.614
1993	0.138	3.428	19.371
1994	0.046	1.143	6.457
1995	0.025	0.634	3.580
1996	0.112	2.794	15.791
1997	0.423	10.541	59.566
1998	0.775	7.037	39.640
1999	0.468	1.456	8.059
2000	1.277	5.352	29.830
2001	1.323	9.897	55.592
2002	6.840	4.890	25.344
2003	3.469	6.859	37.720
2004	3.060	7.052	38.997
2005	2.214	12.497	70.135
2006	0.698	8.285	46.726
2007	0.893	5.873	72.455
2008	0.545	2.964	37.568
2009	0.382	0.958	13.696
2010	0.808	0.919	14.763
2011	0.756	1.783	35.700
2012	0.784	0.920	18.060
2013	0.526	1.212	24.981
2014	0.534	1.019	21.184
2015	0.532	0.973	20.455
2016	0.531	1.354	29.052
2017	0.508	1.375	29.801
2018	0.545	1.838	40.104
2019	0.570	1.929	42.430
2020	0.464	1.411	30.972

Year/Pollutant (kt)	NOx	NMVOC	CO
2021	0.372	1.544	34.474
2022	0.328	1.406	31.596

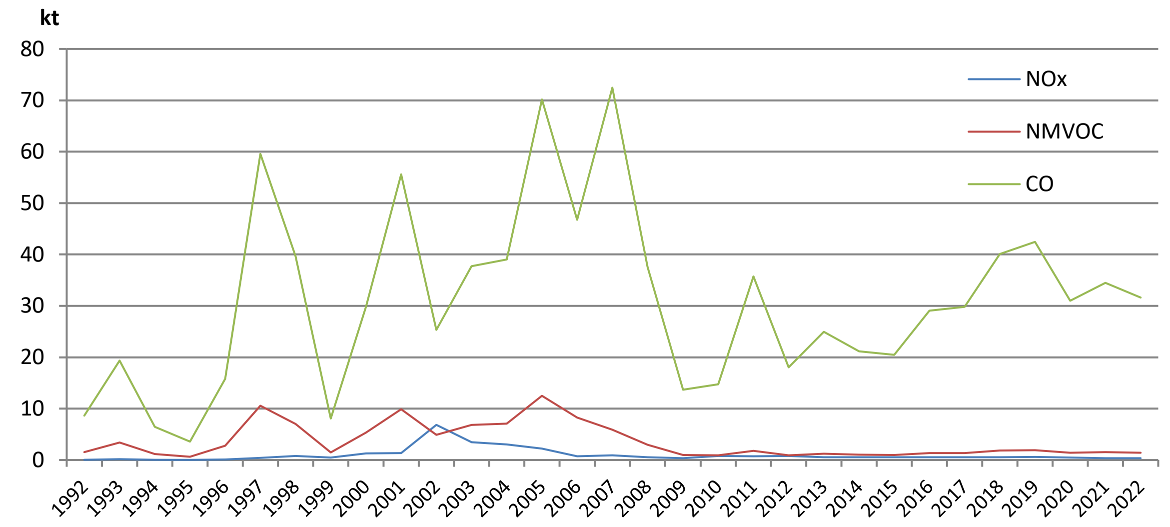


Figure 3.8.1.1 Emissions of NOx, NMVOC and CO (kt) for NFR 1.A.4.a.ii

Emission trends of pollutants follow the variation of the fuel consumption.

Table 3.8.1.2 Fuel consumption (TJ) for NFR 1.A.4.a.ii

Year/Fuel (TJ)	Diesel fuel	Gasoline	Total liquid fuel
1992	0	539.0	539.0
1993	0	1212.0	1212.0
1994	0	404.0	404.0
1995	0	224.0	224.0
1996	0	988.0	988.0
1997	0	3727.0	3727.0
1998	644.0	2470.0	3114.0
1999	429.0	494.0	923.0
2000	1115.0	1841.0	2956.0
2001	987.0	3457.0	4444.0
2002	7250.0	1437.0	8687.0
2003	3604.0	2290.0	5894.0
2004	3260.0	2380.0	5640.0
2005	2102.0	4352.0	6454.0
2006	472.0	2916.0	3388.0
2007	386.0	4238.0	4624.0
2008	343.0	2182.0	2525.0
2009	429.0	783.0	1212.0
2010	1158.0	827.0	1985.0
2011	858.0	2001.0	2859.0
2012	1231.0	1001.0	2232.0
2013	679.0	1392.0	2071.0
2014	806.0	1175.0	1981.0

Year/Fuel (TJ)	Diesel fuel	Gasoline	Total liquid fuel
2015	891.0	1131.0	2022.0
2016	806.0	1610.0	2416.0
2017	801.0	1590.0	2391.0
2018	750.7	2142.4	2893.1
2019	890.2	2270.6	3160.9
2020	889.8	1655.4	2545.2
2021	472,9	1836,8	2309.7
2022	475.6	1690.3	2166.0

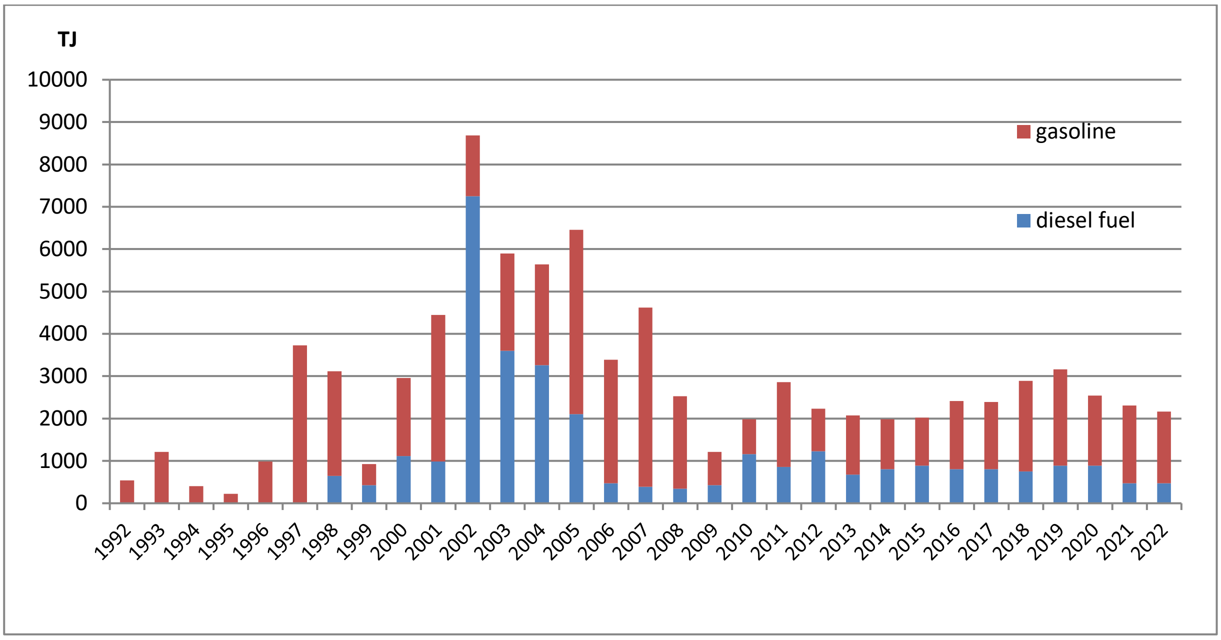


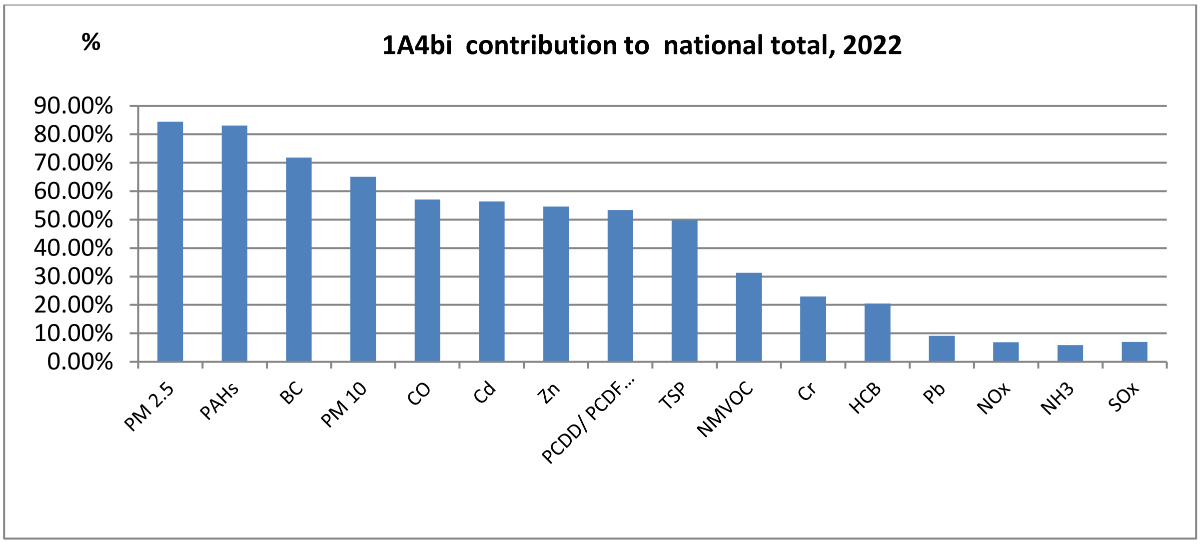
Figure 3.8.1.2 Fuel consumption (TJ) for NFR 1.A.4.a.ii

Recalculations and improvements:

No recalculation was performed on the 1990-2021 time series compared to 2023 submission.

3.9 NFR 1.A.4.b.i Residential

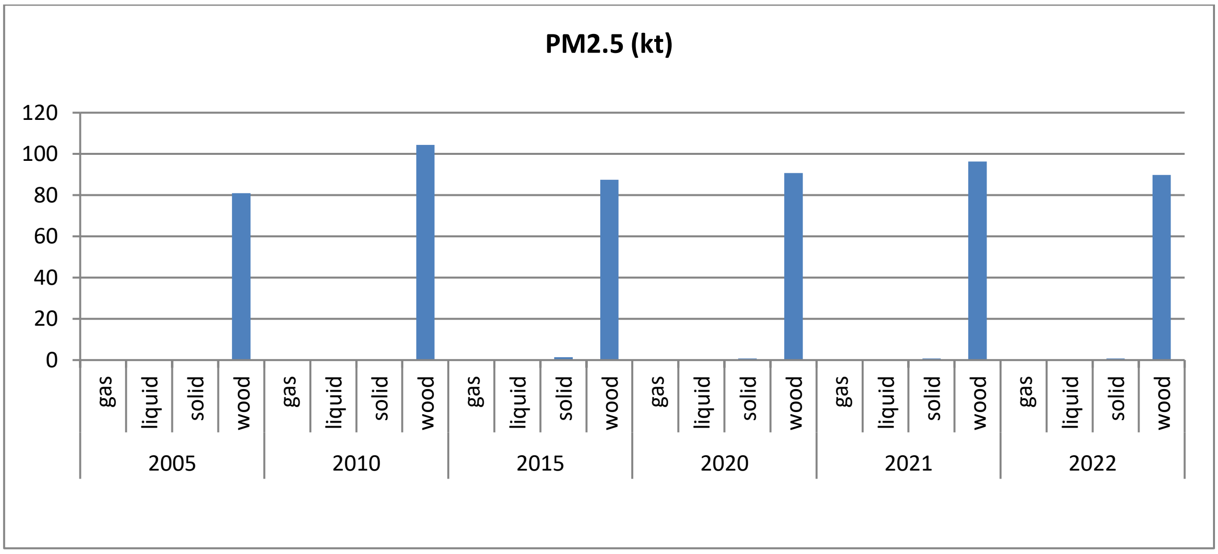
Residential heating is, as for 2022, key category for many pollutants, accounting for the following contributions to the national total: PM2.5 (84,47%), PAH (83,04%), BC (71,85%), PM10 (65,10%), Zn (54,61%), Cd (56,45%), CO (57,06%), PCDD/PCDF (53,41%), TSP (49,74%), NMVOC (31,27%), Cr (26,37%), HCB (20,55%), Pb (9,14%), NOx (6,92%), NH3 (5,87%).

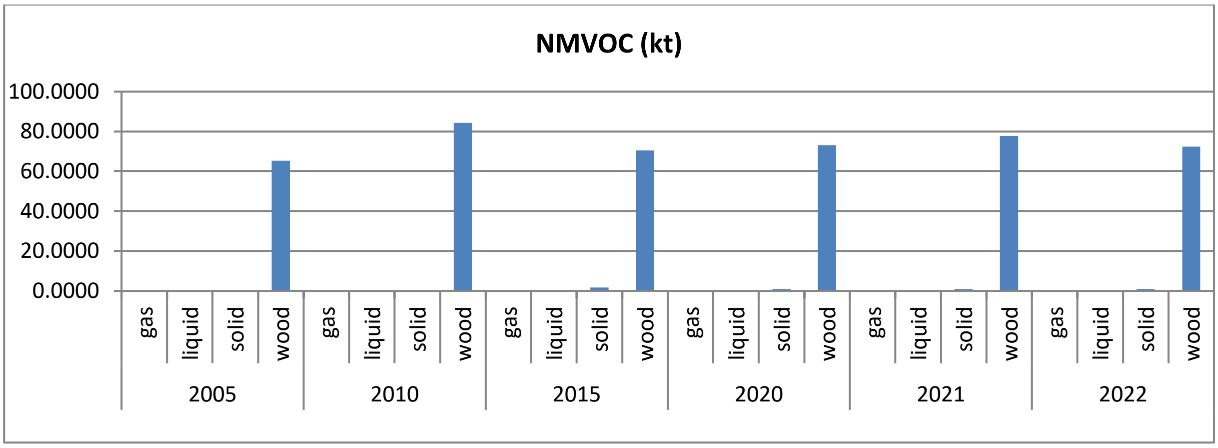


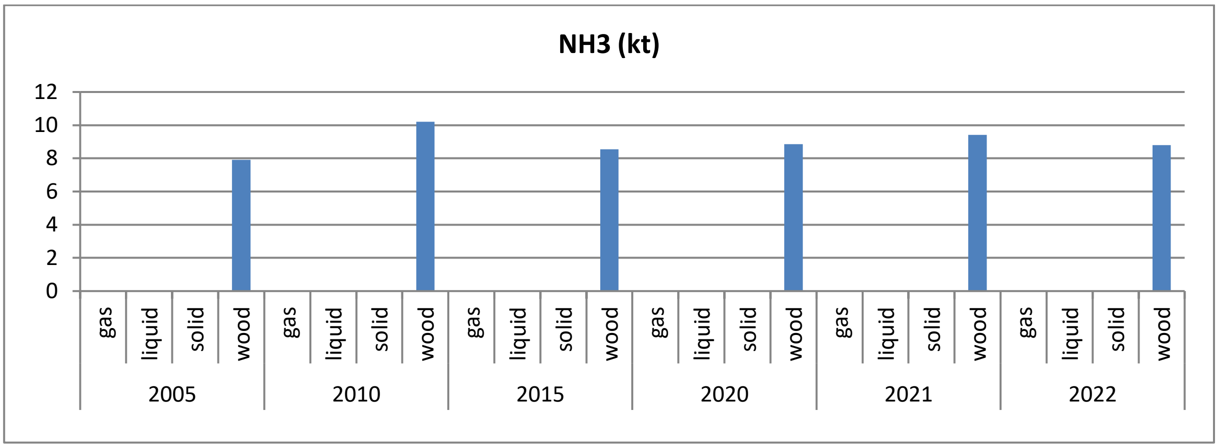
The activity data consist of fuel consumption provided, for the years 1990-2016, by EUROSTAT energy balances (annual data – nrg_110a, *Final energy consumption/Other Sectors/Residential)* and for 2017-2022 by the N.I.S, in the forms of the EUROSTAT ENERGY questionnaires. The diesel and gasoline consumption for this category are not included in 1A4bi but allocated to 1A4bii – Mobile machineries.

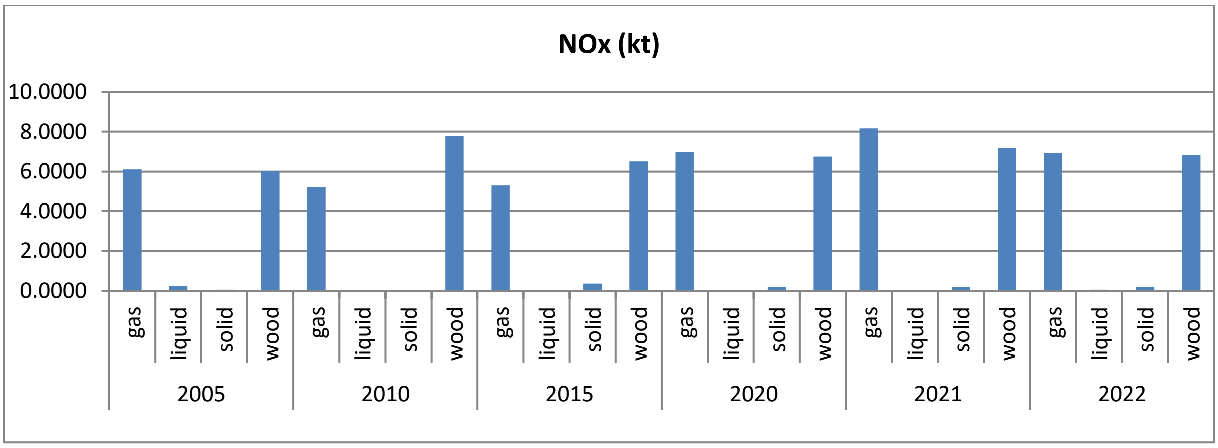
The emission factors are based on EMEP/EEA 2019 Guidebook.

For NFR category 1A4bi, relevant fuels are solid biomass (wood) and natural gas (see Figure 3.9.1). The charts below show the emissions for each type of fuels, for the pollutants $PM_{2.5}$, NOx, NH_3 and NMVOC.









Tier 2 methodology was applied for wood combustion, with following percentages of technologies in 2022: conventional stoves burning wood and similar wood waste 89.7% (*Small combustion, Table 3.40 Tier 2 emission factors for NFR category 1.A.4.b.i*), conventional boilers < 50kW burning wood and similar wood waste 7% (*Table 3.43 Tier 2 emission factors for NFR category 1.A.4.b.i*), pellet stoves and boilers burning wood pellets 3.3% (*Table 3.44 Tier 2 emission factors for NFR category 1.A.4.b.i.*).

Gaseous fuels contribute significantly only to NOx emissions. The pollutants for gaseous fuels are estimated based on emission factors from Guidebook 2019, Small combustion chapter, *Table 3.4, Tier 1 emission factors for NFR category 1.A.4.b.*, which is average of Tier 2 values in Tables 3.13 (stoves) and 3.16 (small boilers).

Improvement and recalculations:

Emissions of the historical time series were recalculated, applying slight corrections on shares of technologies for biomass (stoves, pellets and boilers), resulting in low changes of emission values compared with the previous submission.

The tables and charts below provide the time series of emissions in the residential sector.

Table 3.9.1 Emission Trends (kt) of Main Pollutants, Particulate Matter, BC and CO for NFR 1.A.4.b.i

Year/Pollutant	NOx	NMVOC	SOx	$PM_{2.5}$	PM_{10}	TSP	BC	CO
1990	10.335	30.374	29.997	30.856	31.529	33.792	2.624	249.812
1991	9.627	21.261	17.979	22.220	22.722	24.273	1.947	170.957
1992	6.852	20.229	14.389	21.875	22.390	23.845	1.978	157.729
1993	6.781	23.524	9.414	27.003	27.682	29.314	2.573	172.527
1994	6.127	23.508	3.104	28.350	29.098	30.676	2.809	163.024
1995	6.691	26.387	2.789	31.981	32.828	34.593	3.181	181.916
1996	9.313	56.322	6.318	68.328	70.138	73.923	6.798	387.799
1997	11.784	74.352	5.908	90.760	93.177	98.153	9.072	508.178
1998	11.254	66.630	2.067	82.059	84.262	88.690	8.256	450.693
1999	10.597	63.040	3.036	77.381	79.452	83.652	7.767	428.072
2000	10.856	60.706	2.805	74.617	76.610	80.650	7.523	414.184
2001	8.730	42.895	1.125	52.890	54.306	57.151	5.345	291.680
2002	9.644	43.873	1.749	53.942	55.383	58.296	5.441	299.403
2003	11.104	53.875	1.704	66.368	68.144	71.718	6.703	366.774
2004	12.256	65.658	2.905	80.774	82.933	87.299	8.149	447.723
2005	12.340	66.649	2.147	82.240	84.440	88.860	8.344	455.117
2006	12.030	62.609	1.986	77.275	79.342	83.492	7.842	427.562
2007	11.570	65.257	2.142	80.567	82.723	87.051	8.177	445.442
2008	12.969	83.850	3.643	103.283	106.041	111.618	10.464	573.530
2009	12.743	82.129	2.152	101.482	104.194	109.642	10.343	562.296
2010	12.965	85.129	2.039	105.237	108.050	113.696	10.729	582.561
2011	12.447	76.131	2.224	94.014	96.525	101.575	9.578	521.806
2012	13.158	79.525	2.599	98.145	100.764	106.042	9.994	545.556
2013	12.579	75.202	2.420	92.822	95.299	100.289	9.453	515.918
2014	12.263	76.244	4.129	93.758	96.252	101.327	9.522	525.367
2015	12.167	72.439	4.458	88.952	91.315	96.141	9.024	500.032
2016	12.244	72.423	3.551	89.184	91.553	96.360	9.130	502.607
2017	13.227	73.537	2.763	90.733	93.148	98.025	9.271	507.501
2018	13.415	72.838	2.746	89.874	92.265	97.096	9.184	502.792
2019	13.517	73.345	3.059	90.449	92.855	97.721	9.239	506.715
2020	14.035	73.472	3.209	90.619	93.024	97.895	9.290	510.148
2021	15.628	77.990	3.344	96.192	98.744	103.912	9.862	541.675
2022	14.032	73.587	3.258	90.771	93.180	98.059	9.307	511.065

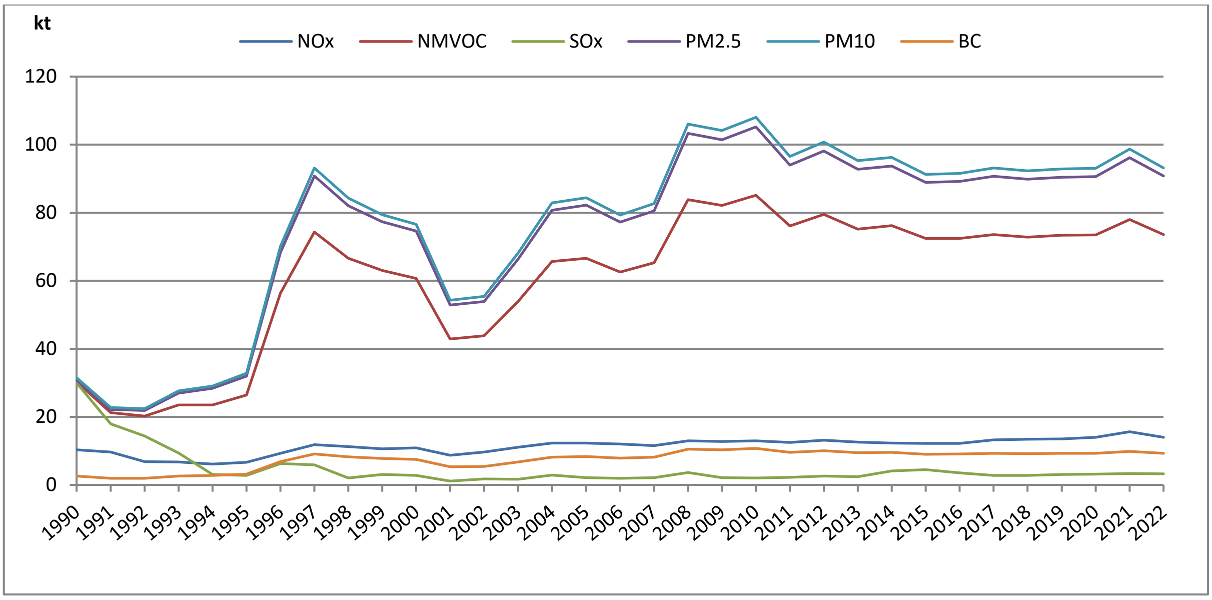


Figure 3.9.1 Emissions (kt) of NOx, NMVOC, SOx, PM_{10}/$PM_{2.5}$ for NFR 1.A.4.b.i

Table 3.9.2 Emissions of Pb, Cd, Cr, Zn (t) and HCB (kg) for NFR 1.A.4.b.i

Year/Pollutant	Pb (t)	Cd (t)	Cr (t)	Zn (t)	HCB (kg)
1990	4.904	0.362	0.921	19.537	0.141
1991	3.060	0.282	0.667	14.261	0.109
1992	2.548	0.301	0.664	14.309	0.117
1993	2.119	0.422	0.831	18.191	0.163
1994	1.377	0.484	0.881	19.527	0.186
1995	1.462	0.550	0.995	22.075	0.212
1996	3.202	1.186	2.148	47.652	0.456
1997	3.932	1.591	2.858	63.469	0.612
1998	3.121	1.459	2.589	57.595	0.561
1999	3.092	1.369	2.439	54.236	0.527
2000	3.003	1.338	2.383	52.984	0.515
2001	2.018	0.953	1.689	37.598	0.367
2002	2.136	0.968	1.722	38.291	0.372
2003	2.565	1.195	2.120	47.159	0.460
2004	3.207	1.450	2.580	57.371	0.558
2005	3.163	1.488	2.639	58.697	0.572
2006	2.961	1.400	2.482	55.206	0.538
2007	3.088	1.460	2.588	57.574	0.562
2008	4.126	1.866	3.319	73.820	0.718
2009	3.913	1.849	3.276	72.895	0.711
2010	4.041	1.920	3.400	75.681	0.738
2011	3.663	1.714	3.039	67.632	0.659
2012	3.864	1.789	3.175	70.647	0.688
2013	3.653	1.694	3.006	66.880	0.652
2014	3.906	1.702	3.036	67.504	0.655
2015	3.772	1.611	2.879	63.996	0.620
2016	3.670	1.623	2.891	64.288	0.624
2017	3.635	1.663	2.954	65.709	0.639
2018	3.602	1.648	2.929	65.145	0.634

Year/Pollutant	Pb (t)	Cd (t)	Cr (t)	Zn (t)	HCB (kg)
2019	3.662	1.659	2.950	65.606	0.638
2020	3.705	1.669	2.969	66.025	0.642
2021	3.930	1.773	3.154	70.144	0.682
2022	3.720	1.675	2.980	66.263	0.644

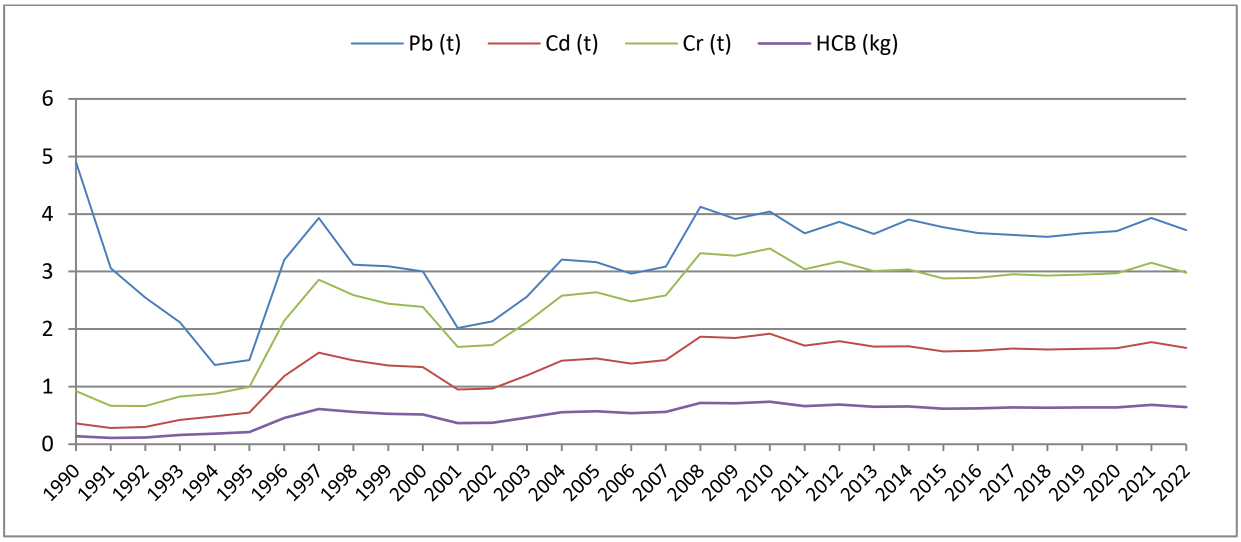


Figure 3.9.2 Emissions of Pb, Cd, Cr and HCB for NFR 1.A.4.bi

Table 3.9.3 Emissions of PCDD/F (g I-TEQ) and Total PAHs (t) for NFR 1.A.4.b.i

Year/Pollutant	PCDD/F (g I-TEQ)	Total 4 PAHs (t)	PCBs (kg)
1990	45.509	34.488	5.563
1991	31.279	22.313	3.314
1992	29.310	19.517	2.577
1993	32.869	18.641	1.667
1994	31.782	15.069	0.501
1995	35.559	16.516	0.431
1996	76.148	35.624	0.995
1997	100.114	45.609	0.847
1998	89.137	38.922	0.127
1999	84.529	37.496	0.339
2000	81.546	36.217	0.306
2001	57.452	25.073	0.055
2002	58.850	25.985	0.172
2003	72.202	31.639	0.118
2004	88.147	38.966	0.267
2005	89.433	39.214	0.103
2006	84.001	36.773	0.078
2007	87.581	38.352	0.082
2008	112.770	50.046	0.343
2009	110.355	48.528	0.107
2010	114.374	50.216	0.080
2011	102.346	45.120	0.145
2012	106.966	47.299	0.206
2013	101.154	44.708	0.188
2014	102.860	46.298	0.504

Year/Pollutant	PCDD/F (g I-TEQ)	Total 4 PAHs (t)	PCBs (kg)
2015	97.805	44.275	0.578
2016	97.764	44.086	0.409
2017	99.094	44.104	0.252
2018	98.157	43.676	0.247
2019	98.898	44.133	0.297
2020	99.208	44.483	0.327
2021	105.298	47.182	0.339
2022	99.394	44.576	0.331

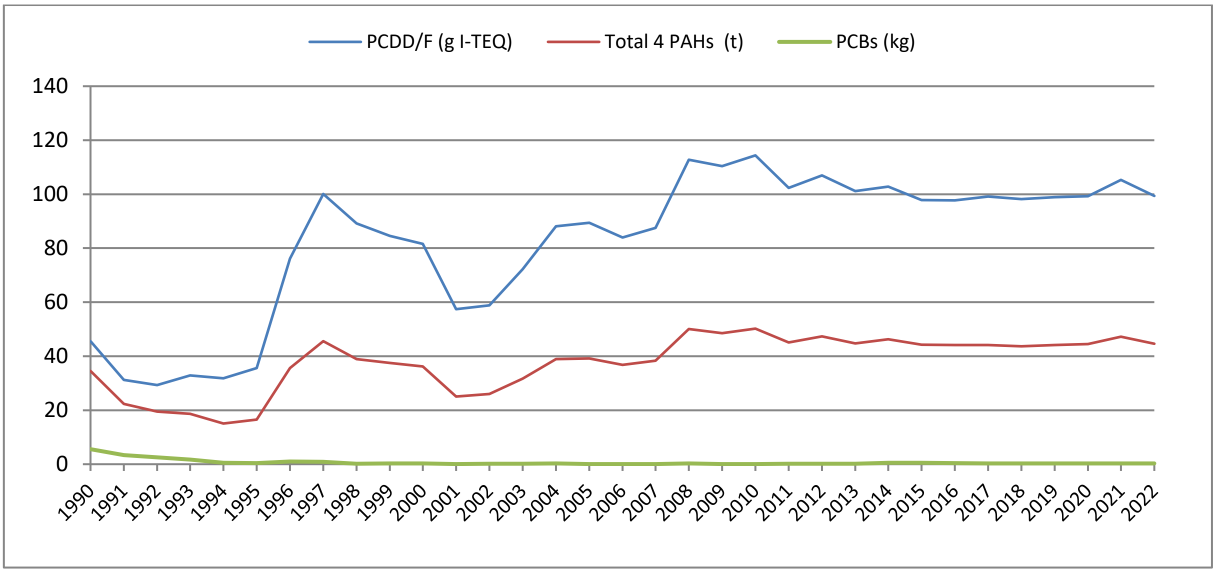


Figure 3.9.3 Emissions of PCDD/F (g I-TEQ) and Total PAHs (t) for NFR 1.A.4.b.i

Most of pollutants generally increased along the time series, in line with increasing of biomass consumption. SOx, PCBs and a few heavy metals decreased in the interval 1990-1998 compared to 1990 because they arise mostly from solid fuel, which decreased in the same interval. Emissions decreased slightly in 2022, compared to 2021, due to fuel consumption reduction and slight improvement of biomass burning technologies.
Compared to 2005, emissions in 2022 increased with 1.69 kt for NOx, 0.9 kt for NH3, 6.93 kt for NMVOC and 8.53 kt for $PM_{2.5}$.

The table and chart below provide the time series of the fuel consumption in the residential sector.

Table 3.9.4 Fuel consumptions (TJ) for Residential heating

Year/Fuel (TJ)	Liquid fuels	Solid fuels	Gaseous fuels	Biomass
1990	3655.00	32716.00	104523.00	24098.00
1991	2663.00	19490.00	124732.00	19477.00
1992	7079.00	15151.00	73326.00	21431.00
1993	3305.00	9794.00	77462.00	31318.00
1994	516.00	2933.00	76715.00	36877.00
1995	504.00	2518.00	83555.00	42033.00
1996	814.00	5823.00	78844.00	90567.00

Year/Fuel (TJ)	Liquid fuels	Solid fuels	Gaseous fuels	Biomass
1997	1337.00	4939.00	97464.00	121839.00
1998	2378.00	706.00	104793.00	112184.00
1999	1272.00	1958.00	97410.00	105087.00
2000	774.00	1766.00	104546.00	102725.00
2001	335.00	296.00	96169.00	73306.00
2002	120.00	988.00	111760.00	74362.00
2003	889.00	661.00	122687.00	91822.00
2004	3800.00	1531.00	120720.00	111392.00
2005	4882.00	568.00	119670.00	114395.00
2006	5544.00	420.00	120046.00	107639.00
2007	6833.00	441.00	104994.00	112254.00
2008	3807.00	1966.00	100489.00	143331.00
2009	516.00	580.00	102737.00	142124.00
2010	120.00	418.00	102120.00	147635.00
2011	200.00	810.00	107214.00	131745.00
2012	43.00	1166.00	114585.00	137482.00
2013	0.00	1061.00	110921.00	130169.00
2014	463.00	2922.00	99751.00	130588.00
2015	695.00	3355.00	103914.00	123550.00
2016	352.00	2361.00	105937.00	124547.00
2017	402.93	1436.62	124027.40	127719.14
2018	680.43	1407.89	128550.83	126630.44
2019	1223.64	1703.62	128500.17	127402.41
2020	957.32	1879.48	136941.65	128146.45
2021	679.40	1945.02	159893.93	136163.37
2022	1279.73	1903.83	135887.06	128600.78

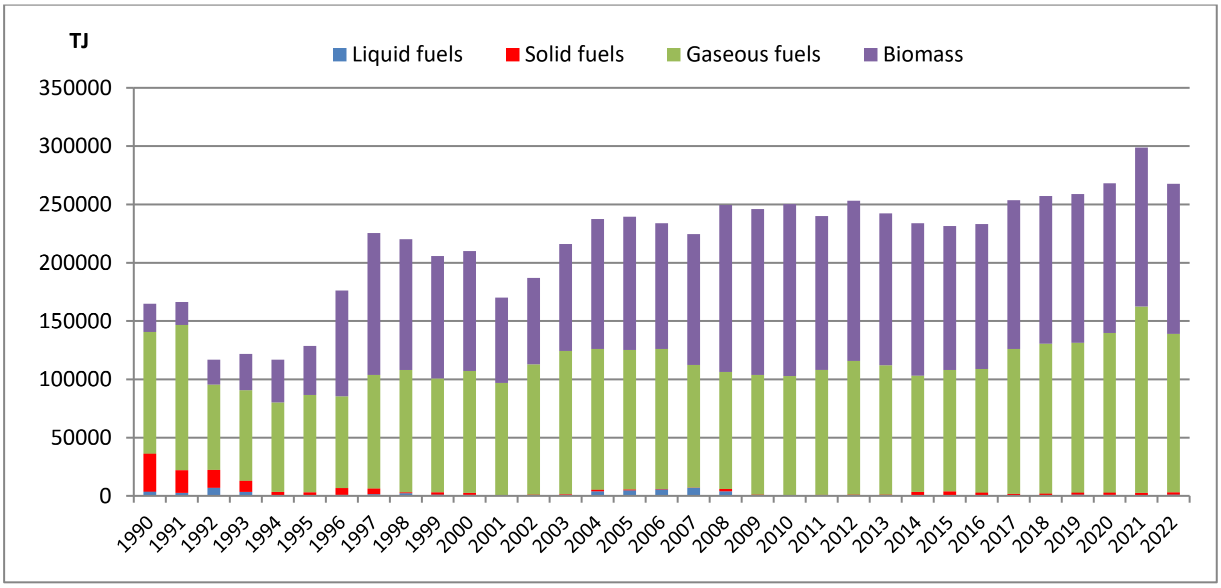


Figure 3.9.4 Fuel consumptions trend (TJ) for Residential heating (NFR 1.A.4.bi)

3.9.1 NFR 1.A.4.b.ii Residential: Household and gardening

NFR 1.A.4.b.ii includes fuel combustion in mobile, non-road sources from residential household and gardening. The estimation is based on diesel and gasoline consumption, provided by EUROSTAT energy balance, category *Final energy consumption/Other Sectors/Residential.* Tier 1 emission factors were used (2019 EMEP/EEA Guidebook, NFR 1.A.4 Non road mobile machinery, Table 3.11.1 - gasoline and diesel oil). SOx are estimated based on sulphur content in the fuel.

Emissions for 1A4bii were estimated only for those years for which there are non-zero values for the fuel consumption in the EUROSTAT energy database. Where data are not available separately, the estimation is considered included in NFRs 1A3b (same for 2022).

The tables and charts below provide the time-series of emissions for the main pollutants and fuel consumption.

Table 3.9.1.1 Emissions of main pollutants for NFR 1.A.4bii

Year/Pollutant (kt)	NOx	NMVOC	$PM_{2.5}$	CO
1990	IE	IE	IE	IE
1991	IE	IE	IE	IE
1992	IE	IE	IE	IE
1993	IE	IE	IE	IE
1994	0.383	0.039	0.021	0.127
1995	2.783	0.286	0.155	0.926
1996	IE	IE	IE	IE
1997	4.036	0.415	0.224	1.343
1998	4.071	0.418	0.226	1.355
1999	3.271	0.336	0.182	1.089
2000	4.663	0.479	0.259	1.552
2001	1.531	0.157	0.085	0.510
2002	0.035	0.004	0.002	0.012
2003	1.600	0.164	0.089	0.533
2004	0.139	0.014	0.008	0.046
2005	0.139	0.014	0.008	0.046
2006	0.487	0.050	0.027	0.162
2007	IE	IE	IE	IE
2008	IE	IE	IE	IE
2009	IE	IE	IE	IE
2010	IE	IE	IE	IE
2011	IE	IE	IE	IE
2012	0.172	0.018	0.010	0.057
2013	IE	IE	IE	IE
2014	IE	IE	IE	IE
2015	IE	IE	IE	IE
2016	IE	IE	IE	IE
2017	IE	IE	IE	IE
2018	IE	IE	IE	IE
2019	IE	IE	IE	IE
2020	IE	IE	IE	IE
2021	IE	IE	IE	IE
2022	IE	IE	IE	IE

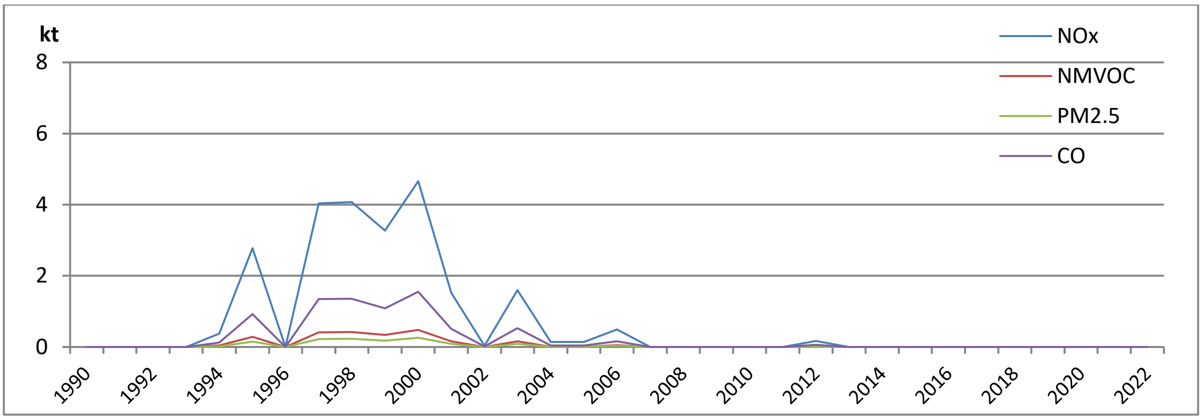


Figure 3.9.1.1 Emissions of main pollutants (kt) from NFR 1A4bii

The fuel consumption for the time-series 1990-2022 for this category is given in the table and chart below.

Table 3.9.1.2 Fuel consumption for NFR 1A4bii

Year/Fuel (TJ)	Diesel Oil
1990	IE
1991	IE
1992	IE
1993	IE
1994	472.00
1995	3432.00
1996	IE
1997	4976.00
1998	5019.00
1999	4033.00
2000	5749.00
2001	1888.00
2002	43.00
2003	1973.00
2004	172.00
2005	172.00
2006	601.00
2007	IE
2008	IE
2009	IE
2010	IE
2011	IE
2012	212.00
2013	IE
2014	IE
2015	IE
2016	IE
2017	IE
2018	IE
2019	IE
2020	IE
2021	IE
2022	IE

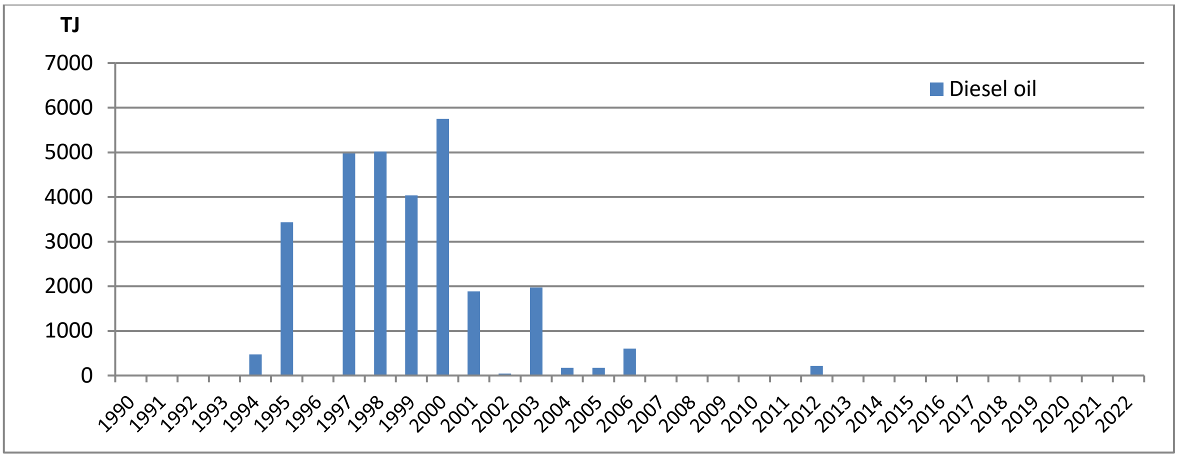


Figure 3.9.1.2 Fuel consumption (TJ) for NFR 1A4bii

Recalculations and improvements:

No recalculation was performed on the 1990-2021 time series compared to 2023 submission.

3.10 NFR 1.A.4.c.i Agriculture/Forestry/Fishing, Stationary

The emissions for 1990-2022 have been estimated by applying Tier 1 emission factors (2019 EMEP/EEA Guidebook, NFR 1.A.4 Small combustion, Tables 3.7-3.10) to the fuel consumption provided by the EUROSTAT energy balances: *Final energy consumption/Other Sectors/Agriculture/Forestry.* From oil category, 100% of the fuel oil and 20% of the diesel oil was allocated to this category. The gasoline and 80% of the diesel/gas oil were used for estimation of emissions for the NFR 1.A.4.c.ii – Non-road vehicles and other machinery.

The Tier 1 emission factors in Table 3.9, for NFR source category 1.A.4.a/c, 1.A.5.a using liquid fuels are “average of Tier 2 EFs for commercial/institutional liquid fuel combustion for all technologies (gas oil and fuel oil)” (Notes to Table3.9).

NFR 1A4ci was not a key category for any pollutant in 2022.

Table 3.10.1 Emission Trends of main pollutants for NFR 1.A.4.c.i

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx (kt)	$PM_{2.5}$ (kt)	BC (kt)	CO (kt)	Ni (t)
1990	2.720	0.859	0.583	0.100	0.007	1.625	0.024
1991	2.565	0.899	0.042	0.096	0.021	1.225	0.021
1992	2.473	0.357	0.822	0.234	0.099	1.167	0.932
1993	2.013	0.330	0.702	0.204	0.082	1.050	0.728
1994	1.387	0.330	0.470	0.197	0.072	0.907	0.498
1995	1.745	0.327	0.530	0.160	0.063	0.893	0.548
1996	1.396	0.273	0.417	0.152	0.060	0.742	0.484
1997	1.699	0.547	0.452	0.291	0.103	1.256	0.557
1998	1.474	0.508	0.439	0.280	0.096	1.201	0.491
1999	0.878	0.274	0.219	0.138	0.049	0.615	0.273
2000	0.719	0.105	0.206	0.061	0.027	0.308	0.260
2001	0.503	0.096	0.144	0.054	0.022	0.258	0.178

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx (kt)	$PM_{2.5}$ (kt)	BC (kt)	CO (kt)	Ni (t)
2002	0.525	0.118	0.218	0.063	0.021	0.361	0.161
2003	0.436	0.081	0.257	0.051	0.015	0.339	0.136
2004	0.458	0.082	0.169	0.039	0.014	0.253	0.135
2005	0.441	0.102	0.217	0.053	0.016	0.338	0.120
2006	0.540	0.157	0.338	0.092	0.025	0.543	0.153
2007	0.575	0.536	0.289	0.292	0.082	1.216	0.130
2008	0.745	0.306	0.417	0.152	0.040	0.863	0.156
2009	0.919	0.287	0.474	0.140	0.038	0.857	0.214
2010	0.900	0.244	0.442	0.115	0.032	0.749	0.212
2011	0.971	0.206	0.488	0.109	0.033	0.717	0.275
2012	1.042	0.197	0.256	0.086	0.036	0.477	0.315
2013	1.060	0.621	0.495	0.332	0.095	1.504	0.266
2014	0.904	0.208	0.441	0.112	0.034	0.687	0.260
2015	0.993	0.242	0.499	0.129	0.039	0.795	0.278
2016	1.059	0.223	0.559	0.122	0.036	0.807	0.301
2017	1.237	0.293	0.646	0.141	0.039	0.984	0.303
2018	1.446	0.311	0.806	0.160	0.044	1.144	0.374
2019	1.416	0.344	0.798	0.183	0.051	1.207	0.373
2020	1.405	0.359	0.851	0.196	0.052	1.287	0.367
2021	1.504	0.342	0.921	0.189	0.051	1.307	0.401
2022	1.462	0.347	0.949	0.209	0.057	1.357	0.419

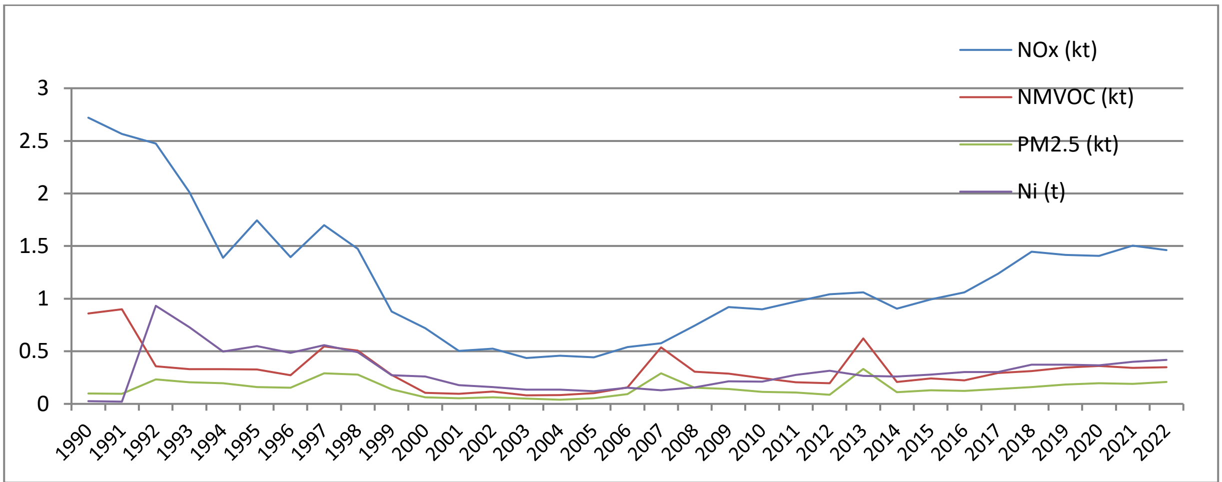


Figure 3.10.1 Emission of main pollutants for NFR 1.A.4.c.i

The table and chart below provide the fuel consumption for the time-series 1990-2022:

Table 3.10.2 NFR 1.A.4.c.i: Agriculture/Forestry/Fishing, stationary

Year/Fuel (TJ)	Liquid fuels	Solid fuels	Gaseous fuels	Biomass
1990	123.00	652.00	34725.00	0.00
1991	160.00	0.00	33484.00	420.00
1992	7433.20	139.00	1718.00	521.00
1993	5794.40	179.00	2216.00	492.00
1994	3958.20	106.00	1261.00	709.00
1995	4364.40	133.00	4741.00	396.00
1996	3858.00	57.00	2197.00	468.00

Year/Fuel (TJ)	Liquid fuels	Solid fuels	Gaseous fuels	Biomass
1997	4433.00	23.00	2992.00	1291.00
1998	3904.00	68.00	2078.00	1253.00
1999	2170.80	8.00	2122.00	604.00
2000	2076.40	10.00	938.00	137.00
2001	1424.20	9.00	680.00	171.00
2002	1269.80	114.00	1371.00	170.00
2003	1069.60	184.00	950.00	72.00
2004	1072.40	79.00	1487.00	65.00
2005	943.80	150.00	1566.00	114.00
2006	1192.60	264.00	1436.00	254.00
2007	995.20	211.00	1245.00	1564.00
2008	1201.80	352.00	3581.00	561.00
2009	1664.60	369.00	4155.00	418.00
2010	1656.00	334.00	4184.00	285.00
2011	2159.20	334.00	3174.00	199.00
2012	2512.20	18.00	3376.00	226.00
2013	2070.80	334.00	3010.00	1603.00
2014	2045.40	290.00	2761.00	258.00
2015	2181.20	343.00	3206.00	315.00
2016	2365.40	396.00	3345.00	214.00
2017	2370.73	495.55	5438.84	254.09
2018	2922.01	624.95	5722.93	218.49
2019	2917.21	614.57	5177.34	374.89
2020	2856.55	684.15	5066.80	415.97
2021	3123.84	738.89	5300.84	307.18
2022	3263.19	755.80	3985.17	410.73

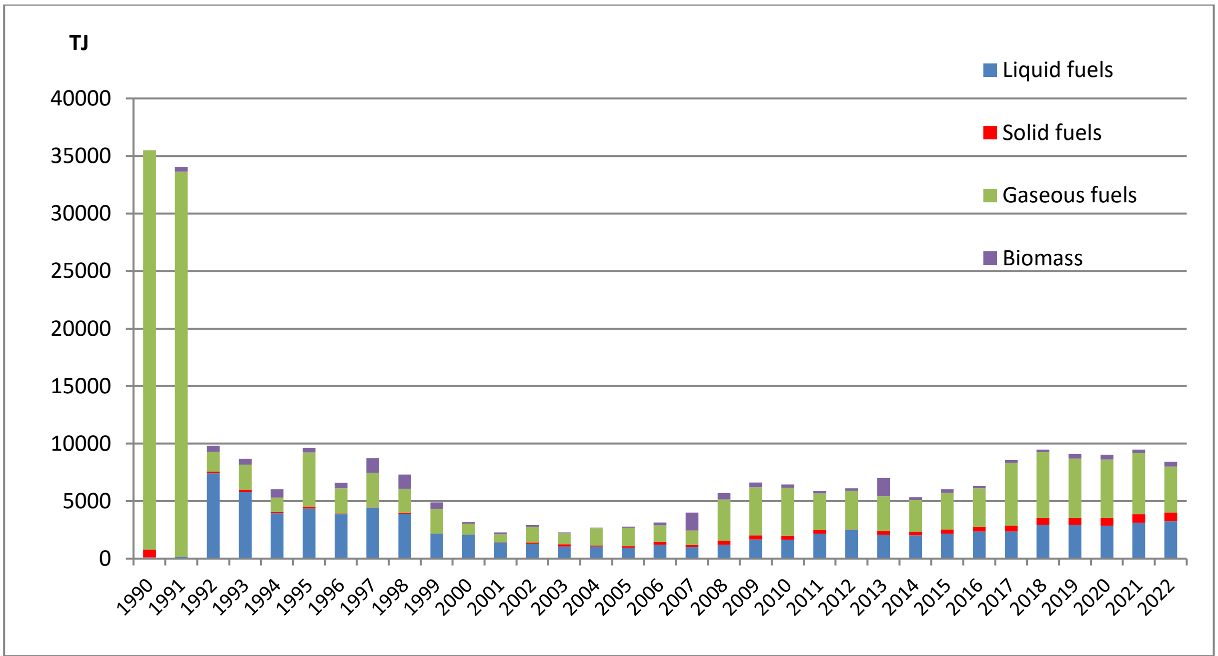


Figure 3.10.2 Fuel consumptions (TJ) for NFR 1.A.4.c.i: Agriculture/Forestry/Fishing, stationary

Recalculations and improvements:
No recalculation was performed on the 1990-2021 time series compared to 2023 submission.

3.10.1 NFR 1.A.4.c.ii Agriculture/Forestry/Fishing: Non-road vehicles and other machinery

The category NFR 1.A.4.c.ii includes the emissions from fuel combustion in mobile machinery, non-road sources from agricultural/forestry sector. NFR 1A4ciii, National fishing, is also included in this category, because the fuel consumption for national fishing is not reported separately to EUROSTAT. NFR 1A4cii is not a key source for any pollutant.

The emissions are estimated on Tier2 level, for all pollutants and years for which the Guidebook provides default values for splitting the fuel consumption by engine age and technologies.

The estimation is based on diesel and gasoline fuel consumptions, given in EUROSTAT Energy balance, category *Final energy consumption/Other Sectors/Agriculture/Forestry/Fishing*.
The activity data consist of 80% of the Gas/Diesel oil and 100% of the Motor Gasoline provided by Energy statistics in the category *Final energy consumption/Other Sectors/Agriculture/Forestry/Fishing*. 20% of the Gas/Diesel oil is allocated to 1A4ci. Of the Gas/Diesel oil quantity allocated to 1A4cii, 70% is considered for agriculture and 30% for forestry activities. Table 3-2 - *Tier 2 emission factors for non-road machinery, Diesel, 1A4cii Agriculture and Forestry*, Guidebook 2019 gives the emission factors used for Tier 2 calculation.

There are no national data on split of the fuel consumption by engine age and technologies. Therefore, the method used for splitting the fuel for Tier 2 estimation is the alternative approach provided by the Guidebook 2019, data derived from Winther (2016) and Winther & Nielsen (2006), given in the Tables 3–3 in the chapter Non-road mobile sources and machinery and Tables 3-5 & 3–6 in the Annex file accompanying the Guidebook chapter. The method applies to 1999-2021 interval. For the interval 1992-1998, Tier 1 method was used for both diesel and gasoline fuels. The estimation for 1990-1991 is included in NFRs 1A3b. Diesel oil has a contribution over 99.5% to NOx emissions, while gasoline less than 0.5%. Therefore, gasoline emissions are calculated on Tier 1 level for all years, using the emission factors in Table 3.11.1, NFR 1.A.4 Non-road mobile machinery, Guidebook 2019. For splitting gasoline consumption between two-stroke and four-stroke machinery, the percentage split (20/80) is used for 2022 consumption (expert judgement).
Estimation of SOx emissions is based on sulphur content in the fuel.

Table 3.10.1.1 Emission Trends of main pollutants for NFR 1.A.4.cii non-road Agriculture/Forestry/Fishing

Year/Pollutant (kt)	NOx	NMVOC	SOx	PM2.5	BC	CO
1990	IE	IE	IE	IE	IE	IE
1991	IE	IE	IE	IE	IE	IE
1992	22.556	4.025	1.382	1.147	0.666	17.882
1993	17.471	2.405	1.070	0.878	0.516	9.815
1994	11.936	1.379	0.731	0.596	0.353	5.210
1995	13.191	1.874	0.808	0.664	0.390	7.744
1996	11.817	3.013	0.724	0.613	0.349	14.485
1997	13.544	2.161	0.830	0.685	0.400	9.291
1998	11.934	2.644	0.731	0.614	0.352	12.370
1999	9.142	1.647	0.142	0.526	0.284	6.561
2000	8.941	2.477	0.140	0.502	0.265	11.445
2001	6.040	1.129	0.095	0.316	0.172	4.743
2002	5.163	0.887	0.084	0.256	0.142	3.712
2003	3.949	0.881	0.069	0.192	0.106	4.051
2004	3.857	0.858	0.072	0.181	0.102	4.014
2005	3.194	0.650	0.009	0.145	0.083	3.032
2006	3.801	1.922	0.012	0.185	0.098	10.159
2007	2.898	0.428	0.010	0.124	0.075	3.109
2008	2.546	0.515	0.009	0.109	0.066	4.493
2009	3.993	0.514	0.003	0.165	0.104	3.506
2010	3.791	0.555	0.003	0.155	0.099	4.205
2011	4.475	0.486	0.004	0.176	0.115	3.010
2012	4.968	0.993	0.005	0.187	0.120	9.146
2013	3.733	0.593	0.004	0.134	0.088	5.103
2014	3.300	0.440	0.004	0.115	0.077	3.567
2015	3.130	0.793	0.004	0.113	0.072	8.059
2016	2.895	0.422	0.004	0.100	0.067	3.681
2017	2.543	0.397	0.004	0.088	0.060	3.591
2018	2.736	0.478	0.006	0.095	0.064	4.555
2019	2.309	0.511	0.005	0.081	0.054	5.212
2020	1.950	0.390	0.005	0.067	0.045	3.949
2021	1.835	0.502	0.006	0.065	0.042	5.406
2022	1.648	0.418	0.006	0.580	0.037	4.494

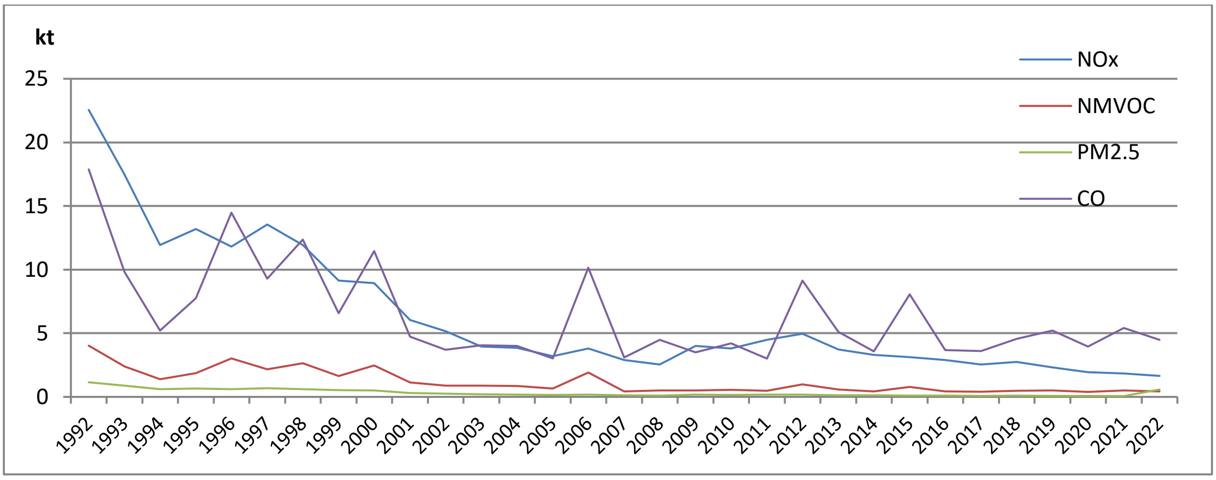


Figure 3.10.1.1 Emissions (kt) of NOx, NMVOC, PM_{10} and CO for NFR 1.A.4.c.ii, 1992-2022

The emission trends are consistent with the variation of the fuel consumption, provided in the table and chart below.

Table 3.10.1.2 Fuel consumptions (TJ) for NFR 1.A.4.cii non-road Agriculture/Forestry/Fishing

Year/Fuel (TJ)	Gasoline	Diesel fuel	Total liquid fuel
1990	IE	IE	IE
1991	IE	IE	IE
1992	674.00	36551.00	29914.80
1993	269.00	28357.00	22954.60
1994	90.00	19391.00	15602.80
1995	224.00	21407.00	17349.60
1996	674.00	19090.00	15946.00
1997	314.00	21965.00	17886.00
1998	539.00	19305.00	15983.00
1999	224.00	10639.00	8735.20
2000	539.00	10382.00	8844.60
2001	180.00	7121.00	5876.80
2002	135.00	6349.00	5214.20
2003	180.00	5148.00	4298.40
2004	180.00	5362.00	4469.60
2005	131.00	4719.00	3906.20
2006	566.00	5963.00	5336.40
2007	131.00	4976.00	4111.80
2008	218.00	4719.00	3993.20
2009	131.00	8108.00	6617.40
2010	174.00	8280.00	6798.00
2011	87.00	10596.00	8563.80
2012	435.00	12561.00	10483.80
2013	218.00	10354.00	8501.20
2014	131.00	10227.00	8312.60
2015	392.00	10906.00	9116.80
2016	131.00	11627.00	9432.60
2017	127.09	9318.40	9445.48
2018	158.89	11518.59	11677.48
2019	198.89	11321.28	11520.19
2020	130.98	11082.34	11213.32
2021	203.68	12146,94	12350.62
2022	148.15	12930.30	13078.45

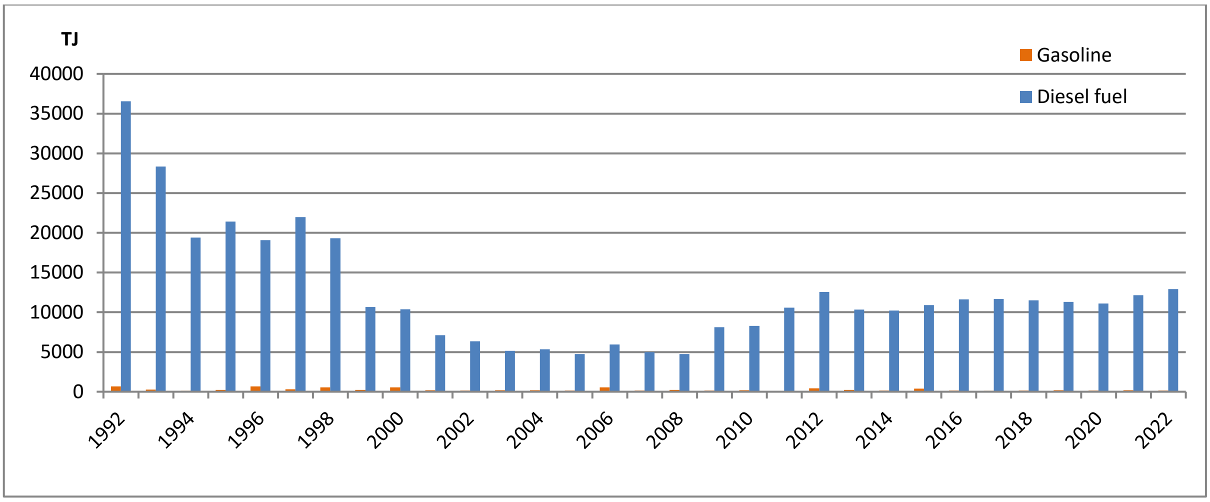


Figure 3.10.1.2 Fuel consumption (TJ) for NFR 1.A.4.c.ii, off road Agriculture/Forestry/Fishing

Recalculations and improvements:

No recalculation was performed on the 1990-2021 time series compared to 2023 submission.

3.11 NFR 1.A.5 - Other stationary (including military)

The estimation of emissions reported at NFR 1A5 - Other stationary (including military) is based on Eurostat Energy data and Guidebook 2019 emission factors. The data for 1990-2016 are provided by the EUROSTAT annual energy balances (nrg_110), in the category: *Final energy consumption/Other Sectors/Non-specified (Oth*er). Data for 2017-2022 are provided by the National Institute of Statistics in the Eurostat Energy questionnaires. NFR 1A5b Other, Mobile (including military, land based and recreational boats) is also included in NFR 1A5a. The relevant fuel for this category is the liquid fuel.

NFR 1A5a is a key source for Ni in 2022, accounting for 17.38 % in the national total. The emission factors in *Table 3.9, for NFR source category 1.A.4.a/c, 1.A.5.a using liquid fuels* are “average of Tier 2 EFs for commercial/institutional liquid fuel combustion for all technologies (gas oil and fuel oil)” (Notes to Table3.9, Small Combustion, Guidebook 2019). For the gaseous and solid fuels, in the historical time series, Tier1 emission factors were applied (Guidebook 2019, Tables 3-7, 3-8).

The table 3.11.1 and chart 3.11.1 below give the values of the significant pollutants.

Table 3.11.1 Emissions for NFR 1.A.5, 1990-2022

Year/Pollutant	NOx	NMVOC	SOx	PM_{10}	BC	CO	Ni
1990	2.251	1.092	10.274	1.435	0.089	11.384	0.216
1991	3.073	0.983	8.887	1.272	0.113	9.802	0.673
1992	1.329	0.554	5.010	0.705	0.049	5.562	0.184
1993	1.167	0.113	0.718	0.128	0.039	0.757	0.449

Year/Pollutant	NOx	NMVOC	SOx	PM_{10}	BC	CO	Ni
1994	1.724	0.150	0.913	0.170	0.057	0.952	0.676
1995	2.050	0.244	1.741	0.289	0.069	1.865	0.754
1996	1.091	0.090	0.514	0.099	0.036	0.533	0.431
1997	3.541	0.237	1.146	0.251	0.117	1.141	1.442
1998	2.906	0.198	0.975	0.210	0.096	0.975	1.181
1999	0.433	0.028	0.133	0.030	0.014	0.132	0.177
2000	0.859	0.117	0.885	0.142	0.029	0.955	0.305
2001	1.483	0.150	0.992	0.173	0.050	1.050	0.567
2002	1.081	0.090	0.531	0.101	0.036	0.551	0.427
2003	1.548	0.118	0.644	0.129	0.051	0.658	0.620
2004	5.283	0.416	2.344	0.459	0.175	2.410	2.105
2005	4.686	0.342	1.801	0.370	0.155	1.828	1.888
2006	2.100	0.143	0.701	0.152	0.069	0.701	0.854
2007	3.925	0.257	1.206	0.269	0.129	1.193	1.604
2008	3.439	0.225	1.057	0.236	0.113	1.045	1.405
2009	1.129	0.074	0.347	0.077	0.037	0.343	0.461
2010	1.142	0.075	0.351	0.078	0.038	0.347	0.467
2011	2.297	0.150	0.706	0.158	0.076	0.698	0.939
2012	2.311	0.151	0.710	0.159	0.076	0.702	0.944
2013	1.753	0.115	0.539	0.120	0.058	0.533	0.716
2014	1.662	0.109	0.511	0.114	0.055	0.505	0.679
2015	1.818	0.119	0.558	0.125	0.060	0.553	0.743
2016	1.714	0.112	0.526	0.118	0.056	0.521	0.700
2017	2.568	0.169	0.787	0.176	0.084	0.781	1.047
2018	2.693	0.176	0.827	0.185	0.089	0.818	1.100
2019	2.633	0.172	0.809	0.181	0.087	0.800	1.076
2020	2.569	0.168	0.789	0.176	0.085	0.781	1.050
2021	4.563	0.298	1.402	0.313	0.150	1.387	1.864
2022	4.888	0.320	1.502	0.335	0.161	0.486	1.997

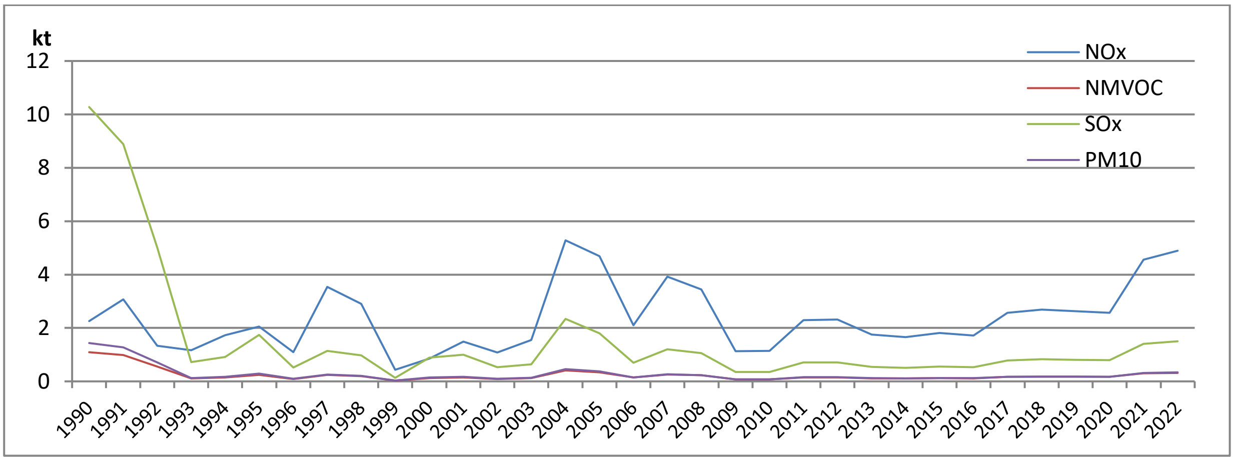


Figure 3.11.1 Emissions for NFR 1A5, 1990-2022

The emissions are consistent with the variation of the fuel consumption in the Energy statistics. The fuel consumption for the time-series 1990-2022 for this category is given in the table and chart below.

Table 3.11.2 Fuel consumption (TJ), 1A5, 1990-2022

Year/Fuel (TJ)	Liquid fuels	Solid fuels	Gaseous fuels
1990	458.00	12180.00	46.00
1991	4334.00	10095.00	0.00
1992	860.00	5867.00	690.00
1993	3544.00	458.00	46.00
1994	5360.00	487.00	0.00
1995	5888.00	1414.00	46.00
1996	3426.00	229.00	46.00
1997	11529.00	74.00	0.00
1998	9438.00	105.00	0.00
1999	1416.00	0.00	0.00
2000	2360.00	790.00	0.00
2001	4462.00	682.00	0.00
2002	3389.00	253.00	0.00
2003	4938.00	214.00	0.00
2004	16746.00	916.00	0.00
2005	15053.00	460.00	0.00
2006	6822.00	71.00	0.00
2007	12828.00	0.00	0.00
2008	11240.00	0.00	0.00
2009	3689.00	0.00	0.00
2010	3732.00	0.00	0.00
2011	7508.00	0.00	0.00
2012	7553.00	0.00	0.00
2013	5729.00	0.00	0.00
2014	5432.00	0.00	0.00
2015	5941.00	0.00	0.00
2016	5601.00	0.00	0.00
2017	8375.84	0.00	73.01
2018	8800.50	0.00	0.00
2019	8605.60	0.00	0.00
2020	8396.36	0.00	0.00
2021	14910.83	0.00	0.00
2022	15973.07	0.00	0.00

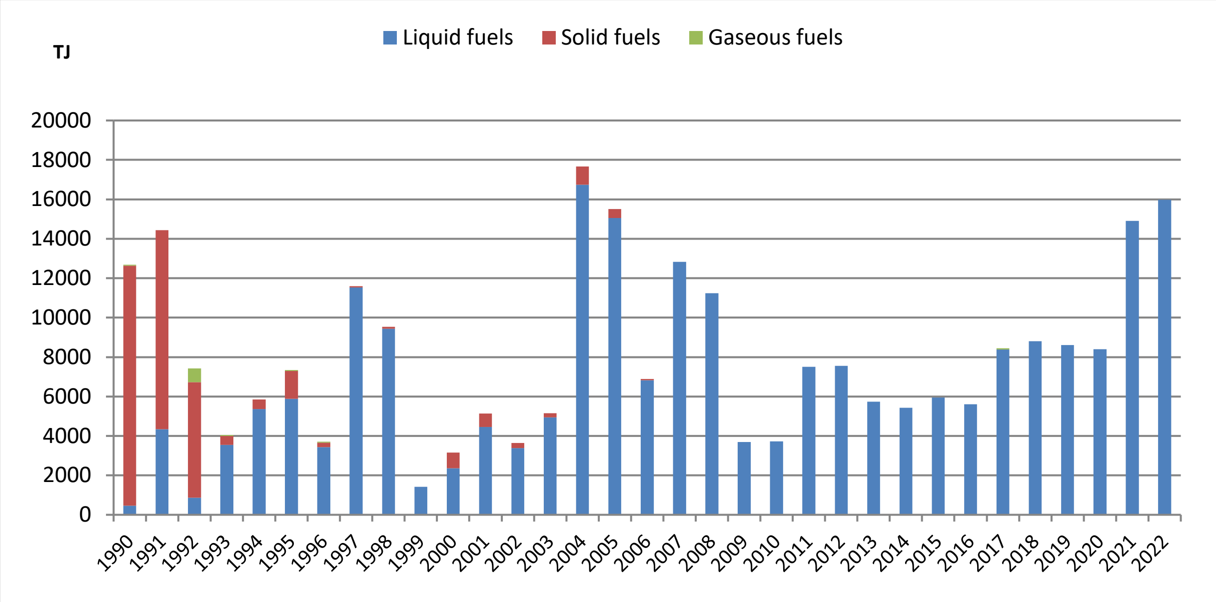


Figure 3.11.2 Fuel consumption (TJ), 1A5, 1990-2022

Recalculations and improvements:

No recalculation was performed on the 1990-2021 time series compared to 2023 submission.

3.12 NFR 1.A.3.a Aviation transport

The emissions from the civil aviation include both, air pollution from national and international aviation, according with the flight phases: for landing and take-off (LTO) cycles comprise under NFR 1.A.3.a.i(i) - International aviation LTO (civil) and NFR 1.A.3.a.ii(i) - Domestic aviation LTO (civil) and for the Cruise cycle (phase for floating over long distance at high altitude (>3000ft (914.4m), are reported as a memo items: NFR 1.A.3.a.i(ii) - International aviation cruise (civil) and NFR 1.A.3.a.ii(ii) - Domestic aviation cruise (civil).

This category does not include military aviation activities.

Table 3.12 Pollutants and Emission factors for 1A3a

NFR	Pollutants Reported	Emission Factor tier and source
1A3ai(i) International aviation LTO (civil)	NOx, NMVOC, SOx, PM2.5, PM10, CO	Average emission factor calculated from EUROCONTROL data (for the period 1990-2004). EUROCONTROL, D2G.1 European Aviation Fuel Burn and Emissions Inventory System (FEIS) for the European Environment Agency (for data from 2005).
1A3aii(i) Domestic aviation LTO (civil)	NOx, NMVOC, SOx, PM2.5, PM10, CO	Average emission factor calculated from EUROCONTROL data (for the period 1990-2004). EUROCONTROL, D2G.1 European Aviation Fuel Burn and Emissions Inventory System (FEIS) for the European Environment Agency (for data from 2005).

The values of pollutants due to aviation activities for the period 2005-2022 were taken from EUROCONTROL, the method is described in D2G.1 European Aviation Fuels and Emissions Inventory System for the European Environment Agency.

A new flight category was added in 2021 EUROCONTROL report, undetermined, defined as "*Flights recorded as departing from a domestic aerodrome and returning to the same aerodrome, without intermediary stop* ("ADEP=ADES" flight type). For most of these flights, the existence of at least one stop in a domestic or international aerodrome can be supposed but cannot be confirmed."

The values of pollutants of this new category were included in Domestic aviation LTO (civil) and Domestic aviation cruise (civil) for the period 2017-2022.

Consumption and emissions have been updated by EUROCONTROL for the years 2017-2020 following changes to the FEIS procedure for those years.

Due to the lack of EUROCONTROL data for the period 1990-2004, emissions were calculated using domestic and international fuel consumption (aviation gasoline, respectively jet kerosene), reported by national statistics in the EUROSTAT Energy database multiplied by average emissions factors calculated for the period 2005-2009 from EUROCONTROL report (expert judgment).

For splitting the fuel consumption between the LTO and cruise phases, the average 2005-2009 fuel of the EUROCONTROL report was taken into account (37.1% fuel for the LTO cycle - Domestic aviation and 13.6% fuel for the LTO cycle - International aviation).

NFR 1.A.3.a.i(i) and 1.A.3.a.ii(i) are not a key source for any pollutant.

Table 3.12.1. Fuel burnt (tonnes), for aviation transport

Year/Fuel burnt (t)	1A3ai(i)	1A3aii(i)*	Memo item 1A3ai(ii)	Memo item 1A3aii(ii)*
1990	30854.14	1112.76	196029.33	1887.24
1991	21883.33	1112.76	139034.02	1887.24
1992	32892.96	741.84	208982.81	1258.16
1993	33300.72	1112.76	211573.51	1887.24
1994	21747.41	1854.60	138170.46	3145.40
1995	24329.91	741.84	154578.20	1258.16
1996	11417.39	741.84	72539.49	1258.16
1997	16310.56	1112.76	103627.84	1887.24
1998	13863.97	2967.36	88083.67	5032.64
1999	17262.01	2596.44	109672.80	4403.56
2000	16718.32	2225.52	106218.54	3774.48
2001	14951.34	1112.76	94992.19	1887.24
2002	12776.60	741.84	81175.14	1258.16
2003	15495.03	741.84	98446.45	1258.16
2004	18077.53	1112.76	114854.19	1887.24
2005	16850.47	3180.26	107700.24	8109.26
2006	19615.08	3594.43	127245.28	8909.44
2007	25950.37	4694.09	170242.07	10847.79

Year/Fuel burnt (t)	1A3ai(i)	1A3aii(i)*	Memo item 1A3ai(ii)	Memo item 1A3aii(ii)*
2008	29441.04	5756.02	206924.12	14088.73
2009	29120.20	6369.11	200587.17	15530.53
2010	31152.48	6411.82	213601.98	15874.32
2011	31612.13	5370.95	213317.27	13238.78
2012	31898.99	4495.79	220257.70	11779.79
2013	31644.76	3908.51	217537.90	9808.26
2014	35738.74	3708.58	233871.35	9080.91
2015	39514.95	3936.81	254183.73	9353.27
2016	45456.24	6618.82	295565.63	14458.85
2017*	52236.65	9507.86	336341.08	19969.71
2018*	55538.59	9868.48	358307.61	20588.95
2019*	58383.63	8374.66	380360.56	18032.02
2020*	24055.54	3870.29	160248.03	8606.52
2021*	30725.06	4829.22	219391.09	11494.59
2022*	46539.34	6172.57	331067.31	14841.91

** Included fuel burnt of new category – UNDETERMINED.*

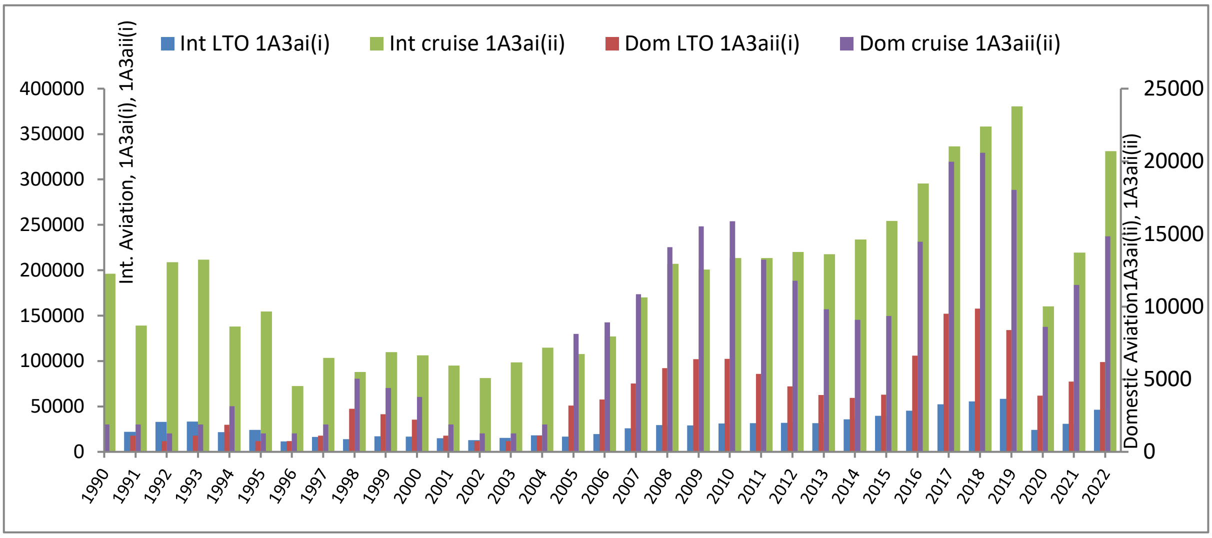


Figure 3.12.1. Fuel burnt (tonnes), for Aviation transport

Table 3.12.2. Emissions trends (kt), NFR 1.A.3.a.ii(i) - Domestic aviation LTO (civil)

Year/Pollutant	NOx	NMVOC	SOx	$PM_{2.5}$=PM_{10}	CO
1990	0.0128	0.0020	0.0010	0.00007	0.017
1991	0.0128	0.0020	0.0010	0.00007	0.017
1992	0.0085	0.0014	0.0007	0.00005	0.011
1993	0.0128	0.0020	0.0010	0.00007	0.017
1994	0.0214	0.0034	0.0017	0.00012	0.028
1995	0.0085	0.0014	0.0007	0.00005	0.011
1996	0.0085	0.0014	0.0007	0.00005	0.011
1997	0.0128	0.0020	0.0010	0.00007	0.017
1998	0.0342	0.0054	0.0028	0.00019	0.045
1999	0.0299	0.0048	0.0024	0.00017	0.040
2000	0.0256	0.0041	0.0021	0.00014	0.034
2001	0.0128	0.0020	0.0010	0.00007	0.017
2002	0.0085	0.0014	0.0007	0.00005	0.011
2003	0.0085	0.0014	0.0007	0.00005	0.011

Year/Pollutant	NOx	NMVOC	SOx	$PM_{2.5}$=PM_{10}	CO
2004	0.0128	0.0020	0.0010	0.00007	0.017
2005	0.0301	0.0053	0.0027	0.00014	0.046
2006	0.0359	0.0075	0.0030	0.00020	0.050
2007	0.0492	0.0083	0.0039	0.00027	0.062
2008	0.0635	0.0080	0.0048	0.00042	0.075
2009	0.0715	0.0089	0.0054	0.00040	0.092
2010	0.0700	0.0093	0.0054	0.00038	0.079
2011	0.0593	0.0064	0.0045	0.00041	0.063
2012	0.0501	0.0055	0.0038	0.00032	0.058
2013	0.0442	0.0040	0.0033	0.00021	0.045
2014	0.0416	0.0039	0.0031	0.00019	0.043
2015	0.0443	0.0053	0.0033	0.00022	0.047
2016	0.0766	0.0061	0.0056	0.00043	0.074
2017*	0.1098	0.0102	0.0080	0.00087	0.1026
2018*	0.1161	0.0105	0.0083	0.00087	0.1047
2019*	0.0967	0.0101	0.0070	0.00063	0.0946
2020*	0.0452	0.0046	0.0033	0.00031	0.0441
2021*	0.0613	0.0049	0.0041	0.00041	0.0475
2022*	0.0772	0.0053	0.0052	0.00067	0.0593

** Included emissions of new category – UNDETERMINED.*

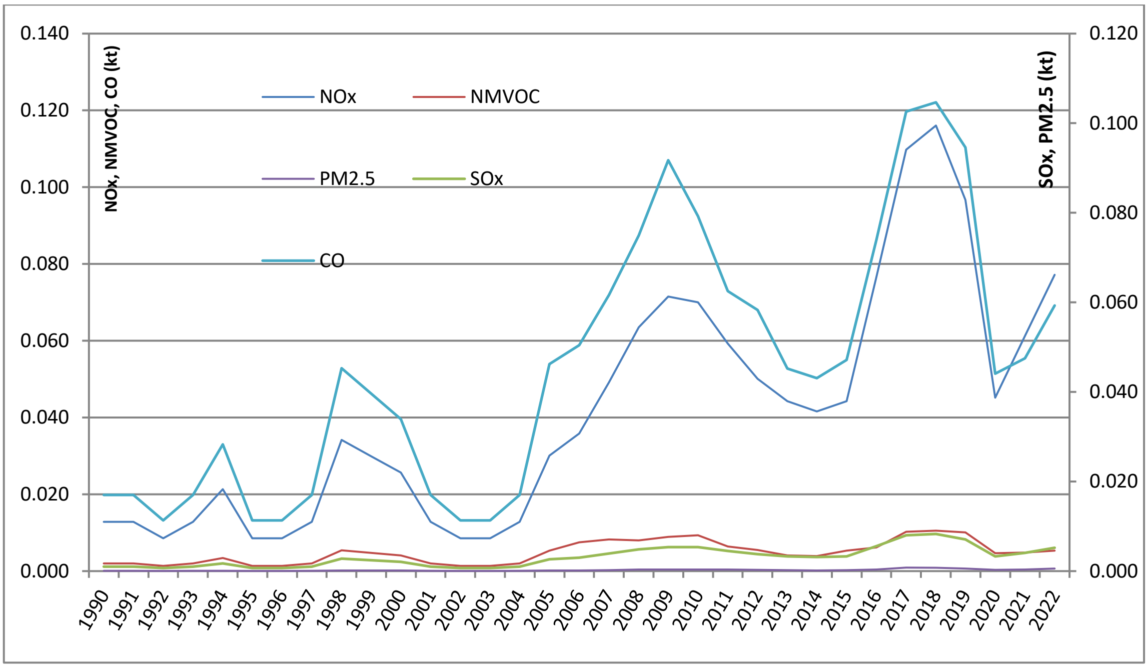


Figure 3.12.2. Emissions trends (kt), NFR 1.A.3.a.ii(i) - Domestic aviation LTO (civil)

There is an oscillating trend in emissions with a peak in 2018, trend directly correlated with fuel consumption. In 2022, compared to 2021, emissions from aviation increased by an average of 26% for NOx, SOx, CO and 64% for $PM_{2.5}$.

3.13 NFR 1.A.3.b Road transport

This sector includes emissions from road transport from Passenger Cars (1.A.3.b.i), Light Duty Vehicles (1.A.3.b.ii), Heavy Duty Vehicles and Busses (1.A.3.b.iii), Mopeds and Motorcycles (1.A.3.b.iv), as well as emissions from Gasoline Evaporation (1.A.3.b.v), Automobile tyre and brake wear (1.A.3.b.vi), and Automobile road abrasion (1.A.3.b.vii).

An overview of pollutants reported and the emission factors for 1A3b is given in Table 3.13.

Table 3.13 Pollutants and Emission factors for 1A3b

NFR	Pollutants Reported	Emission Factor tier and source
1A3bi Road transport: Passenger cars	NOx, NMVOC, NH3, PM2.5, PM10, TSP, BC, CO, Pb, PAHs for period 1990-2004 SO2 for period 1990-2004 All CLRTAP pollutants since 2005	Linear regression between T1 - EMEP EEA guidebook (2019) factors and T3 – COPERT version 5.7.3 factors T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.7.3 factors
1A3bii Road transport: Light duty vehicles	NOx, NMVOC, NH3, PM2.5, PM10, TSP, BC, CO, Pb, PAHs for period 1990-2004 SO2 for period 1990-2004 All CLRTAP pollutants since 2005	Linear regression between T1 - EMEP EEA guidebook (2019) factors and T3 – COPERT version 5.7.3 factors T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.7.3 factors
1A3biii Road transport: Heavy duty vehicles and buses	NOx, NMVOC, NH3, PM2.5, PM10, TSP, BC, CO, Pb, PAHs for period 1990-2004 SO2 for period 1990-2004 All CLRTAP pollutants since 2005	Linear regression between T1 - EMEP EEA guidebook (2019) factors and T3 – COPERT version 5.7.3 factors T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.7.3 factors
1A3biv Road transport: Mopeds & motorcycles	NOx, NMVOC, NH3, PM2.5, PM10, TSP, BC, CO, Pb, PAHs for period 1990-2004 SO2 for period 1990-2004 All CLRTAP pollutants since 2005	Linear regression between T1 - EMEP EEA guidebook (2019) factors and T3 – COPERT version 5.7.3 factors T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.7.3 factors
1A3bv Road transport: Gasoline evaporation	NMVOC for period 1990-2004 NMVOC since 2005	T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.7.3 factors
1A3bvi Road transport: Automobile tyre and brake wear	PM2.5, PM10, TSP for period 1990-2004 PM2.5, PM10, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn since 2005	T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.7.3 factors
1A3bvii Road transport: Automobile road abrasion	PM2.5, PM10, TSP for period 1990-2004 PM2.5, PM10, TSP, BC since 2005	T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.7.3 factors

Road transport contributed mainly to the national total in 2022 with 44.22% for NOx, 8.39% for NMVOC, 17.25% for BC, 12.74% for CO, 22.51% for Pb, 26.80 % for Cr, 93.25% for Cu and 19.43% for Zn.

Table 3.13.1. Share of emissions (%) from 1A3b in the national total in 2022

Pollutant	1A3bi	1A3bii	1A3biii	1A3biv	1A3bv	1A3bvi	1A3bvii	1A3b
NOx	16.45%	6.49%	21.24%	0.04%				44.22%
NMVOC	3.75%	0.79%	1.14%	0.27%	2.44%			8.39%
SOx	0.14%	0.04%	0.09%	0.00%				0.27%
NH_3	0.54%	0.04%	0.05%	0.00%				0.63%
$PM_{2.5}$	1.08%	0.52%	1.01%	0.01%		1.09%	0.49%	4.20%

PM_{10}	0.81%	0.39%	0.76%	0.01%		1.61%	0.69%	4.26%
TSP	0.59%	0.28%	0.55%	0.01%		1.47%	1.00%	3.90%
BC	7.03%	3.22%	4.82%	0.02%		2.00%	0.16%	17.25%
CO	9.06%	1.96%	1.35%	0.37%				12.74%
Pb	0.01%	0.00%	0.00%	0.00%		22.50%		22.51%
Cd	0.01%	0.00%	0.00%	0.00%		1.34%		1.35%
Hg	1.52%	0.34%	0.79%	0.01%				2.66%
As	0.02%	0.00%	0.01%	0.00%		3.27%		3.30%
Cr	0.21%	0.06%	0.15%	0.00%		26.37%		26.80%
Cu	0.02%	0.01%	0.02%	0.00%		93.20%		93.25%
Ni	0.03%	0.00%	0.00%	0.00%		4.55%		4.59%
Se	0.01%	0.00%	0.00%	0.00%		0.91%		0.92%
Zn	0.07%	0.01%	0.03%	0.00%		19.31%		19.43%
PCDD/PCDF	0.96%	0.22%	0.21%	0.00%				1.39%
Total PAH	0.57%	0.14%	0.29%	0.00%				1.01%
HCB	0.06%	0.01%	0.01%	0.00%				0.08%
PCBs	0.00%	0.00%	0.00%	0.00%				0.00%

Note – Only two decimals are displayed in the table.

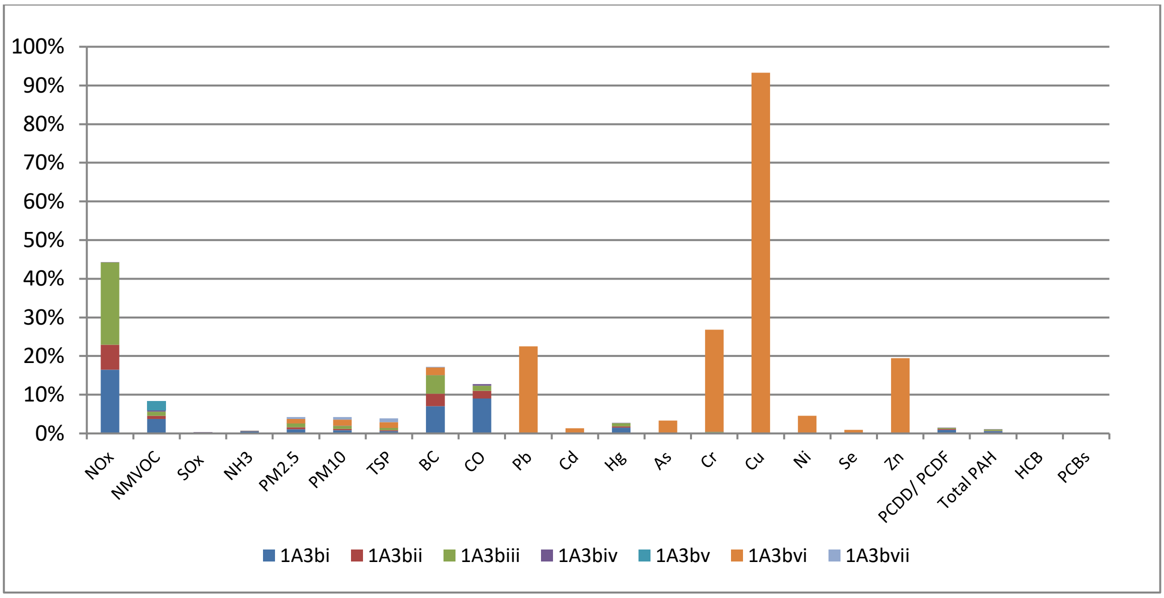


Figure 3.13.1 Share of emissions (%) from 1A3b in the national total in 2022

In 2022, the key sources from road transport are:

- NFR 1A3bi - Road transport: Passenger cars, for NOx, NMVOC, BC and CO;
- NFR 1A3bii - Road transport: Light duty vehicles, for NOx;
- NFR 1A3biii - Road transport: Heavy duty vehicles and buses, for NOx and BC;
- NFR 1A3bv – Road transport: Gasoline evaporation, for NMVOC
- NFR 1A3vi - Road transport: Automobile tyre and brake wear, for Pb, Cr, Cu, Ni and Zn.

Table 3.13.2. Share of 1A3b - Road transport emissions by key categories pollutants in the national total in 2022 (%)

NFR/Pollutant	NOx	NMVOC	BC	CO	Pb	Cr	Cu	Ni	Zn
1A3bi Road transport: Passenger cars	16.5%	3.8%	7.0%	9.1%					
1A3bii Road transport: Light duty vehicles	6.5%								
1A3biii Road transport: Heavy duty vehicles and buses	21.2%		4.8%						
1A3bv Road transport: Gasoline evaporation		2.4%							
1A3bvi Road transport: Automobile tyre and brake wear					22.5%	26.4%	93.2%	4.5%	19.3%
Total	44.2%	6.2%	11.8%	9.1%	22.5%	26.4%	93.2%	4.5%	19.3%

Details on calculations and trends are given in the following section.

For the period 1990-2004:

Due to lack of detailed data for this period, emissions were not calculated with COPERT.

Emissions from NFR 1.A.3.b.i to NFR 1.A.3.b.iv were estimated based on fuel consumption data from Romania CRF report, for each category of main vehicles (Passenger cars, Light duty vehicles, Heavy duty vehicles and Buses, Mopeds & Motorcycles). Emission factors for pollutants, with the exception of SO_2, have been calculated by applying a linear regression between the maximum emission factors (Tier 1) from 2019 EMEP/EEA Guidebook for year 1990 and the emission factors from COPERT 5.7.3 (Tier 3) for year 2005 (recommendation RO-1A3b-2021-0001).

The emissions of SO_2 per fuel-type are estimated by assuming that all sulphur in the fuel is transformed completely into SO_2, using the formula from 2019 EMEP/EEA Guidebook, chapter 1.A.3.b.i-iv, page 22.

To estimate the SO_2 emissions, the sulphur content of the fuel from table 3-14 was used for 1990-1999 period and national values for 2000-2005 period (150 ppm for petrol, respectively 350 ppm for diesel).

Emissions from NFR 1.A.3.b.v were estimated based on the numbers of gasoline fuelled vehicles in each category from Romania CRF report, the national daily temperature range and the default Tier 1 emission factors (2019 EMEP/EEA Guidebook, chapter 1.A.3.b.v, Tables 3.1 to 3.4).

Emissions from NFR 1.A.3.b.vi and 1.A.3.b.vii were estimated based on the numbers of vehicles in each category, the average mileage driven per vehicle in each category from Romania CRF report and the default Tier 1 emission factors (2019 EMEP/EEA Guidebook, chapter 1.A.3.b.vi-vii, Tables 3.1 to 3.2).

For the period 2005-2022:

For the period 2005-2022 the emissions were estimated with COPERT version 5.7.3.

Input data for COPERT have been provided by National Institute of Statistics (NIS), for fuel consumption from Energy Balance/EUROSTAT ENERGY Questionnaires, Romanian Automobile Registry (RAR), for fleet data and National Meteorological Administration, for maximum and minimum temperatures and relative humidity.

The fuel consumption from Romania's Energy Balance was converted into energy consumption (TJ), using the net calorific power provided by the NIS.

Emissions were calculated by inputting detailed vehicle fleet data classified by sector, sub-sector and technology, vehicle stock and annual mileage, speed and driving shares, trip length, trip duration, data collected through monitoring systems traffic (video cameras located on public roads provided by the Romanian Police) and through field surveys (performed by RAR partners).

The average travel distance of 12.1 km was used for vehicles (other than heavy vehicles and buses) based on the results of previous research conducted by the RAR. For heavy vehicles and buses the average travel distance from COPERT was used. Travel time of 25 minutes was taken into account.

National values for fuel sulphur content are used to estimate SO_2 emissions.

The sulphur content of the fuel are given in the table below.

Table 3.13.3. Sulphur content of fuel (1 ppm = 10-6 g/g fuel)

Fuel/Year	2005 - 2006	2007 - 2008	≥ 2009
Petrol	150 ppm	50 ppm	10 ppm
Diesel	350 ppm	50 ppm	10 ppm

Default COPERT heavy metals contents have been taken into account for emission estimates.

Data on maximum and minimum temperatures and relative humidity for each month are provided by the National Meteorological Administration, for 41 regions in Romania and are calculated as an arithmetic average.

Information on the source sectors including the condensable component of PM10 and PM2.5 is provided by the 2019 EMEP/EEA Guidebook, chapter 1.A.3.bi-iv: "… at a temperature lower than 52ºC. At this temperature, PM contains a large fraction of condensable species. Hence, PM mass emission factors in this chapter are considered to include both filterable and condensable material."

The fleet evolution and the fuel consumption per fuel type, for Road Transport 1.A.3.b, are shown in the tables and figures below.

Table 3.13.4. Fleet evolution (number of vehicles)

Year/ number of vehicles	Passenger Cars – Gasoline+ LPG	Passenger Cars – Diesel	Light duty vehicles - Gasoline	Light duty vehicles - Diesel	Heavy duty vehicles - Gasoline	Heavy duty vehicles and buses - Diesel	Mopeds & motorcycles - Gasoline
1990	1163055	129228	78864	91933	-	375824	311646
1991	1288409	143157	81471	97022	-	392875	315479
1992	1433726	159303	87131	102796	-	409138	322756
1993	1613749	179305	93563	109118	-	430348	326505
1994	1818015	202002	101463	117387	-	456580	325701
1995	1977729	219748	113652	127921	-	474837	327724
1996	2093559	232618	123126	136214	-	489510	254996
1997	2202378	244709	132559	142987	-	501382	250510
1998	2335114	259457	147970	153983	-	517112	245719
1999	2431864	270207	163646	165695	-	534542	242583
2000	2499835	277759	169692	169090	-	533941	239208
2001	2593072	288119	175049	170185	-	528059	237901
2002	2676051	297339	170720	161234	-	477555	238480
2003	2778865	308763	183168	175032	-	517104	235850
2004	2902830	322537	197097	177804	-	495394	234702
2005	2577574	531086	155951	188506	2958	217808	42281
2006	2753270	735042	165721	232966	2988	239358	56848
2007	2865048	878212	159836	262753	993	275852	91591
2008	3109937	1120927	160997	305222	991	293753	126907
2009	3224375	1229908	159311	322429	967	1475	142075
2010	3197552	1321954	151099	331007	968	291210	148001
2011	3174988	1374744	145355	358752	951	295685	157328
2012	3253328	1479473	141386	397814	947	303454	149815
2013	3356558	1605702	137555	436478	934	310619	176288
2014	3460973	1741099	134074	475379	931	322269	184261
2015	3564137	1905592	130674	515391	949	339095	191307
2016	3693451	2119555	127149	561171	949	355718	199645
2017	3875064	2515792	124036	607344	950	371599	209330
2018	3915218	2890563	120345	658713	951	386418	211120
2019	4039798	3230053	117230	707833	949	400223	225028
2020	4096596	3512068	115404	752814	958	410308	235752
2021	4154402	3767903	114190	800413	805	422198	249760
2022	4195489	3946451	111224	825453	805	431982	267312

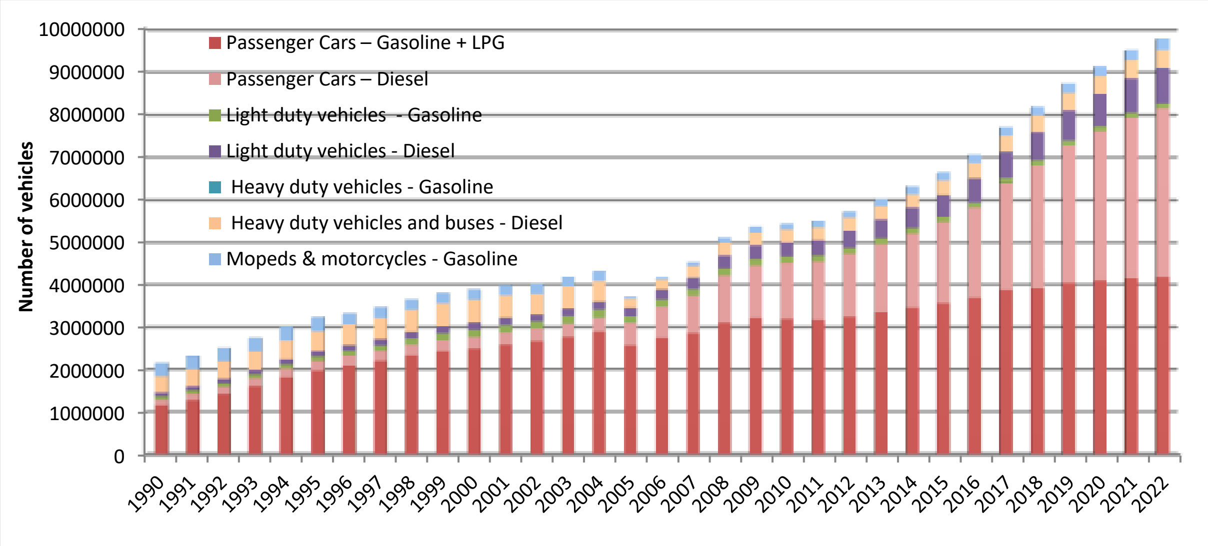


Figure 3.13.2. Fleet evolution (number of vehicles)

Compared to 2005 data, in 2022 the number of vehicles increased by 643% for diesel cars, 532% for gasoline mopeds and motorcycles, 338% for light diesel vehicles and 98% for heavy diesel vehicles and buses.

Table 3.13.5. Fuel consumption per fuel type (TJ), for Road Transport 1.A.3.b

Year/fuel consumption	Gasoline	Diesel	LPG	Biomass
1990	90429	49216	-	-
1991	75712	38842	-	-
1992	50446	58648	-	-
1993	44846	50294	-	-
1994	50811	52796		-
1995	43876	50931	-	-
1996	57299	80785	-	-
1997	61911	70565	-	-
1998	61386	68953	-	-
1999	52152	54578	-	-
2000	53533	58225	-	-
2001	68568	75357	-	-
2002	66873	80403	144	
2003	68004	91005	337	
2004	70431	91938	3947	
2005	66980	90387	2311	
2006	62585	102735	770	
2007	63301	101802	1540	1693
2008	63201	123146	2118	2061
2009	62686	127560	3129	1690
2010	59130	122849	818	4768
2011	56345	129087	3466	7776
2012	55736	140502	2407	7268
2013	53082	138762	2214	6380

Year/fuel consumption	Gasoline	Diesel	LPG	Biomass
2014	56694	143261	2455	5532
2015	53126	147377	2647	6584
2016	55519	159556	3129	10285
2017	55813	172900	3773	11434
2018	55279	180528	3924	12231
2019	55364	184630	4129	15417
2020	51676	182914	3704	18031
2021	55125	193743	3741	16734
2022	56482	214357	3721	16684

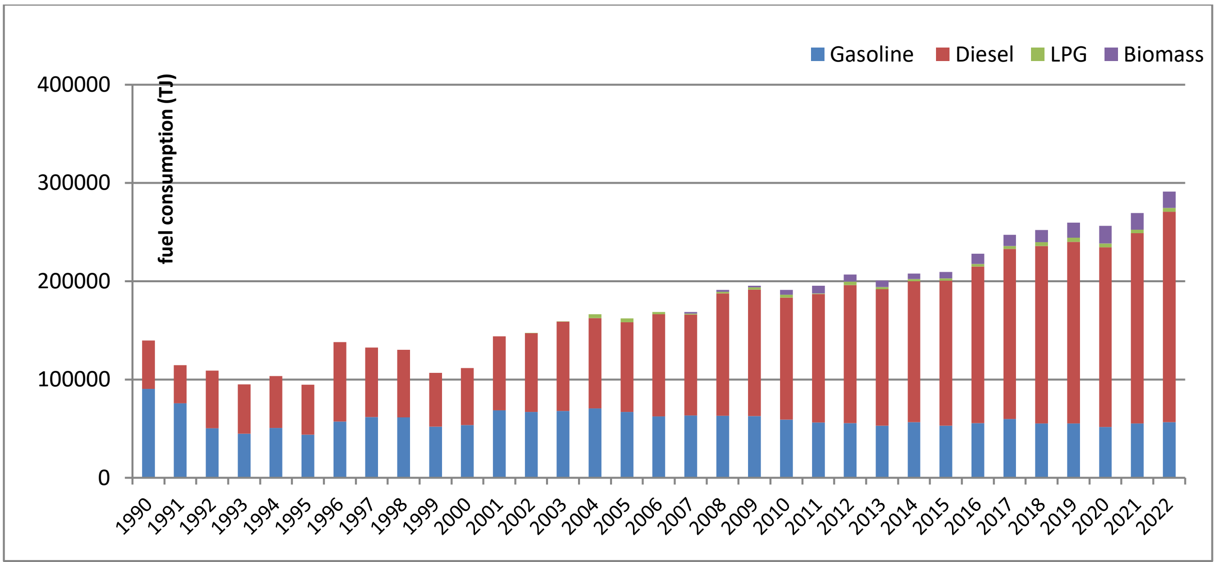


Figure 3.13.3. Fuel consumption (TJ), for Road Transport 1.A.3.b

NFR 1.A.3.b.i, 1.A.3.b.ii and 1.A.3.b.iii are key source for emissions of NOx in 2022.

Table 3.13.6. NOx (kt) emissions for Road Transport 1.A.3.b by NFR

Year/NOx (kt)	1A3bi	1A3bii	1A3biii	1A3biv
1990	59.421	4.192	38.209	0.235
1991	48.024	3.927	30.096	0.228
1992	31.586	4.049	44.718	0.223
1993	27.249	3.773	37.872	0.215
1994	30.313	4.429	38.915	0.205
1995	25.037	4.208	38.299	0.196
1996	33.579	5.399	59.908	0.145
1997	34.988	5.276	52.480	0.135
1998	33.604	5.557	50.867	0.124
1999	27.198	5.120	40.091	0.115
2000	27.111	5.485	42.619	0.106
2001	35.179	6.212	54.413	0.098
2002	34.138	6.367	56.626	0.092
2003	33.945	6.949	64.580	0.083

Year/NOx (kt)	1A3bi	1A3bii	1A3biii	1A3biv
2004	35.587	6.358	68.695	0.076
2005	34.716	9.060	52.448	0.017
2006	31.902	9.227	54.536	0.023
2007	29.173	8.395	50.650	0.040
2008	28.827	8.904	55.566	0.048
2009	28.815	8.891	54.618	0.052
2010	25.837	8.366	51.488	0.053
2011	25.908	8.893	53.345	0.054
2012	25.790	9.701	54.718	0.047
2013	24.522	9.630	51.328	0.057
2014	25.250	10.092	50.028	0.061
2015	24.672	10.244	48.672	0.059
2016	26.222	11.214	49.986	0.062
2017	28.248	11.737	49.797	0.076
2018	29.012	12.002	48.174	0.089
2019	28.727	12.260	44.177	0.083
2020	29.378	11.169	42.781	0.072
2021	30.913	12.016	41.353	0.075
2022	33.381	13.164	43.100	0.079

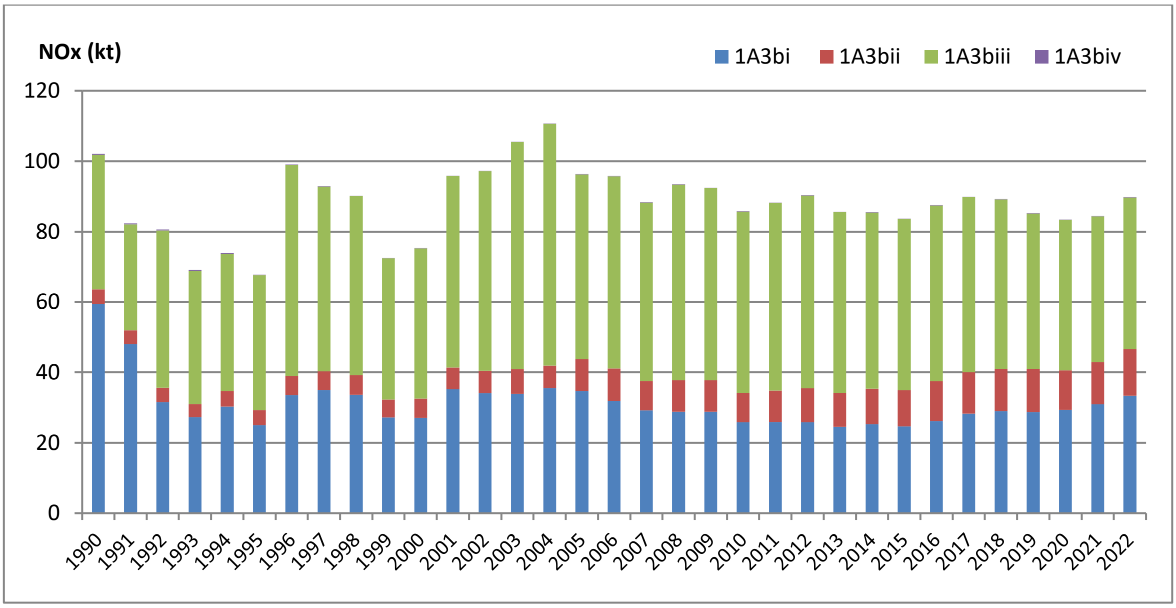


Figure 3.13.4. NOx emissions trend (kt) for Road Transport 1.A.3.b by NFR

NFR 1.A.3.b.i and 1.A.3.b.v are key source for emissions of NMVOC in 2022.

Table 3.13.7. NMVOC (kt) emissions for Road Transport 1.A.3.b by NFR

Year/NMVOC (kt)	1A3bi	1A3bii	1A3biii	1A3biv	1A3bv
1990	67.326	2.905	3.762	7.983	3.919
1991	54.285	2.957	2.973	7.799	4.270
1992	34.673	2.483	4.432	7.707	4.694
1993	29.687	2.450	3.766	7.504	5.207
1994	33.099	2.645	3.882	7.215	5.785

Year/NMVOC (kt)	1A3bi	1A3bii	1A3biii	1A3biv	1A3bv
1995	27.101	2.784	3.833	6.995	6.267
1996	35.691	3.091	6.016	5.213	6.505
1997	37.620	3.210	5.287	4.916	6.829
1998	35.941	3.460	5.141	4.613	7.241
1999	29.148	3.277	4.065	4.343	7.562
2000	28.733	3.626	4.336	4.080	7.764
2001	37.003	3.758	5.553	3.856	8.033
2002	35.153	3.664	5.798	3.669	8.237
2003	34.682	3.798	6.634	3.425	8.561
2004	36.259	3.675	7.080	3.208	8.949
2005	32.166	4.490	5.520	0.760	8.279
2006	27.300	4.044	5.473	0.721	8.389
2007	22.742	3.348	5.111	0.581	8.908
2008	20.119	3.102	5.092	0.642	7.648
2009	18.169	2.792	4.729	0.657	7.898
2010	14.985	2.488	4.290	0.655	6.498
2011	13.975	2.384	4.213	0.649	6.572
2012	12.604	2.311	4.083	0.545	7.117
2013	11.245	2.112	3.689	0.534	5.868
2014	11.066	2.094	3.470	0.607	5.597
2015	9.961	1.946	3.269	0.576	5.909
2016	10.168	2.033	3.284	0.591	5.667
2017	9.943	2.021	3.202	0.715	5.709
2018	9.110	1.920	3.040	0.730	5.789
2019	8.591	1.741	2.653	0.769	5.671
2020	8.303	1.681	2.570	0.574	5.534
2021	9.735	1.957	2.504	0.637	3.071
2022	8.828	1.853	2.672	0.641	5.750

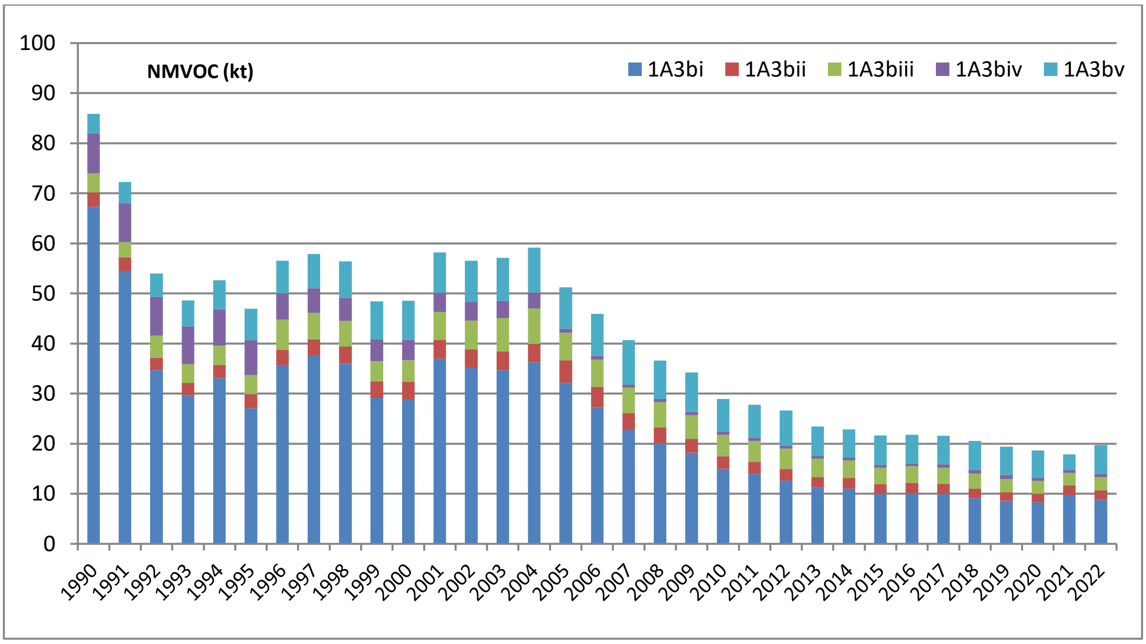


Figure 3.13.5. NMVOC emissions trend (kt) for Road Transport 1.A.3.b by NFR

NFR 1.A.3.b.i and 1.A.3.b.iii are key source for emissions of BC in 2022.

Table 3.13.8. BC (kt) emissions for Road Transport 1.A.3.b by NFR

Year/BC (kt)	1A3bi	1A3bii	1A3biii	1A3biv	1A3bvi	1A3bvii
1990	0.1268	0.1352	0.8303	0.0145	NE	NE
1991	0.1038	0.1024	0.6517	0.0144	NE	NE
1992	0.1690	0.1593	0.9648	0.0146	NE	NE
1993	0.1618	0.1338	0.8141	0.0145	NE	NE
1994	0.1633	0.1781	0.8334	0.0143	NE	NE
1995	0.1520	0.1410	0.8172	0.0142	NE	NE
1996	0.2621	0.2263	1.2735	0.0109	NE	NE
1997	0.2161	0.2004	1.1114	0.0105	NE	NE
1998	0.2160	0.2008	1.0732	0.0102	NE	NE
1999	0.1589	0.1740	0.8427	0.0099	NE	NE
2000	0.1817	0.1725	0.8924	0.0096	NE	NE
2001	0.2512	0.2274	1.1350	0.0094	NE	NE
2002	0.3042	0.2490	1.1766	0.0093	NE	NE
2003	0.3112	0.2888	1.3367	0.0090	NE	NE
2004	0.2352	0.2406	1.4163	0.0088	NE	NE
2005	0.5796	0.4149	1.0744	0.0022	0.1334	0.0107
2006	0.6529	0.4474	1.0985	0.0021	0.1403	0.0113
2007	0.5485	0.3769	0.9986	0.0019	0.1457	0.0118
2008	0.6818	0.4226	1.0356	0.0020	0.1640	0.0134
2009	0.7143	0.4241	0.9865	0.0021	0.1704	0.0138
2010	0.6988	0.4010	0.9122	0.0022	0.1654	0.0134
2011	0.7281	0.4369	0.9200	0.0022	0.1743	0.0142
2012	0.7615	0.4772	0.9177	0.0017	0.1814	0.0150
2013	0.7268	0.4642	0.8428	0.0014	0.1776	0.0146
2014	0.7236	0.4778	0.8063	0.0019	0.1830	0.0151
2015	0.7150	0.4795	0.7698	0.0018	0.1845	0.0153
2016	0.7691	0.5183	0.7785	0.0019	0.2010	0.0166
2017	0.8673	0.5371	0.7648	0.0023	0.2141	0.0176
2018	0.8941	0.5266	0.7307	0.0023	0.2230	0.0181
2019	0.8441	0.4586	0.6367	0.0024	0.2315	0.0188
2020	0.8151	0.3772	0.6184	0.0018	0.2277	0.0184
2021	0.9101	0.4231	0.5999	0.0020	0.2364	0.0191
2022	0.9107	0.4176	0.6245	0.0021	0.2586	0.0208

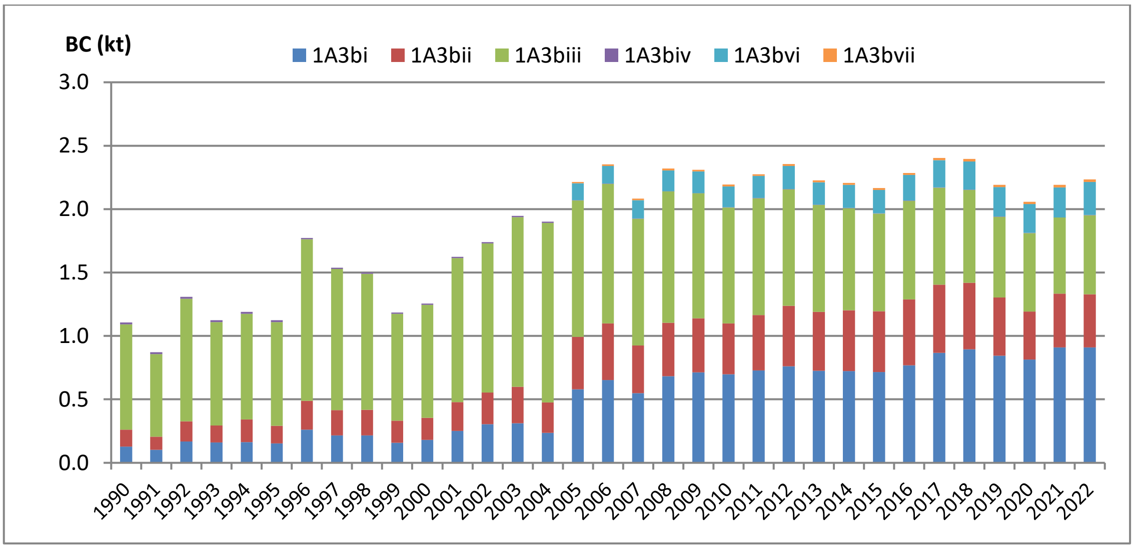


Figure 3.13.6. BC emissions trend (kt) for Road Transport 1.A.3.b by NFR

NFR 1.A.3.b.i is key source for emissions of CO in 2022.

Table 3.13.9. CO (kt) emissions for Road Transport 1.A.3.b by NFR

Year/CO (kt)	1A3bi	1A3bii	1A3biii	1A3biv
1990	526.638	26.033	10.548	14.541
1991	427.632	26.917	8.333	14.524
1992	274.686	22.551	12.420	14.690
1993	236.904	22.600	10.550	14.655
1994	266.292	24.524	10.874	14.454
1995	219.743	26.337	10.734	14.395
1996	291.560	29.248	16.841	11.036
1997	310.343	30.928	14.797	10.721
1998	299.184	33.865	14.386	10.383
1999	245.062	32.605	11.372	10.108
2000	243.874	36.714	12.126	9.838
2001	317.262	38.298	15.528	9.655
2002	304.106	37.717	16.208	9.568
2003	303.089	39.492	18.540	9.324
2004	315.227	39.125	19.781	9.148
2005	283.074	47.636	15.227	2.280
2006	242.311	42.431	15.705	2.300
2007	196.300	35.159	14.675	2.315
2008	173.968	32.342	15.630	2.570
2009	155.244	28.507	15.072	2.695
2010	130.396	24.933	14.081	2.744
2011	119.114	23.239	14.453	2.735
2012	109.389	22.118	14.809	2.088
2013	98.600	19.803	13.899	2.526
2014	98.278	19.697	13.571	2.831
2015	88.686	17.912	13.235	2.703
2016	91.016	18.548	13.623	2.817
2017	89.375	18.243	13.581	3.336
2018	82.416	17.018	13.153	3.635
2019	78.211	15.503	12.373	3.858
2020	75.525	15.799	12.036	3.121
2021	89.747	18.760	11.509	3.267
2022	81.120	17.580	12.074	3.351

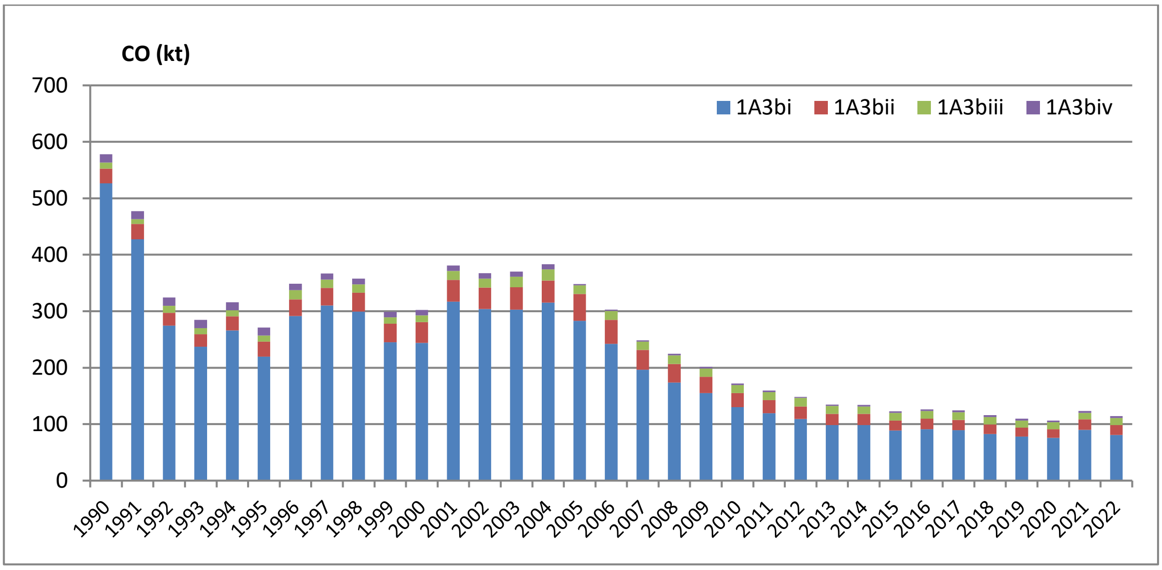


Figure 3.13.7. CO emissions trend (kt) for Road Transport 1.A.3.b by NFR

NFR 1.A.3.b.vi is key source for emissions of Pb, Cr, Cu, Ni and Zn in 2022. These emissions are estimate for the 2005-2022 period.
For the other NFRs of road transport, these emissions are not significant.

Table 3.13.10. Pb, Cr, Cu, Ni and Zn (t) emissions for NFR 1.A.3.b.vi Road transport: Automobile tyre and brake wear

Year/A.3.b.vi	Pb (t)	Cr (t)	Cu (t)	Ni (t)	Zn (t)
2005	5.271	1.975	43.415	0.299	12.754
2006	5.517	2.067	45.436	0.313	13.385
2007	5.715	2.141	47.069	0.324	13.883
2008	6.364	2.383	52.392	0.361	15.541
2009	6.548	2.452	53.895	0.372	16.066
2010	6.311	2.363	51.935	0.358	15.541
2011	6.620	2.478	54.473	0.376	16.341
2012	6.755	2.528	55.557	0.384	16.841
2013	6.595	2.468	54.236	0.375	16.465
2014	6.669	2.494	54.812	0.380	16.810
2015	6.657	2.489	54.694	0.379	16.866
2016	7.224	2.701	59.352	0.412	18.338
2017	7.676	2.870	63.059	0.438	19.513
2018	8.010	2.995	65.803	0.457	20.342
2019	8.257	3.087	67.823	0.471	21.046
2020	8.099	3.028	66.521	0.462	20.672
2021	8.366	3.127	68.697	0.477	21.412
2022	9.156	3.423	75.190	0.522	23.425

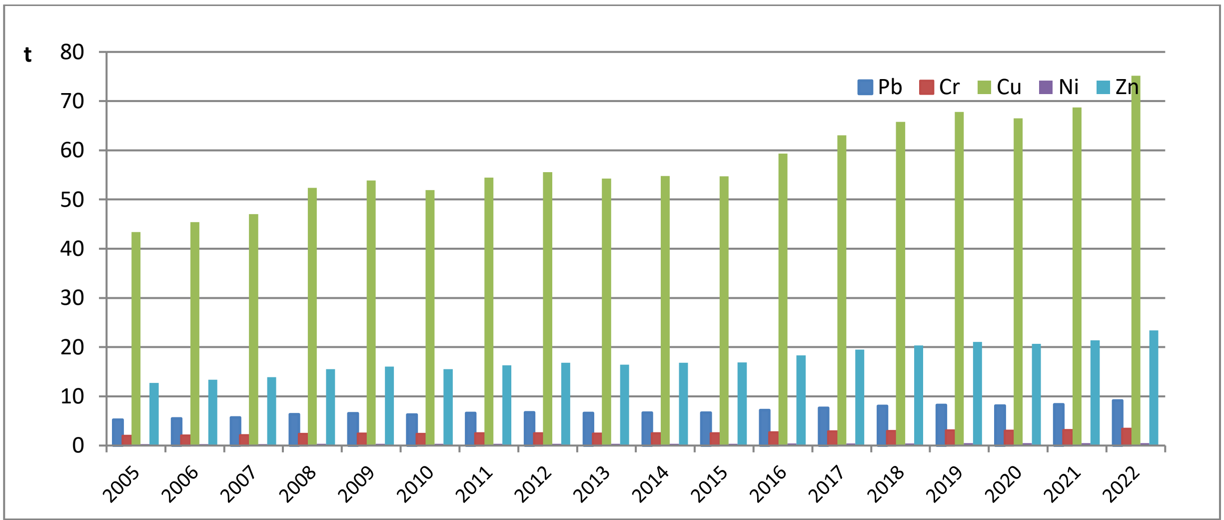


Figure 3.13.8. Pb, Cr, Cu, Ni and Zn (t) emissions for NFR 1.A.3.b.vi Road transport: Automobile tyre and brake wear

The trend of SO_2 emissions for 1990-2022 is shown in the table below.

Table 3.13.11. SO_2 (kt) emissions for Road Transport 1.A.3.b by NFR

Year/SOx (kt)	1A3bi	1A3bii	1A3biii	1A3biv
1990	0.7065	0.1004	0.7983	0.0072
1991	0.5820	0.0869	0.6294	0.0073
1992	0.4338	0.1093	0.9361	0.0075

Year/SOx (kt)	1A3bi	1A3bii	1A3biii	1A3biv
1993	0.3879	0.0979	0.7935	0.0075
1994	0.4318	0.1237	0.8162	0.0075
1995	0.3709	0.1090	0.8040	0.0076
1996	0.5327	0.1578	1.2589	0.0059
1997	0.5396	0.1487	1.1039	0.0058
1998	0.5320	0.1549	1.0710	0.0057
1999	0.4318	0.1406	0.8449	0.0056
2000	0.4055	0.1310	0.7867	0.0050
2001	0.5432	0.1605	1.0054	0.0050
2002	0.5613	0.1719	1.0473	0.0050
2003	0.5718	0.1956	1.1955	0.0050
2004	0.5483	0.1738	1.2729	0.0049
2005	0.7024	0.2745	0.9719	0.0012
2006	0.7754	0.3088	1.0377	0.0014
2007	0.1852	0.0531	0.1449	0.0006
2008	0.2076	0.0593	0.1665	0.0007
2009	0.0432	0.0121	0.0333	0.0002
2010	0.0420	0.0112	0.0316	0.0002
2011	0.0419	0.0119	0.0326	0.0002
2012	0.0439	0.0131	0.0346	0.0001
2013	0.0432	0.0131	0.0332	0.0002
2014	0.0459	0.0138	0.0336	0.0002
2015	0.0454	0.0140	0.0342	0.0002
2016	0.0491	0.0152	0.0361	0.0002
2017	0.0537	0.0159	0.0372	0.0002
2018	0.0565	0.0163	0.0374	0.0002
2019	0.0566	0.0161	0.0394	0.0002
2020	0.0567	0.0143	0.0385	0.0002
2021	0.0606	0.0157	0.0400	0.0002
2022	0.0656	0.0173	0.0436	0.0003

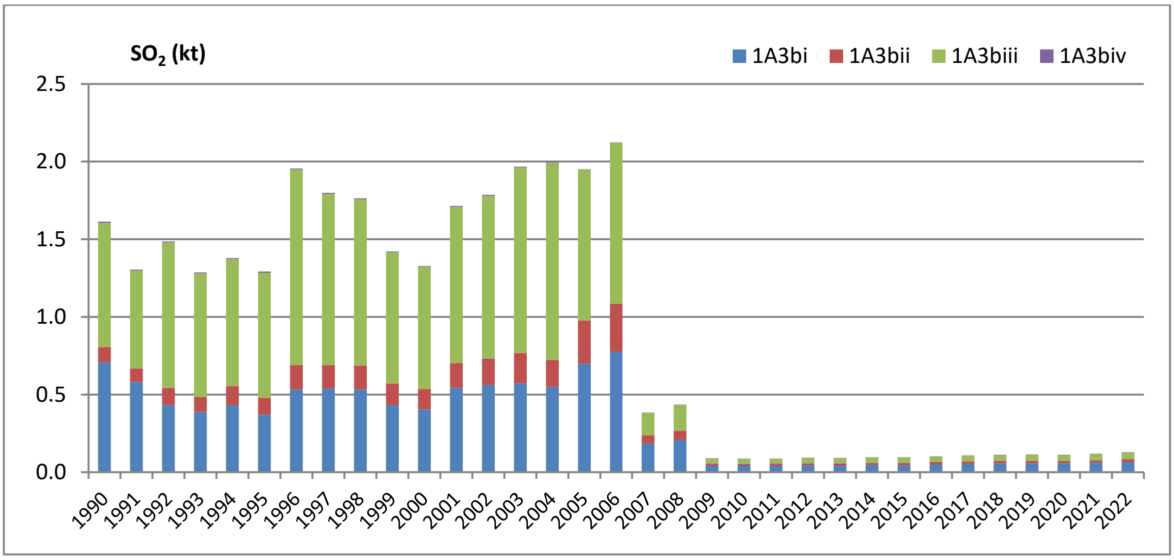


Figure 3.13.9. SO_2 (kt) emissions for NFR 1.A.3.b Road transport

SO_2 emissions have decreased due to increasing stringent fuel quality standards regulating the maximum allowable sulfur content of fuels used in road transport.

Recalculations and improvements:

- For 2005-2021, recalculated using the new version of COPERT (5.7.3);

- For 1991-2004, recalculated NOx (for 1A3bi) and NMVOC, CO (for 1A3bi, 1A3bii) due to slight change of EFs in COPERT 5.7.3.

3.14 NFR 1.A.3.c Railways

This sector covers emissions from rail transport regarding the movement of goods or persons by rail. The emissions arise from combusting the fuel in an internal combustion engine. The emissions for electric locomotives are not estimated here, these are accounted in chapter 1.A.1 Energy industries.

The emissions from railway activities were estimated using the default Tier 1 emission factors from 2019 EMEP/EEA Guidebook, chapter 1.A.3.c, Table 3-1 and the diesel consumption for railways from Energy Balance provided by the N.I.S.

Following TERT recommendation RO-1A3c-2023-0001, in order to develop a Tier 2 method for NOX emissions, the collection of data from private railway operators and the Romanian National Railway Company has begun.

We will present the results or the progress made in our next submission because historical data is difficult to collect and estimate for the entire time series.

Table 3.14 Pollutants and Emission factors for 1.A.3.c

NFR	Pollutants Reported	Emission Factor tier and source
1A3c Railways	CLRTAP pollutants (except Pb, Hg, As, PCDD/F, benzo(k)fluoranthene, Indeno (1,2,3-cd) pyrene,)	T1 - EMEP EEA guidebook (2019) factors

Table 3.14.1.Fuel consumption (t) for NFR 1.A.3.c – Railway

Year	Diesel (t)
1990	133958
1991	116218
1992	315000
1993	309000
1994	276000
1995	279000
1996	286000
1997	285000
1998	246000
1999	201000
2000	287000
2001	143000
2002	192000

Year	Diesel (t)
2003	170000
2004	195000
2005	72000
2006	71000
2007	180000
2008	168000
2009	126000
2010	143000
2011	193000
2012	182000
2013	161000
2014	107000
2015	111000
2016	108000
2017	113870
2018	92581
2019	127425
2020	110182
2021	129004
2022	100803

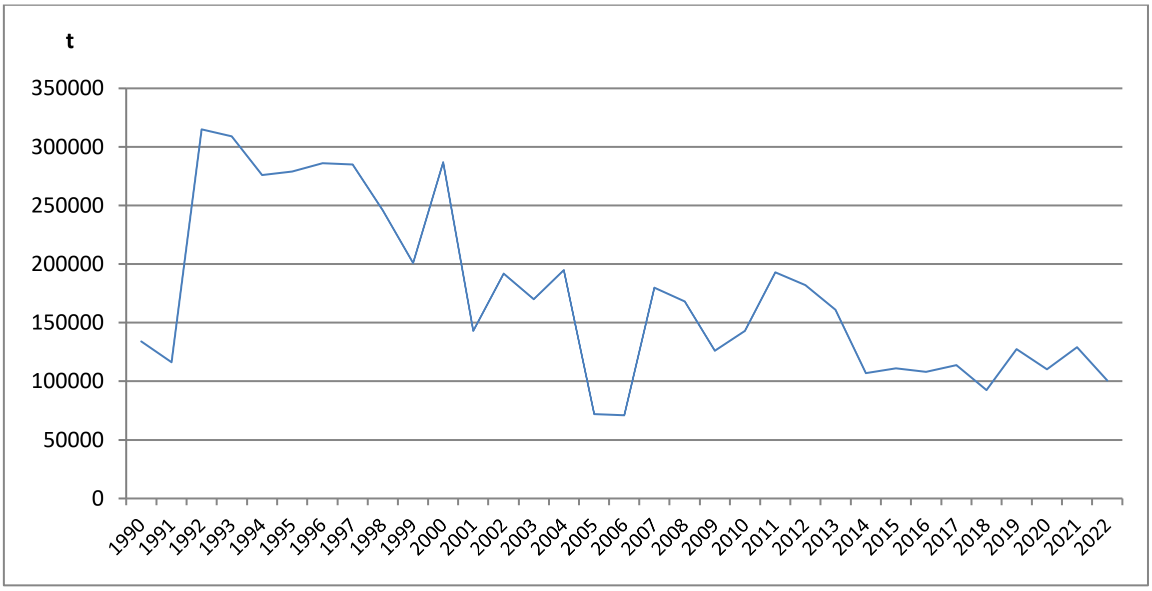


Figure 3.14.1. Fuel consumption (t) for NFR 1.A.3.c – Railway

Diesel consumption for rail transport in the period 1990-2009 shows large fluctuations (maximum 315000t in 1992, minimum 71000t in 2006 and 72000t in 2005), and in the period 2011-2022 it has a decreasing trend (from 193000t in year 2011 to 100803t in year 2022, almost 48 %).

In 2022 NFR 1.A.3.c is a key source for NOx pollutant with 2.6% of the national total.

The emissions trend of the main pollutants, $PM_{2.5}$ and CO from rail transport is shown in the following table and figures.

Table 3.14.2. Emissions trend (kt) of Main Pollutants, $PM_{2.5}$ and CO for NFR 1.A.3.c – Railway

Year/Pollutant	NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	CO
1990	7.019	0.623	0.268	0.001	0.184	1.433
1991	6.090	0.540	0.232	0.001	0.159	1.244
1992	16.506	1.465	0.630	0.002	0.432	3.371
1993	16.192	1.437	0.618	0.002	0.423	3.306
1994	14.462	1.283	0.552	0.002	0.378	2.953
1995	14.620	1.297	0.558	0.002	0.382	2.985
1996	14.986	1.330	0.572	0.002	0.392	3.060
1997	14.934	1.325	0.570	0.002	0.390	3.050
1998	12.890	1.144	0.492	0.002	0.337	2.632
1999	10.532	0.935	0.141	0.001	0.275	2.151
2000	15.039	1.335	0.201	0.002	0.393	3.071
2001	7.493	0.665	0.100	0.001	0.196	1.530
2002	10.061	0.893	0.134	0.001	0.263	2.054
2003	8.908	0.791	0.119	0.001	0.233	1.819
2004	10.218	0.907	0.137	0.001	0.267	2.087
2005	3.773	0.335	0.007	0.001	0.099	0.770
2006	3.720	0.330	0.007	0.000	0.097	0.760
2007	9.432	0.837	0.018	0.001	0.247	1.926
2008	8.803	0.781	0.017	0.001	0.230	1.798
2009	6.602	0.586	0.013	0.001	0.173	1.348
2010	7.493	0.665	0.003	0.001	0.196	1.530
2011	10.113	0.897	0.004	0.001	0.264	2.065
2012	9.537	0.846	0.004	0.001	0.249	1.947
2013	8.436	0.749	0.003	0.001	0.221	1.723
2014	5.607	0.498	0.002	0.001	0.147	1.145
2015	5.816	0.516	0.002	0.001	0.152	1.188
2016	5.659	0.502	0.002	0.001	0.148	1.156
2017	5.967	0.529	0.002	0.001	0.156	1.218
2018	4.851	0.431	0.002	0.001	0.127	0.991
2019	6.677	0.593	0.003	0.001	0.175	1.363
2020	5.774	0.512	0.002	0.001	0.151	1.179
2021	6.760	0.600	0.003	0.001	0.177	1.380
2022	5.282	0.469	0.002	0.001	0.138	1.079

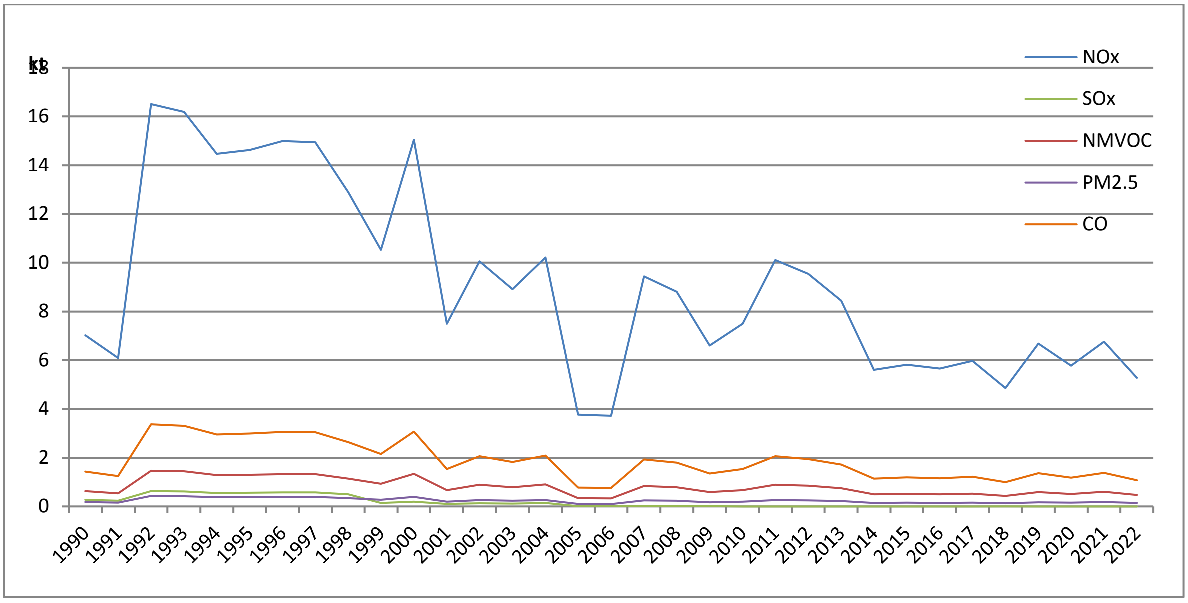


Figure 3.14.2. Emissions trend (kt) of NOx, NMVOC, SOx, $PM_{2.5}$ and CO for NFR 1.A.3.c – Railway

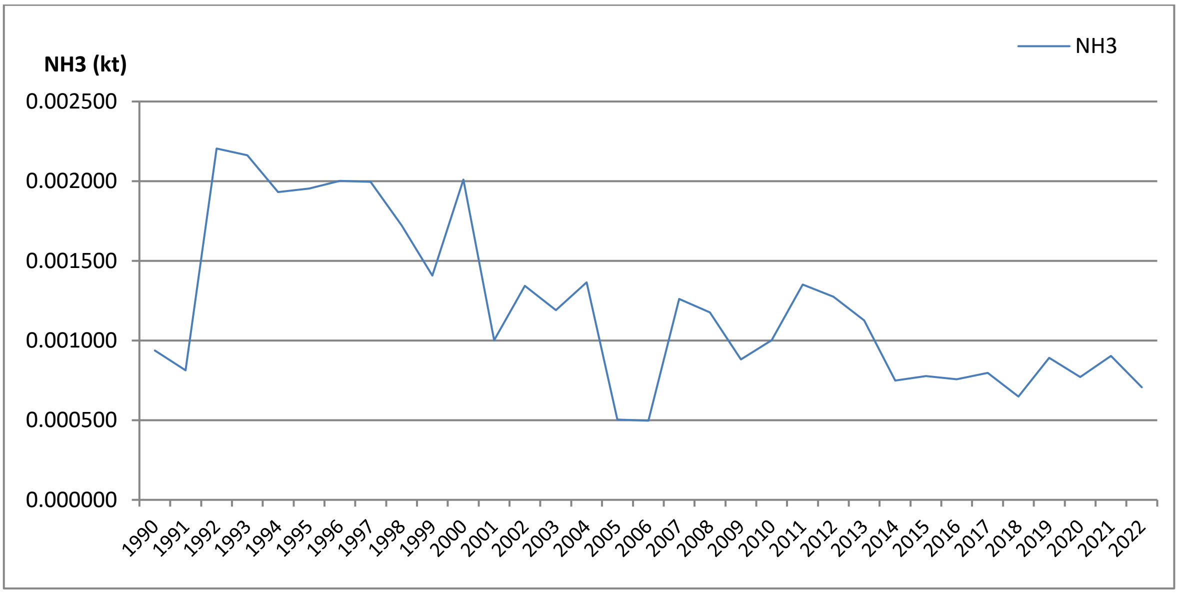


Figure 3.14.3. Emissions trend (kt) of NH_3 for NFR 1.A.3.c – Railway

Emissions trend of pollutants are consistent with the fuel consumption variation. In 2022, 1A3c emissions decreased by 22% compared to 2021.

Recalculations and improvements:

- There were no recalculations and improvements for this category.

3.15 NFR 1.A.3.d. Navigation

In this section the emissions from the following NFR are estimated:

- **1.A.3.d.i(ii) - International inland waterways;**
- **1.A.3.d.ii - National navigation (shipping);**
- **1.A.3.d.i(i) - International maritime navigation – Memo item.**

The navigation sector is not a key source for any pollutant.
An overview of pollutants reported and the emission factors for 1A3d is given in Table 3.15.

Table 3.15 Pollutants and Emission factors for 1A3d

NFR	Pollutants Reported	Emission Factor tier and source
1A3di(ii) International inland waterways	All CLRTAP pollutants (except NH3)	T1 - EMEP EEA guidebook (2023) factors
1A3dii National navigation (shipping)	All CLRTAP pollutants (except NH3)	T1 - EMEP EEA guidebook (2023) factors
1.A.3.d.i(i) International maritime navigation - Memo item	All CLRTAP pollutants (except NH3)	T1 - EMEP EEA guidebook (2023) factors

Emissions from navigation activities were estimated using the default Tier 1 emission factors from 2023 EMEP/EEA Guidebook, chapter 1.A.3.d, Table 3-1 and Table 3-2 and fuel consumption from Energy Balance provided by the National Institute of Statistics (N.I.S.).
There are no emission factors for $PM_{2.5}$ and TSP in this version of this chapter.
In the previous versions of the guidebook, the emission factors for TSP and PM_{10} are the same, and the emission factors for $PM_{2.5}$ are 90% and 93% of those for PM_{10} for fuel oil and marine diesel respectively. In order to estimate these emissions, this was assumed for the emission factors.

Emissions from **1.A.3.d.i(ii) - International inland waterways and 1.A.3.d.i(i) - International maritime navigation - Memo item**, are estimated using international marine bunkers fuel provided by the National Institute of Statistics.

Table 3.15.1. International maritime bunkers (t)

Year	Fuel oil	Marine diesel oil
2007	14000	20000
2008	52000	18000
2009	9000	6000
2010	4000	11000
2011	-	9000
2012	-	14000
2013	-	41000
2014	-	79000
2015	-	44000
2016	-	31000
2017	-	27527
2018	-	17853

Year	Fuel oil	Marine diesel oil
2019	-	33720
2020	-	42498
2021	-	33471
2022	-	16869

In the last submission, emissions from 1.A.3.d.i(ii) are included in 1A3di(i) because the N.I.S. cannot provide separate fuel consumption data for international maritime shipping and international inland waterways.

A technical correction was calculated by TERT during the review of national air pollutant emission inventory 2023 (RO-1A3di(ii)-2023-0001).

The technical correction was calculated using % share of inland waterways vs % share of maritime in total freight transport (tonne - kilometres) from EUROSTAT as proxy data to disaggregate emissions between 1A3di(ii) - International inland waterways and 1A3di(i) - International maritime navigation – Memo item (Modal split of air, sea and inland freight transport - https://ec.europa.eu/eurostat/web/products-datasets/-/tran_hv_ms_frmod).

The share of maritime and inland waterways in total freight transport (%, based on tonne-kilometres), for Romania is shown in the table below.

Table 3.15.2. Share of maritime and inland waterways in total freight transport

Year	SEA,PC,RO (%)	IWW,PC,RO (%)
2008	17.7	20.9
2009	18.5	19.7
2010	19.8	26.6
2011	22.6	20.8
2012	22	22.4
2013	22.8	22
2014	22.9	21.9
2015	19.4	24.1
2016	18.6	23.5
2017	19.6	21.6
2018	21.2	20.9
2019	22.4	21.5
2020	20.6	22.4
2021	19.5	19.8

Based on EUROSTAT data, the percentage share of fuel consumption for international maritime navigation and international waterways was estimated.

Table 3.15.3. Share of fuel consumption for international maritime navigation and international waterways

Year	1A3di(i) %	1A3di(ii)%
2005	45.9	54.1
2006	45.9	54.1
2007	45.9	54.1

Year	1A3di(i) %	1A3di(ii)%
2008	45.9	54.1
2009	48.4	51.6
2010	42.7	57.3
2011	52.1	47.9
2012	49.5	50.5
2013	50.9	49.1
2014	51.1	48.9
2015	44.6	55.4
2016	44.2	55.8
2017	47.6	52.4
2018	50.4	49.6
2019	51.0	49.0
2020	47.9	52.1
2021	49.6	50.4
2022	49.6	50.4

Due to the lack of activity data for 2005-2006, fuel consumption was estimated by interpolation between 1376 TJ for year 1998 and 1461 TJ for year 2007, data from EUROSTAT. The share of fuel consumption for international maritime navigation and international waterways was assumed to be the same for 2005-2007 as for 2008 and for 2021 the same as for 2022.

The emission trends of main pollutants, $PM_{2.5}$ and CO are shown below in the following table and figures.

Table 3.15.4. Emissions trend (kt) of Main Pollutants, $PM_{2.5}$ and CO for 1.A.3.d.i(ii) - International inland waterways

Year/Pollutant (kt)	NOx	NMVOC	SOx	$PM_{2.5}$	CO
2005	1.3439	0.0325	0.2787	0.0476	0.0714
2006	1.3527	0.0327	0.2805	0.0479	0.0719
2007	1.3057	0.0316	0.2707	0.0463	0.0694
2008	2.6492	0.0641	0.8836	0.1415	0.1408
2009	0.5441	0.0132	0.1516	0.0248	0.0289
2010	0.6137	0.0149	0.0172	0.0170	0.0326
2011	0.3114	0.0075	0.0086	0.0043	0.0166
2012	0.5100	0.0124	0.0141	0.0070	0.0271
2013	1.4537	0.0352	0.0403	0.0200	0.0773
2014	2.7882	0.0676	0.0772	0.0384	0.1483
2015	1.7600	0.0427	0.0488	0.0243	0.0936
2016	1.2494	0.0303	0.0346	0.0172	0.0664
2017	1.0420	0.0253	0.0289	0.0144	0.0554
2018	0.6399	0.0155	0.0177	0.0088	0.0340
2019	1.1923	0.0289	0.0330	0.0164	0.0634
2020	1.5984	0.0387	0.0443	0.0220	0.0850
2021	1.2175	0.0295	0.0337	0.0168	0.0648
2022	0.6136	0.0149	0.0170	0.0085	0.0326

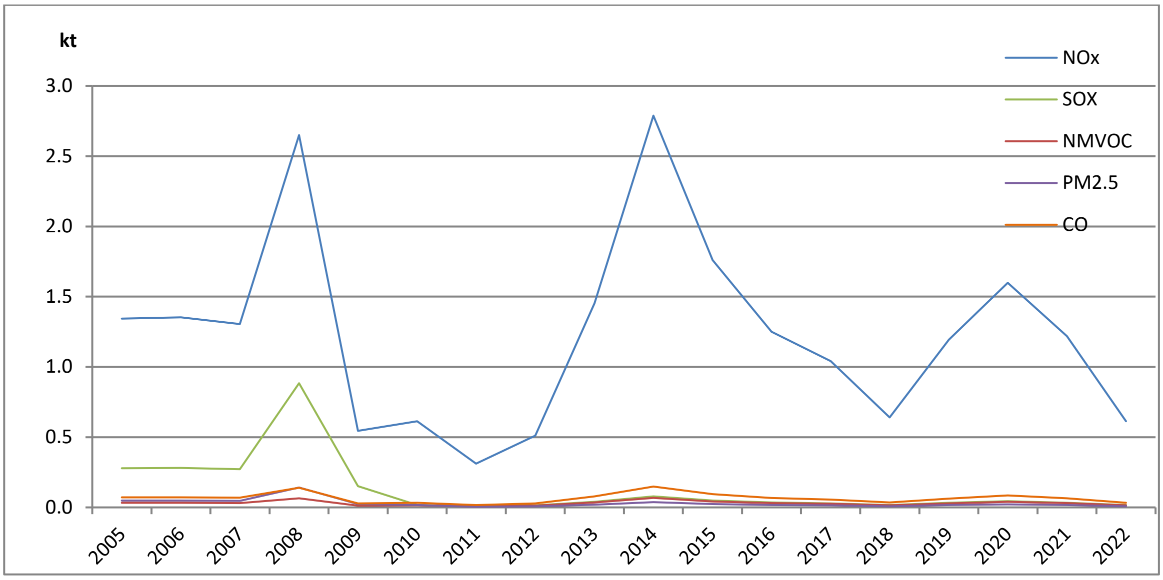


Figure 3.15.1. Emissions trend of Main Pollutants, $PM_{2.5}$ and CO (kt) for 1.A.3.d.i(ii) - International inland waterways

Table 3.15.5. Emissions trend (kt) of Main Pollutants, $PM_{2.5}$ and CO for NFR 1.A.3.d.i(i) - International maritime navigation - Memo item

Year/Pollutant (kt)	NOx	NMVOC	SOx	$PM_{2.5}$	CO
2005	1.1381	0.0276	0.2360	0.0403	0.0605
2006	1.1456	0.0277	0.2375	0.0406	0.0609
2007	1.1057	0.0268	0.2293	0.0392	0.0588
2008	2.2436	0.0543	0.7484	0.1198	0.1192
2009	0.5110	0.0124	0.1424	0.0233	0.0272
2010	0.4569	0.0111	0.0128	0.0127	0.0243
2011	0.3384	0.0082	0.0094	0.0047	0.0180
2012	0.5008	0.0121	0.0139	0.0069	0.0266
2013	1.5065	0.0365	0.0417	0.0208	0.0801
2014	2.9156	0.0707	0.0808	0.0402	0.1551
2015	1.4168	0.0343	0.0392	0.0195	0.0754
2016	0.9888	0.0240	0.0274	0.0136	0.0526
2017	0.9455	0.0229	0.0262	0.0130	0.0503
2018	0.6491	0.0157	0.0180	0.0089	0.0345
2019	1.2422	0.0301	0.0344	0.0171	0.0661
2020	1.4700	0.0356	0.0407	0.0203	0.0782
2021	1.1991	0.0291	0.0332	0.0165	0.0638
2022	0.6043	0.0146	0.0167	0.0083	0.0321

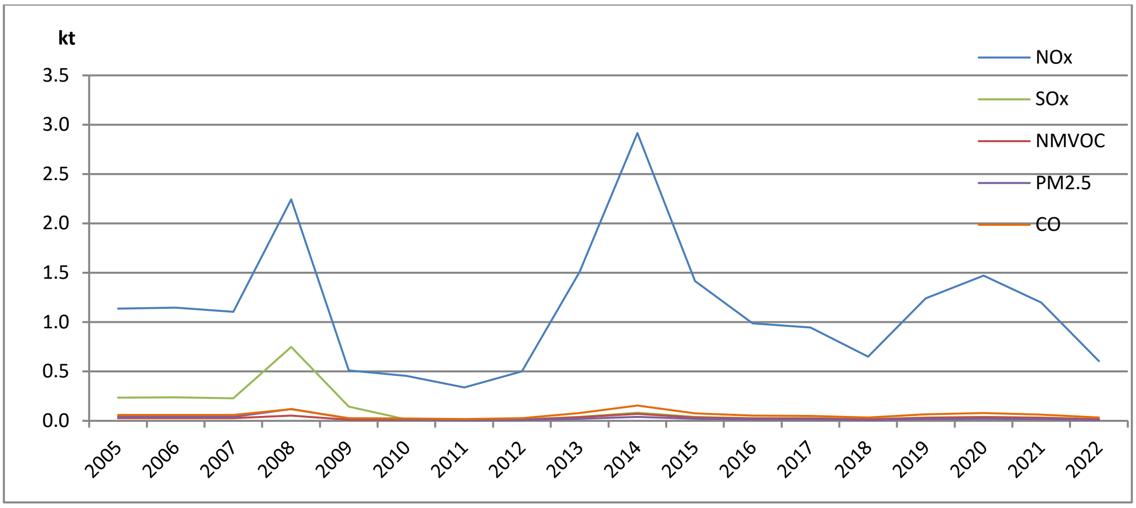


Figure 3.15.2. Emissions trend (kt) of Main Pollutants, $PM_{2.5}$ and CO for NFR 1.A.3.d.i(i) - International maritime navigation-Memo item

Emissions from **1.A.3.d.ii - National navigation (shipping)**, are estimated using fuel consumption provided by the National Institute of Statistics and Tier 1 emission factors from 2023 EMEP/EEA Guidebook (see above).

For the period 1992-2006, NFR 1.A.3.dii included fuel oil and marine diesel and therefore emission values are higher.

The following table and chart give details on the shares of fuel consumption by fuel type and the emissions trends for NFR 1.A.3.d.ii.

Table 3.15.6. Fuel consumption (t) for NFR 1.A.3.d.ii - National navigation (shipping)

Year	Fuel oil (t)	Marine diesel oil (t)
1990	327000	-
1991	399000	-
1992	230000	124000
1993	69000	65000
1994	78000	52000
1995	54000	50000
1996	92000	59000
1997	239000	106000
1998	163000	59000
1999	161000	60000
2000	61000	53000
2001	91000	13000
2002	75000	30000
2003	57000	13000
2004	22000	20000
2005	1000	40000
2006	1000	39000

Year	Fuel oil (t)	Marine diesel oil (t)
2007	-	82000
2008	-	70000
2009	-	54000
2010	-	58000
2011	-	51000
2012	-	42000
2013	-	41000
2014	-	37000
2015	-	43000
2016	-	40000
2017	-	39853
2018	-	39812
2019	-	42975
2020	-	41271
2021	-	50879
2022	-	44577

Table 3.15.7. Emissions trend (kt) of Main Pollutants, $PM_{2.5}$ and CO
for NFR 1.A.3.d.ii - National navigation

Year/Pollutant (kt)	NOx	NMVOC	SOx	$PM_{2.5}$	CO
1990	22.596	0.546	17.658	1.530	1.200
1991	27.571	0.666	21.546	1.867	1.464
1992	24.846	0.601	13.660	1.200	1.320
1993	9.461	0.229	4.376	0.388	0.503
1994	9.144	0.221	4.732	0.417	0.486
1995	7.341	0.178	3.416	0.302	0.390
1996	10.617	0.257	5.558	0.489	0.564
1997	24.168	0.585	13.966	1.224	1.284
1998	15.523	0.375	9.392	0.822	0.825
1999	15.457	0.374	9.294	0.813	0.821
2000	8.042	0.195	3.824	0.338	0.427
2001	7.227	0.175	5.044	0.439	0.384
2002	7.349	0.178	4.170	0.381	0.390
2003	4.877	0.118	3.130	0.280	0.259
2004	2.964	0.072	1.268	0.123	0.158
2005	2.957	0.072	0.214	0.044	0.157
2006	2.885	0.070	0.186	0.043	0.153
2007	5.920	0.144	0.328	0.082	0.315
2008	5.054	0.123	0.280	0.070	0.269
2009	3.899	0.095	0.216	0.054	0.207
2010	4.188	0.102	0.116	0.058	0.223
2011	3.682	0.089	0.102	0.051	0.196
2012	3.032	0.074	0.084	0.042	0.161
2013	2.960	0.072	0.082	0.041	0.157
2014	2.671	0.065	0.074	0.037	0.142
2015	3.105	0.075	0.086	0.043	0.165
2016	2.888	0.070	0.080	0.040	0.154

Year/Pollutant (kt)	NOx	NMVOC	SOx	$PM_{2.5}$	CO
2017	2.877	0.070	0.080	0.040	0.153
2018	2.874	0.070	0.080	0.040	0.153
2019	3.103	0.075	0.086	0.043	0.165
2020	2.980	0.072	0.083	0.041	0.158
2021	3.673	0.089	0.102	0.051	0.195
2022	3.218	0.078	0.089	0.044	0.171

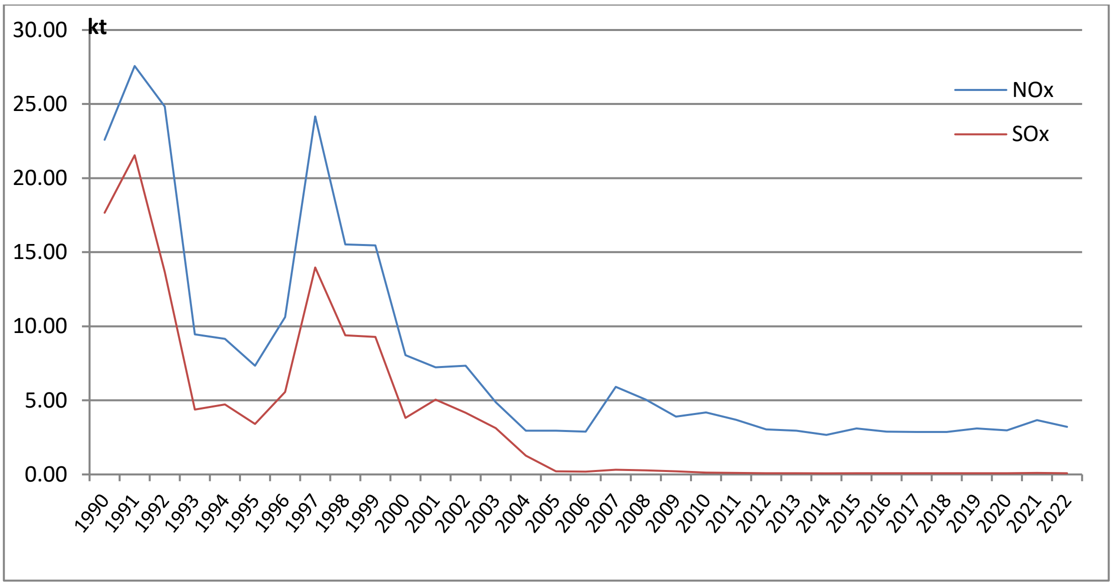


Figure 3.15.3. Emissions trend (kt) of NOx and SOx for NFR 1.A.3.d.ii - National navigation

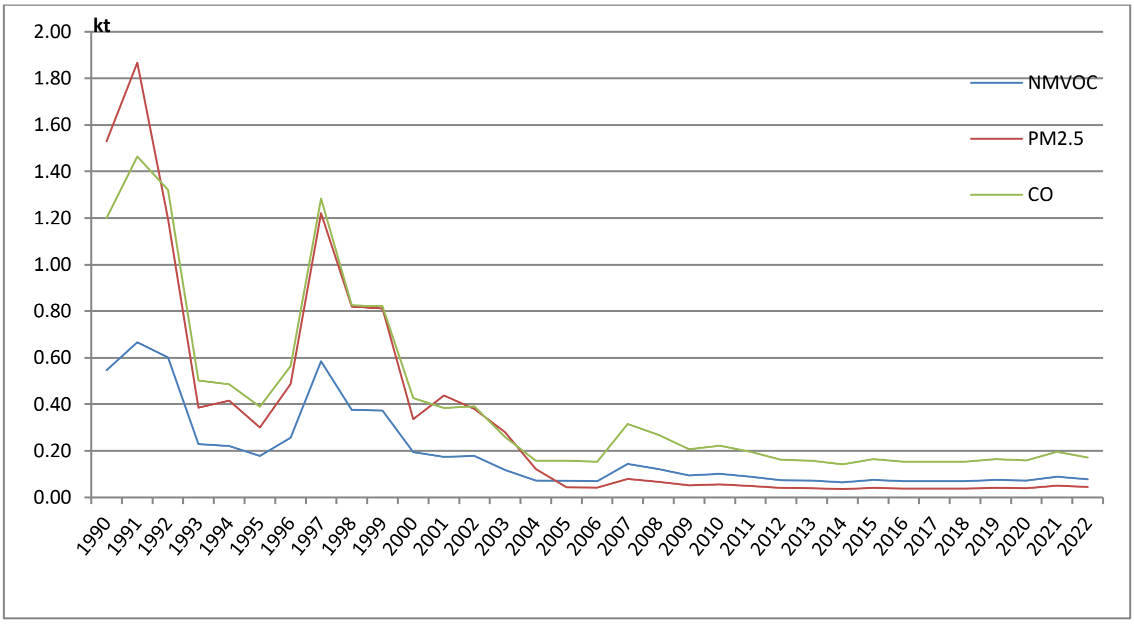


Figure 3.15.4. Emissions trend (kt) of NMVOC, $PM_{2.5}$ and
CO for NFR 1.A.3.d.ii - National navigation

Emissions trend of pollutants are consistent with the fuel consumption variation.

Recalculations and improvements:

- For 1A3di(ii) - International inland waterways, emissions were estimated for the first time for 2005-2022;
- For 1A3di(i) - International maritime navigation – Memo Item, emissions were estimated for the first time for 2005-2006 and recalculated for the years 2007-2021;
- For 1.A.3.d.ii - National navigation, PAHs were estimated for 1990-2022.

3.16 NFR 1.B.1.a Coal mining and handling

Table 3.16.1. Pollutants and Emission factors for 1B

NFR	Pollutants Reported	Emission Factor tier and source
1B1a Fugitive emission from solid fuels: Coal mining and handling	NMVOC, PM10, PM2.5, TSP	T2 - EMEP EEA guidebook (2019) factors
1B1b Fugitive emission from solid fuels: Solid fuel transformation	-	
1B1c Other fugitive emissions from solid fuels	-	
1B2ai Fugitive emissions oil: Exploration, production, transport	NMVOC	T1 - EMEP EEA guidebook (2019) factors
1B2aiv Fugitive emissions oil: Refining and storage	All CLRTAP pollutants (except PCDD/ PCDF, HCB, PCBs)	T2 - EMEP EEA guidebook (2019) factors
1B2av Distribution of oil products	NMVOC	T2 – country specific factor
1B2b Fugitive emissions from natural gas (exploration, production, processing, transmission, storage, distribution and other)	NMVOC	T1 - EMEP EEA guidebook (2019) factors
1B2c Venting and flaring (oil, gas, combined oil and gas)	All CLRTAP pollutants (except NH3, POPs)	T1 for 1990-2011 and T1 for SNAP 090206 (Flaring in gas and oil extraction) and T2 for SNAP 090203 (Flaring in oil refinery) for 2012-2022 - EMEP EEA guidebook (2019) factors
1B2d Other fugitive emissions from energy production	-	

NFR 1.B.1.a, Fugitive emission from solid fuels: Coal mining and handling is a key source for NMVOC pollutant with 2% of the national total.

Activity data for NFR 1B1a – Coal mining and handling, provided by the N.I.S. and from the Romania's Greenhouse Gas Inventory – N.I.R., improving the consistency between data for NFR and CRF. Default 2019 EMEP/EEA Guidebook emission factors (Tier 2) were used. To apply the Tier 2 methodology the activity data and the emission factors needed to be stratified according to the different techniques that may occur in the country. The approach followed to apply a Tier 2 methodology was to stratify the coal mining/storage/handling in the country to model the different product and process types occurring in the national coal mining industry into the inventory by:

- defining the production using each of the separate product and/or process types (together called 'technologies' in the formulae below) separately, and
- applying technology specific emission factors for each process type.

As a result, it split NFR 1.B.1.a into two SNAPs:

- Open cast mining with default 2019 EMEP/EEA Guidebook emission factors (Tier 2, Table 3-2).
- Underground mining with default 2019 EMEP/EEA Guidebook emission factors (Tier 2, Table 3-3).

Table 3.16.2 Emissions Trend (kt) for NFR 1.B.1.for NMVOC pollutant

Year	NMVOC (kt)
1990	34.266
1991	29.218
1992	33.546
1993	27.550
1994	28.380
1995	28.216
1996	29.092
1997	25.130
1998	19.610
1999	16.784
2000	28.033
2001	29.509
2002	27.248
2003	25.717
2004	23.570
2005	21.414
2006	18.971
2007	12.336
2008	11.316
2009	9.889
2010	8.437
2011	9.482
2012	8.914
2013	6.428
2014	5.559
2015	5.486
2016	4.596
2017	7.270
2018	6.315
2019	5.492
2020	4.210
2021	4.249

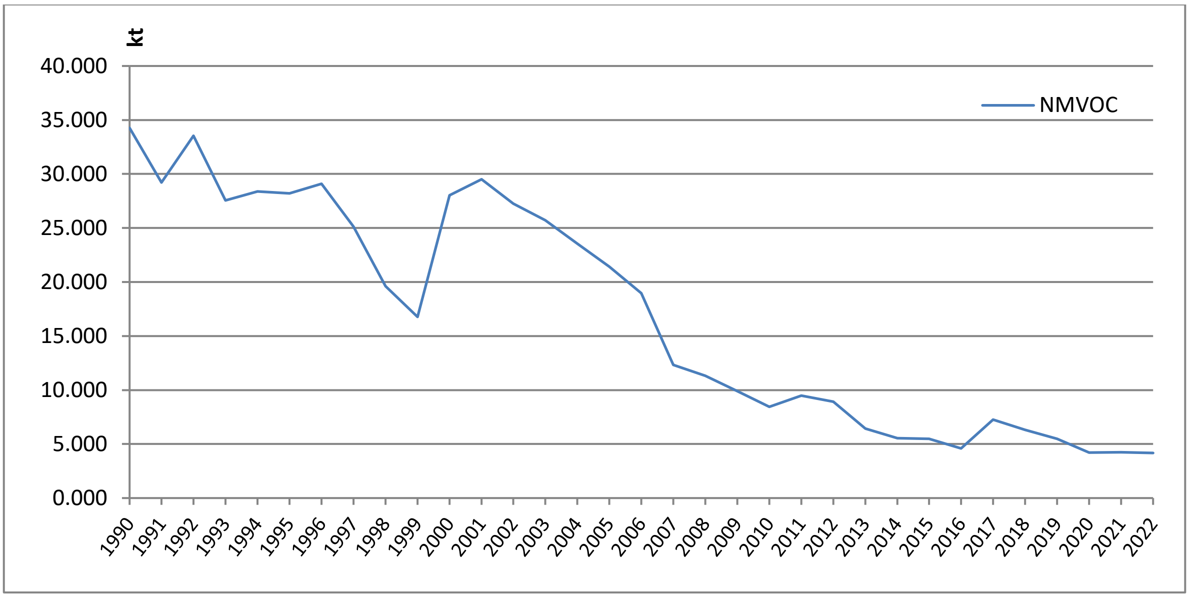


Figure 3.16.2 NMVOC Emissions Trend (kt) for NFR 1.B.1.a

It can be noted the NMVOC emissions trend have the same variation as the activity data (coal produced).

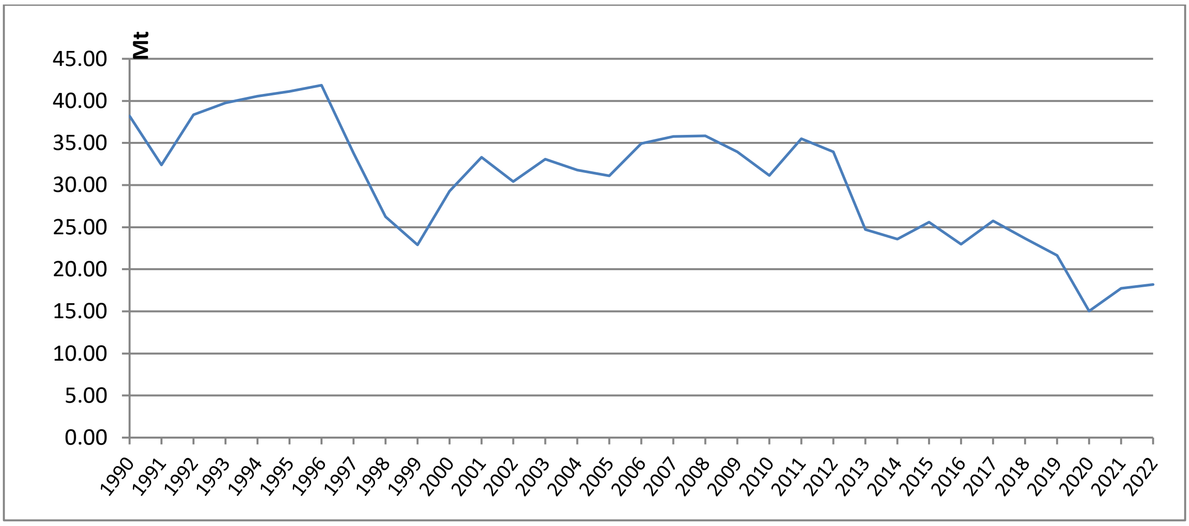


Figure 3.16.3 Activity data trend (Mt) for NFR 1.B.1.a

3.17 NFR 1.B.1.b Fugitive emissions from solid fuels: solid fuel transformation

Activity data is represented by coke production, taken from N.I.S. Default 2019 EMEP/EEA Guidebook Tier 1 emission factors were used. The pollutants emissions are calculated based on Tier 1 methodology, applying the general equation:

$$E_{pollutant} = AR_{production} \times EF_{pollutant}, \text{ where:}$$

- Epollutant - is the emission of a pollutant (kg).
- ARproduction - is the annual production of coke (in Mg).
- EFpollutant - is the emission factor of the relevant pollutant (in kg pollutant/Mg coke produced).

Coke production has been decreasing from 3965000 t in 1990 down to 0 t in 2010.

Table 3.17.1. Activity data trends (t product) for NFR 1.B.1.b coke production

Year	AD (t coke production)
1990	3965000
1991	2581000
1992	2903000
1993	2601000
1994	2884000
1995	3384000
1996	3153000
1997	3316000
1998	3132000
1999	1716000
2000	1613000
2001	1413000
2002	1866000
2003	1638000
2004	1675000
2005	1891000
2006	1790000
2007	1647000
2008	1138000
2009	341000

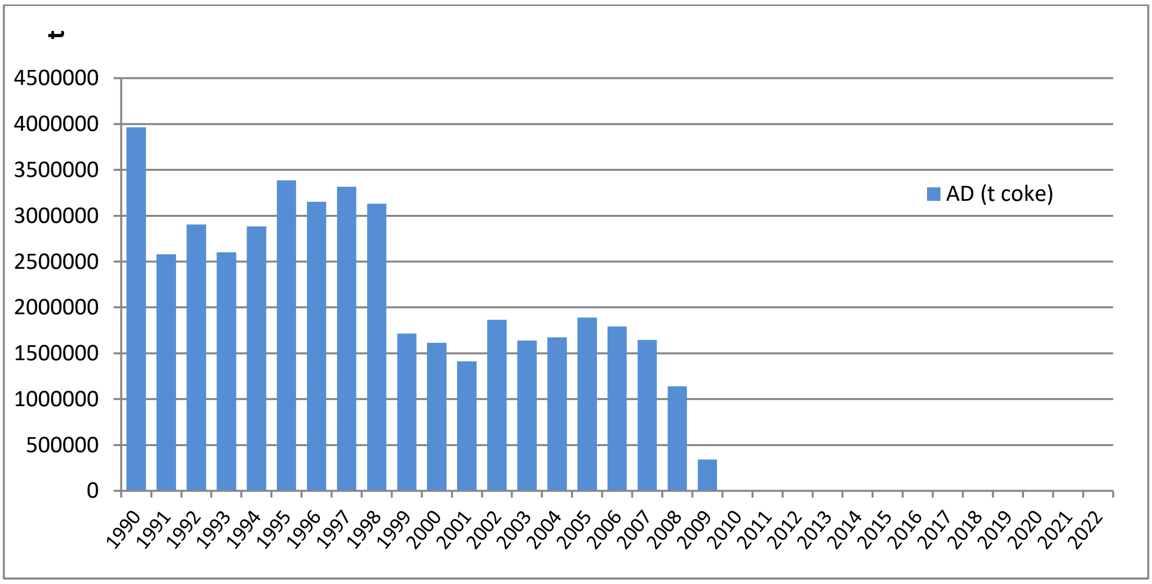


Figure 3.17.1. Activity data trends (t product) for NFR 1.B.1.b coke production

The pollutants emissions trend had the same variation as the activity data, it decreased to zero in the years without production.

3.18 NFR 1.B.2.a.i Oil

Activity data were oil produced and imports from the Energy Balance provided by N.I.S. Default 2019 EMEP/EEA Guidebook emission factors (Table 3-1, Tier 1) were used.
The emissions of NMVOC are calculated based on Tier 1 methodology for process emissions from oil exploration, production and transport, applying the general equation:

$$Epollutant = ARproduction \times EFpollutant$$, where:

- Epollutant - is the emission of a pollutant (kg);
- ARproduction - is the annual production of oil and imports (in Mg);
- EFpollutant - is the emission factor of the relevant pollutant (in kg pollutant/Mg oil produced and imports).

Activity data fluctuates, increasing and decreasing during the 1990-2022 time series.

Table 3.18.1 Emissions Trend (kt) for NFR 1.B.2.a.i for NMVOC

Year	NMVOC (kt)
1990	4.797
1991	3.038
1992	2.637
1993	2.859
1994	2.972
1995	3.075
1996	2.756
1997	2.552
1998	2.457
1999	2.087
2000	2.160
2001	2.311
2002	2.434
2003	2.174
2004	2.555
2005	2.781
2006	2.691
2007	2.615
2008	2.592
2009	2.256
2010	1.998
2011	1.905
2012	1.798
2013	1.868
2014	2.138
2015	2.100
2016	2.231
2017	2.259
2018	2.350
2019	2.421
2020	2.081

Year	NMVOC (kt)
2021	2.015
2022	2.322

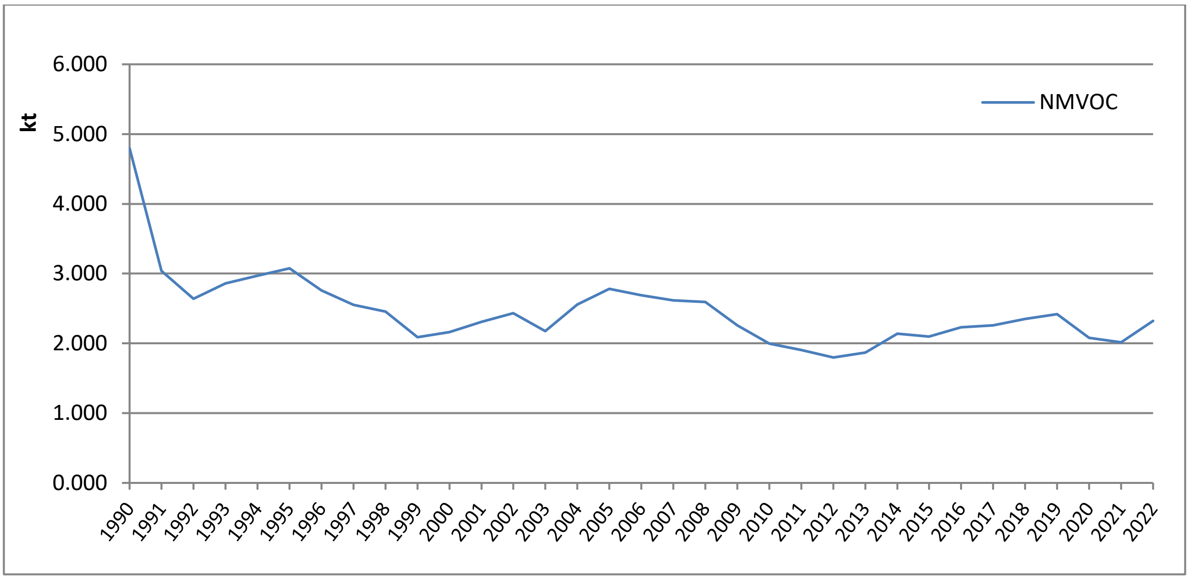


Figure 3.18.1 Emissions Trend (kt) for NFR 1.B.2.a.i for NMVOC

3.19 NFR 1.B.2.a.iv Refining, storage

This chapter treats emissions from the petroleum refining industry. This industry converts crude oil into many refined products, such as liquid fuel, by-product fuels and feedstock and primary petrochemicals.

In previous submissions for NFR 1.B.2.a.iv, although it was the key source, the emissions were calculated based on Tier 1 methodology activity data were represented by refinery oil inputs from the Energy Balance provided by N.I.S., together with default 2019 EMEP/EEA Guidebook emission factors (Table 3-1, Tier 1). To apply the Tier 2 methodology the activity data and the emission factors needed to be stratified according to the different techniques that may occur to economic operators.

As a result, it split NFR 1B2aiv into three SNAPs:

- 040102 - Fluid catalytic cracking - CO boiler with default 2019 EMEP/EEA Guidebook emission factors (Tier 2, Table 3-2) and activity data represented by the total annual amount of fresh feed (mc) obtained from economic operators.
- 040103 - Sulphur recovery plants with default 2019 EMEP/EEA Guidebook emission factors (Tier 2, Table 3-5) and activity data represented by amount of sulphur produced (t) obtained from economic operators.
- 040104 – Storage and handling of petroleum products in refinery with default 2019 EMEP/EEA Guidebook emission factors (Tier 2, Table 3-6) and activity data represented by annual crude oil throughput (t) obtained from economic operators.

Activity data are provided by economic operators for the years 2015-2022.

SOx emissions were estimated based on specific reduction yields imposed by the implementation of BAT technologies.

Economic operators used SOx emission reduction yields at:

- SNAP 040102 - Catalytic cracking of 82.5%, 95% and 100%.
- SNAP 040103 - Sulphur recovery of 99.9%, 99.8 and 99.5%.

NH_3 emissions were estimated taking used abatement efficiency (99.5%) from Table 3-7 from 2019 EMEP/EEA Guidebook, 2015-2022.

In 2022 NFR 1B2aiv was key source for NMVOC (2%), CO (16.3%), Hg (16.9%) and Ni (19.9%), Cd (8%) from national total. The tables and figures below show trends in activity data and NMVOC and CO emissions pollutants for which NFR 1B2aiv was the key source.

Table 3.19.1 Activity data trends (m^3) total annual amount of fresh feed for NFR 1.B.2.a.iv

Year	AD (mc)
1990	3927181.00
1991	2948699.00
1992	2475178.00
1993	2751162.50
1994	2576603.00
1995	2667846.80
1996	3056951.00
1997	2428522.80
1998	2808448.10
1999	3221215.00
2000	3321559.00
2001	3407212.30
2002	3039462.00
2003	2835001.30
2004	3149508.00
2005	3402793.50
2006	3644495.00
2007	3444667.00
2008	3391529.40
2009	3254223.90
2010	3501450.47
2011	3941221.60
2012	3463216.50
2013	3970462.00
2014	4026669.00
2015	3448736.61
2016	3877332.52
2017	3928947.15
2018	4023984.65
2019	4155669.00
2020	3697802.50
2021	3389641.10

Year	AD (mc)
2022	3750556.54

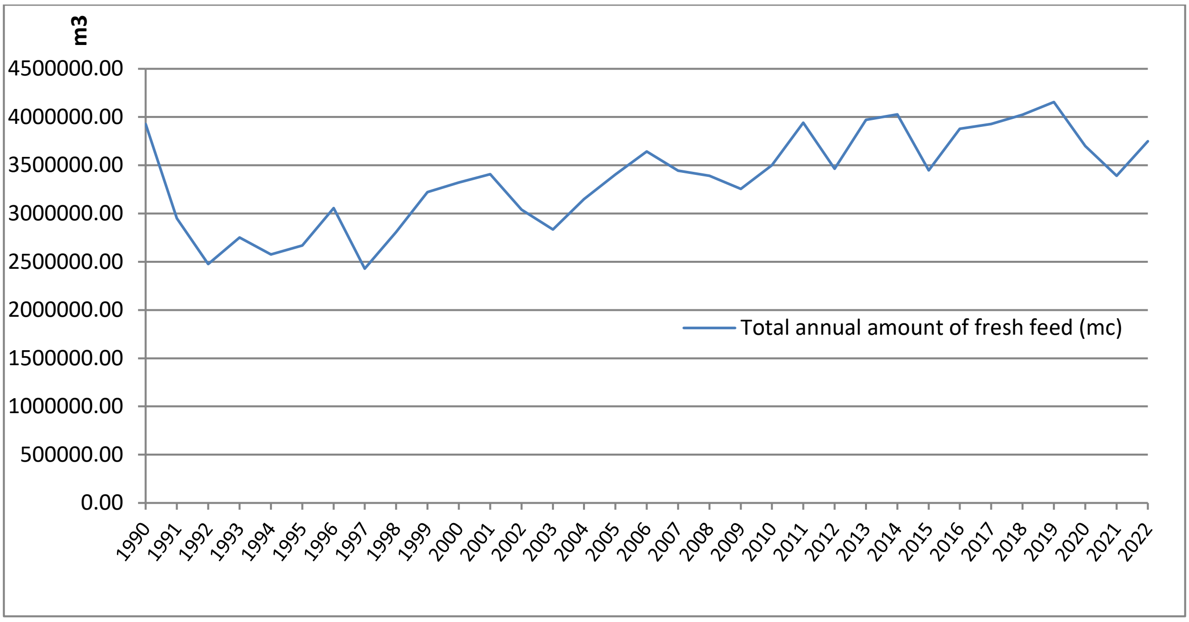


Figure 3.19.1 Activity data trends (m^3 total annual amount of fresh feed) for NFR 1.B.2.a.iv

Table 3.19.2 Emissions Trend (kt) for NFR 1.B.2.a.iv for NMVOC and CO, 1990-2022

Year	NMVOC (kt)	CO (kt)
1990	3.359	153.160
1991	2.522	114.999
1992	2.117	96.532
1993	2.425	110.565
1994	1.623	100.488
1995	1.681	104.046
1996	2.926	119.221
1997	2.315	94.712
1998	2.595	109.529
1999	2.970	125.627
2000	3.144	129.541
2001	3.037	132.881
2002	2.599	118.539
2003	2.425	110.565
2004	2.744	122.831
2005	3.236	132.709
2006	3.431	142.135
2007	3.290	134.342
2008	3.217	132.270
2009	3.090	126.915
2010	3.336	136.557
2011	3.672	153.708
2012	3.241	135.065
2013	3.631	154.848
2014	3.751	157.040

Year	NMVOC (kt)	CO (kt)
2015	4.243	134.501
2016	4.724	151.216
2017	4.721	153.229
2018	4.843	156.935
2019	4.196	162.071
2020	4.389	144.214
2021	4.133	132.196
2022	4.699	146.272

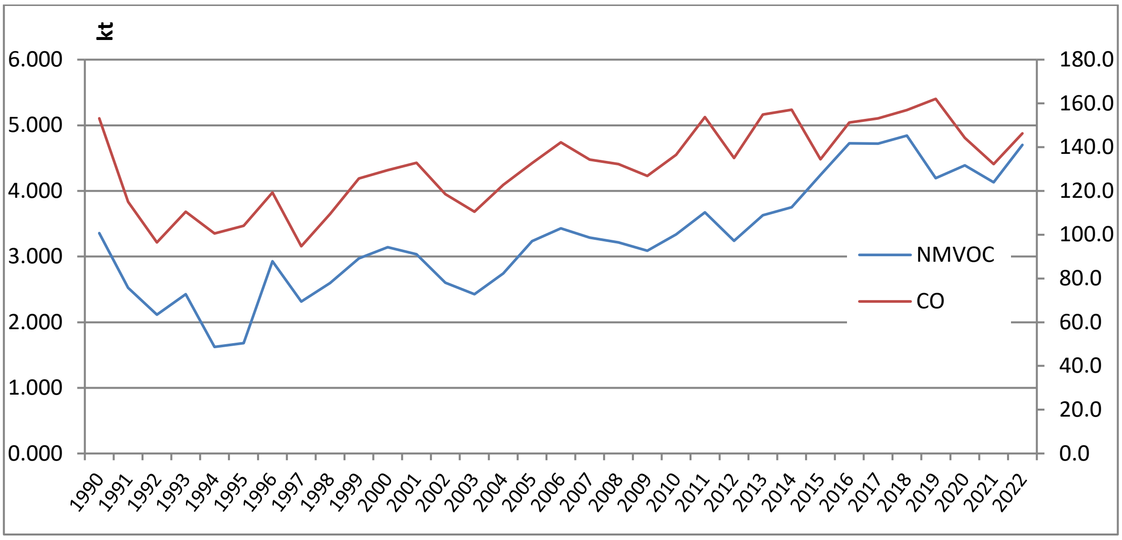


Figure 3.19.2 Emissions Trend (kt) for NFR 1.B.2.a.iv for NMVOC and CO

It is observed that pollutant emissions follow the activity data trends of NFR 1B2aiv.

- Recalculations: There were no recalculations and improvements for this category.

3.20 NFR 1.B.2.a.v Distribution of oil products

For NFR 1.B.2.a.v, statistical activity data consisted of gasoline refinery gross outputs and imports minus exports.

AD = (Refinery gross outputs + Imports) – Exports (Mg)

The activity data provided by the N.I.S. and by the Romania's Greenhouse Gas Inventory, improved the consistency between data for NFR and CRF. In the 2019 EMEP/EEA Guidebook: "considerable reduction of hydrocarbon emissions from gasoline distribution network is achieved by modifying truck, barge or rail car tanks loading practices, installing vapour recovery units (VRU). These emission controls have been mandated under the terms of Directive 94/63/EU (EU, 1994). Stage I controls refer to a variety of techniques reducing NMVOC emissions at marketing terminals (Stage IA) and when gasoline is delivered to service stations (Stage IB). Stage II applies to vapour balancing systems between automobile fuel tanks during refueling and the service station ta supplying the gasoline (Directive 2009/126/EC)". Directive 94/63/EC has been transposed into Romanian legislation by

Government Decision 568/2001 and Directive 2009/126/EC has been transposed by Government Decision 958/2012.

Tier 2 emission factor is calculated taking into account Stage I and II control. The abatement efficiencies related to this control options provided in the 2019 EMEP/EEA Guidebook are taken into account.

For the calculation of the Tier 2 emission factor, two country-specific characteristics are needed: the average annual temperature of Romania that is taken from the Statistical Yearbook and the maximal RVP (Reid Vapour Pressure) which is determined by Government Decision 689/2004 (Appendix 3).

During the desk Review 2020, in RO–1B2av-2020-0001 “the TERT notes that Stage I and Stage II abatement efficiencies have been applied for all years, and not only for the years after the respective government decisions. This may lead to an underestimation for the years before the government decisions.” This mistake has been corrected and below, you find the calculation of the Romanian country specific Tier 2 emission factor and recalculating abatement efficiencies as it is noted the TERT.

$TVP = RVP \times 10^{AT+B}$,

where:

A = 0.000007047 x RVP + 0.0132, B = 0.0002311 x RVP – 0.5236,

T – average annual temperature of Romania (^{0}C) = 9.5 ^{0}C (Statistical Yearbook of Romania;
RVP – is Reid Vapour Pressure (kPa) = 60 (determined by Government Decision 689/2004, Appendix 3).

A = 0.000007047 x 60 + 0.0132 = 0.01362282

B = 0.0002311 x 60 – 0.5236 = - 0.509734
AT + B = - 0.380317

$10^{AT+B} = 10^{-0.380317} = 0.416572$

TVP = 24.994 kPa = 25 kPa

Calculation of Tier 2 emission factor:

Category	Emission source	EF NMVOC default (g/m^{3}throughput/kPa TVP)	Abatement efficiency (%)	TVP- true vapour pressure (kPa)	IEF NMVOC =EF abated*TVP (g/mc) 1990-2000	IEF NMVOC =EF abated*TVP (g/mc) 2001-2011	IEF NMVOC =EF abated*TVP (g/mc) 2012-2019
Service stations	Storage ta filling without Stage I (table 3-8)	24	95% (stage I)	25	600	30	30

Category	Emission source	EF NMVOC default (g/m³throughput/kPa TVP)	Abatement efficiency (%)	TVP- true vapour pressure (kPa)	IEF NMVOC =EF abated*TVP (g/mc) 1990-2000	IEF NMVOC =EF abated*TVP (g/mc) 2001-2011	IEF NMVOC =EF abated*TVP (g/mc) 2012-2019
	Storage ta breathing (table 3-9)	3		25	75	75	75
	Automobile refuelling with no emission controls in operation (table 3-10)	37	85% (stage II)	25	925	925	138.75
	Automobile refuelling: drips and minor spillage (table 3-11)	2		25	50	50	50
SUM					**1650**	**1080**	**293.75**
					no stage	stage I	stage II
					2.260274	**1.4794521**	**0.4023973**

Using "the assumed liquid gasoline density is 730 kg/m^3" from chapter 3.3.2.3 of 2019 EMEP/EEA Guidebook, the 293.75 g/m^3 NMVOC results 0.4023 kg NMVOC/t gasoline (293.75 x 10^{-3} kg NMVOC/730 x10^{-3} t gasoline). The same calculation was made for the stage I and for no stage.

Table 3.20.1. Emissions Trend (kt) for NFR 1.B.2.a.v for NMVOC 1990 -2022

Year	NMVOC (kt)
1990	4.721
1991	3.842
1992	4.540
1993	2.251
1994	2.398
1995	3.684
1996	3.017
1997	4.115
1998	4.073
1999	3.295
2000	3.431
2001	2.573
2002	2.392
2003	2.431
2004	2.281
2005	2.341
2006	2.102
2007	2.473
2008	2.105
2009	2.510
2010	2.366
2011	1.943
2012	0.529
2013	0.523
2014	0.543
2015	0.524
2016	0.566

Year	NMVOC (kt)
2017	0.589
2018	0.531
2019	0.550
2020	0.499
2021	0.552
2022	0.546

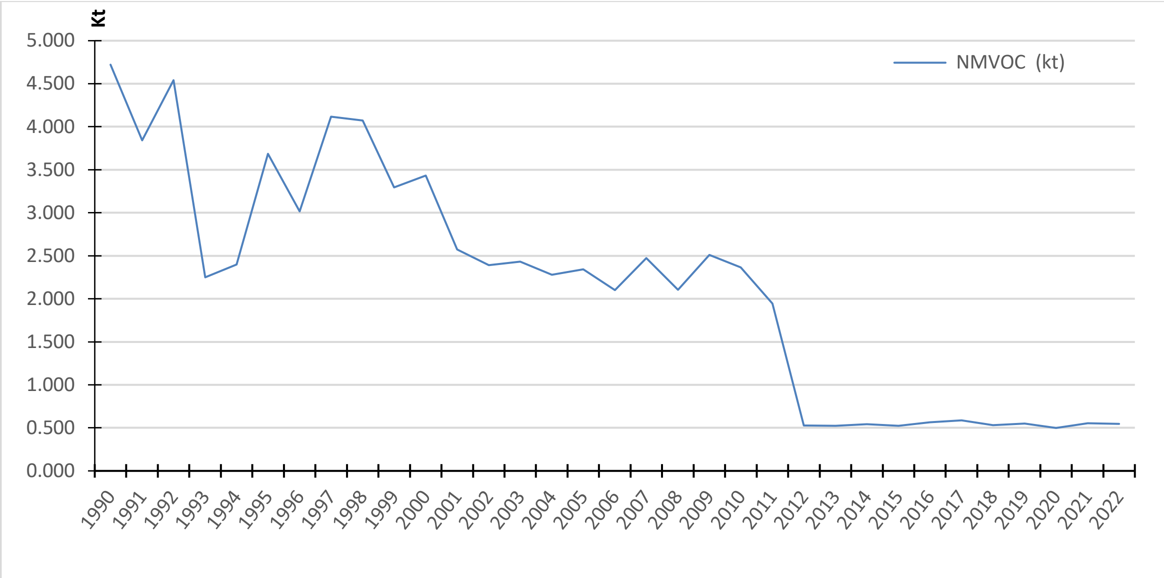


Figure 3.20.1. Emissions Trend (kt) for NFR 1.B.2.a.v for NMVOC

It can be observed that emissions of NMVOC follow the activity data trend of NFR 1.B.2.a.v - Distribution of oil products.

3.21 NFR 1.B.2.b Natural gas

This source includes emissions from the exploration, production and transport for natural gas. The emission factor for NMVOC is Tier 1 default emission factor for natural gas from 2019 EMEP/EEA Guidebook (Table 3-2). Activity data is represented by the extracted natural gas and imports and it is taken from the Energy Balance provided by N.I.S. and by the Romania's Greenhouse Gas Inventory, improved the consistency between data for NFR and CRF. The emissions were calculated, applying the general equation:

Epollutant = ARproduction× EFpollutant, where:

- Epollutant - is the emission of a pollutant (g);
- ARproduction - is the annual volume of gas extracted and imported (in m^3);
- EFpollutant - is the emission factor of the relevant pollutant (in g pollutant/m^3 gas).

Table 3.21.1. Emissions Trend (kt) for NFR 1.B.2.b. for NMVOC 1990-2022

Year	NMVOC (kt)

Year	NMVOC (kt)
1990	3.567
1991	2.943
1992	2.623
1993	2.523
1994	2.315
1995	2.400
1996	2.427
1997	1.997
1998	1.869
1999	1.718
2000	1.711
2001	1.644
2002	1.681
2003	1.890
2004	1.792
2005	1.722
2006	1.779
2007	1.622
2008	1.567
2009	1.317
2010	1.313
2011	1.399
2012	1.381
2013	1.231
2014	1.164
2015	1.129
2016	1.128
2017	1.177
2018	1.180
2019	1.264
2020	1.106
2021	1.250
2022	1.191

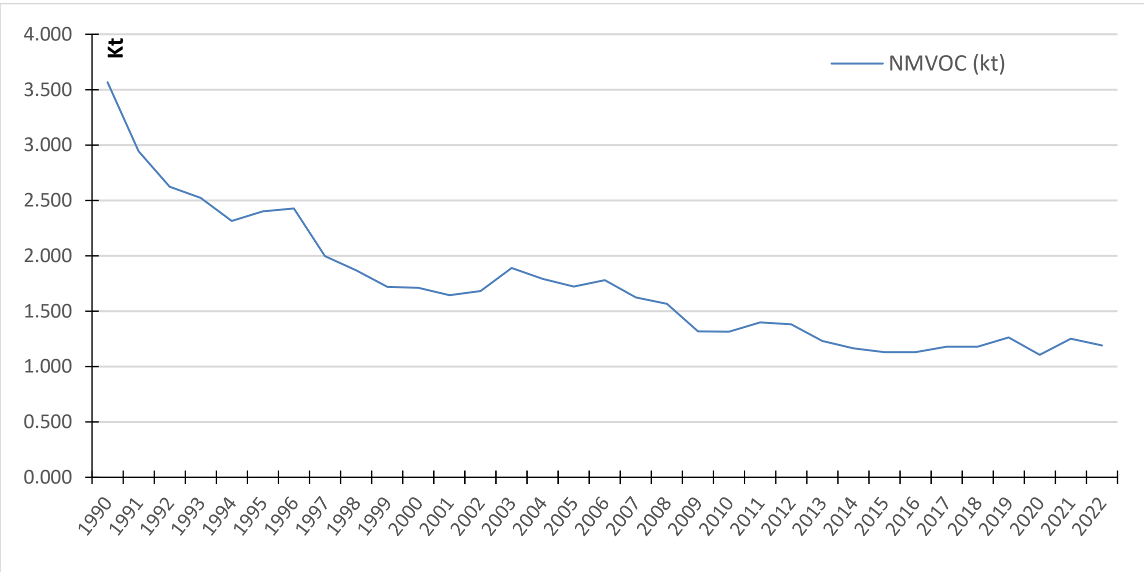


Figure 3.21.1. Emissions Trend (kt) for NFR 1.B.2.b. for NMVOC

It is observed that the emissions trend of NMVOC is decreasing for the 1990-2022 time series.

3.22 NFR 1.B.2.c Venting and flaring

This NFR "treats emissions from venting and flaring in the extraction and refining of oil and gas".

The emissions for years 1990-2011 were calculated by applying Tier 1 emission factors (2019 EMEP/EEA Guidebook, Tables 3.1) to activity data provided by the N.I.S energy balances (the category "losses" of natural gas) due to the lack of activity data from economic operators.

For the period 2012-2022, activity data are provided by economic operators field oil and gas extraction and refining (m3) and the following activities with corresponding SNAP codes are included:

- Flaring in oil refinery (SNAP 090203);
- Flaring in gas and oil extraction (SNAP 090206).

The emissions for SNAP 090203 are calculated based on Tier 2 methodology from 2019 EMEP/EEA Guidebook in which it is specified "the factors are identical to the emission factors for flaring in oil refineries as given in Tier 1, (Table 3,2)".

The emissions for SNAP 090206 are calculated based on Tier 1 methodology from 2019 EMEP/EEA Guidebook (Table 3-1), applying the general equation:

Epollutant = ARproduction× EFpollutant, where:

- Epollutant - is the emission of a pollutant (kg).
- EFpollutant - is the emission factor of the relevant pollutant (in kg pollutant/Mg gas burned/throughput).
- ARproduction - is the volume of gas burned (m^3).

Table 3.22.1. Emissions Trend (kt) for NFR 1.B.2.c. for NOx and SOx

Year	NOx (kt)	SO_X (kt)
1990	0.263	0.002
1991	1.028	0.010
1992	0.840	0.008
1993	1.092	0.010
1994	1.393	0.013
1995	0.793	0.007
1996	0.710	0.007
1997	0.196	0.002
1998	0.446	0.004
1999	0.571	0.005
2000	0.452	0.004
2001	0.561	0.005
2002	0.263	0.002
2003	1.028	0.010
2004	0.840	0.008
2005	0.616	0.006

Year	NOx (kt)	SO_X (kt)
2006	0.877	0.008
2007	0.642	0.006
2008	0.856	0.008
2009	1.324	0.012
2010	0.646	0.006
2011	0.668	0.006
2012	0.472	0.004
2013	0.509	0.005
2014	0.490	0.005
2015	0.063	0.061
2016	0.797	1.112
2017	0.055	0.060
2018	0.795	1.117
2019	0.579	0.813
2020	0.147	0.195
2021	0.144	0.193
2022	0.148	0.026

The chart below shows the variation of the pollutants for 1.B.2.c.

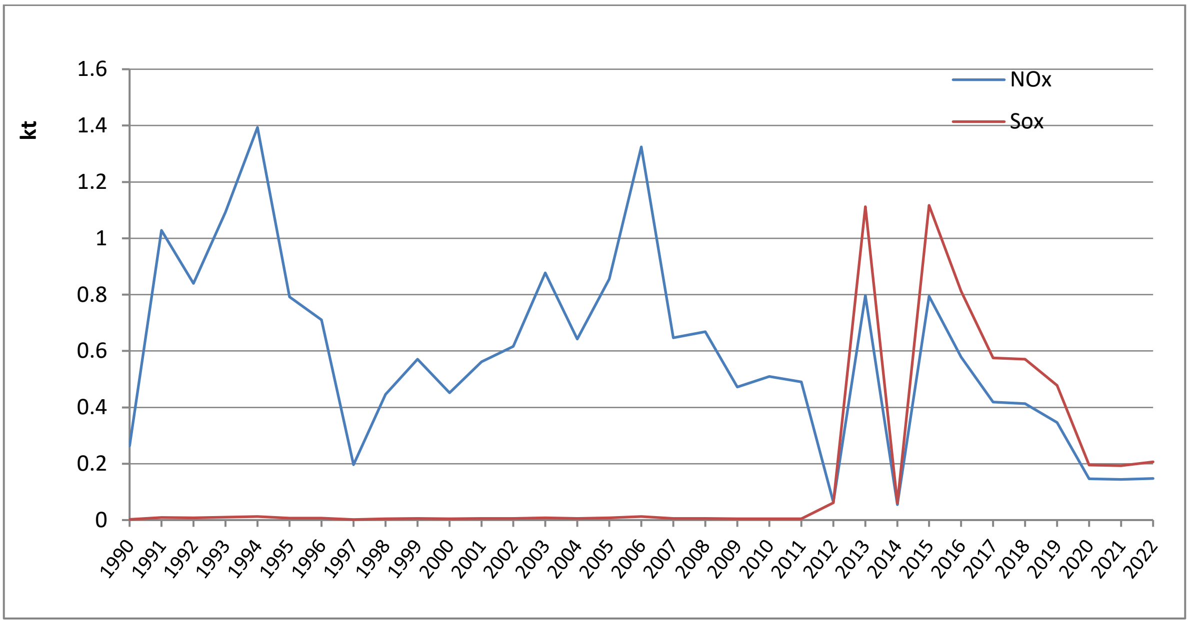


Figure 3.22.1. SO_X and NOx emissions trend (kt) for NFR 1.B.2.c

Recalculations and improvements:

- Activity data update and recalculation 2021.

4. INDUSTRIAL PROCESSES AND PRODUCT USE (NFR sector 2)

The industrial processes and product use sector is a key category of NMVOC, PM_{10}, TSP, Pb, Cd, Hg, As, Cr, Ni, Zn, PCDD/F and PCBs.

Table 4.1. The key category for Industrial Processes and product use (2022)

Pollutant	NFR code	Category	Level assessment (%)
NMVOC	2D3a	Domestic solvent use including fungicides	9.8%
NMVOC	2D3g	Chemical products	6.6%
NMVOC	2H2	Food and beverages industry	3.4%
NMVOC	2D3d	Coating applications	2.8%
NMVOC	2D3i	Other solvent use (please specify in the IIR)	2.1%
PM10	2A5a	Quarrying and mining of minerals other than coal	3.5%
TSP	2D3b	Road paving with asphalt	11.2%
TSP	2A5a	Quarrying and mining of minerals other than coal	5.2%
TSP	2A5b	Construction and demolition	2.2%
Pb	2C1	Iron and steel production	45.1%
Cd	2C1	Iron and steel production	10.5%
Hg	2C1	Iron and steel production	11.5%
As	2C1	Iron and steel production	22.9%
Cr	2C1	Iron and steel production	30.8%
Ni	2C1	Iron and steel production	9.7%
Zn	2C1	Iron and steel production	8.6%
PCDD/F	2C1	Iron and steel production	13.4%
PCBs	2C1	Iron and steel production	69.5%

Industrial processes and product use sector mainly contributes to the PCBs emissions (69.51% of the total national), Pb emissions (51.01% of the total national), Cr emissions (31.73% of the total national), NMVOC emissions (25.81% of the total national), TSP emissions (23.87% of the total national), As (25.44% of the total national) and with a relatively low contribution to the emissions of the rest of pollutants reported.

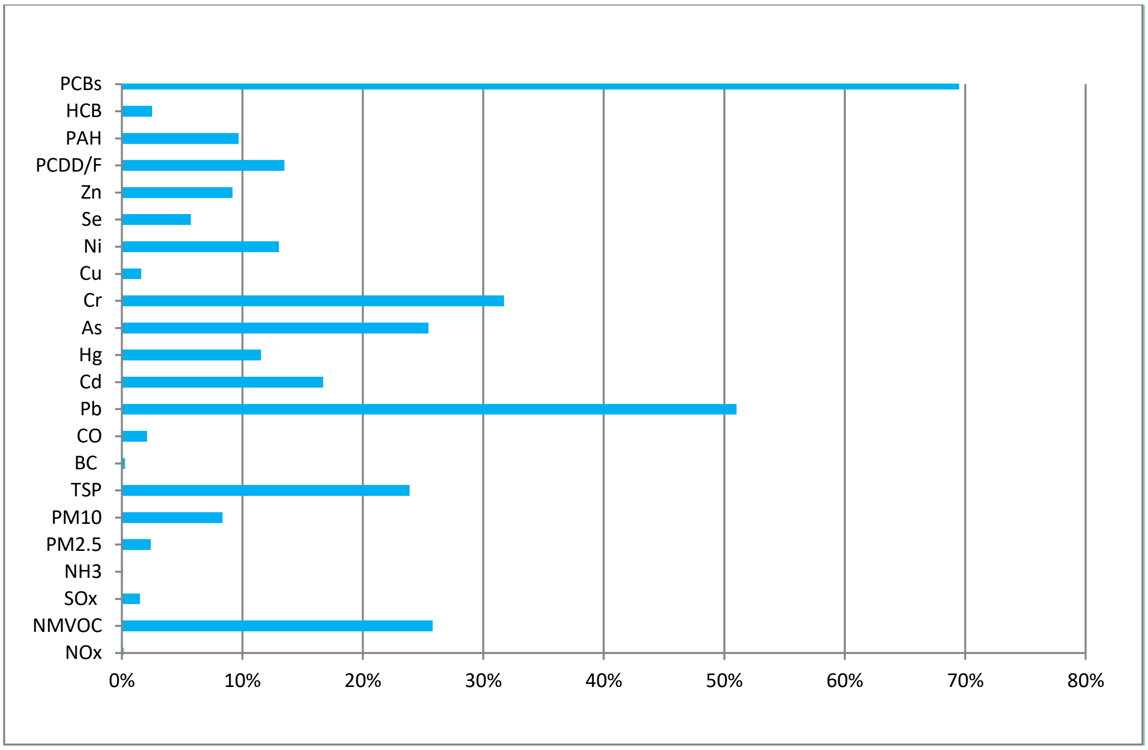


Figure 4.1. Emissions of pollutants (%) for IPPU sector in 2022

This sector only covers process related emissions arising from industrial processes. Emissions due to fuel combustion in manufacturing industries have been allocated to NFR 1.A.2 Fuel Combustion in Manufacturing Industries and Construction.

Table 4.2 Pollutants and Emission factors for Sector 2

NFR	Pollutants Reported	Emission Factor tier and source
2A1 Cement production	PM2.5, PM10, TSP, BC	T1, T2 - EMEP EEA guidebook (2019) factors
2A2 Lime production	PM2.5, PM10, TSP, BC	T1, T2 - EMEP EEA guidebook (2019) factors
2A3 Glass production	All CLRTAP pollutants (except NOx, SOx, CO, POPs)	T2 - EMEP EEA guidebook (2019) factors
2A5a Quarrying and mining of minerals other than coal	PM2.5, PM10, TSP	T1 - EMEP EEA guidebook (2019) factors
2A5b Construction and demolition	PM2.5, PM10, TSP	T1 - EMEP EEA guidebook (2019) factors
2A5c Storage, handling and transport of mineral products	-	
2A6 Other mineral products (please specify in the IIR)	-	
2B1 Ammonia production	NOx, NH3, CO	T1 - EMEP EEA guidebook (2019) factors
2B2 Nitric acid production	NOx	T3 - measured emissions T2 - EMEP EEA guidebook (2019) factors
2B3 Adipic acid production	NOx, CO	T2 - EMEP EEA guidebook (2019) factors

NFR	Pollutants Reported	Emission Factor tier and source
2B5 Carbide production	TSP	T1 - EMEP EEA guidebook (2019) factors
2B6 Titanium dioxide production	-	
2B7 Soda ash production	NH3, TSP, CO	T1 - EMEP EEA guidebook (2019) factors
2B10a Chemical industry: Other (please specify in the IIR)	NOx, NMVOC, SOx, NH3, PM2.5, PM10, TSP, BC, CO, Hg	T1, T2 - EMEP EEA guidebook (2019) factors
2B10b Storage, handling and transport of chemical products (please specify in the IIR)	-	
2C1 Iron and steel production	All CLRTAP pollutants (except NH3)	T2 - EMEP EEA guidebook (2019) factors
2C2 Ferroalloys production	PM2.5, PM10, TSP, BC - Use NO notation after 2012	T1 - EMEP EEA guidebook (2019) factors
2C3 Aluminum production	NOx, SOx, PM2.5, PM10, TSP, BC, CO, PCDD/ PCDF, PAHs	T2 - EMEP EEA guidebook (2019) factors
2C4 Magnesium production	SOx, TSP	T1 - EMEP EEA guidebook (2019) factors
2C5 Lead production	SOx, PM2.5, PM10, TSP, Pb, Cd, As, Zn, PCDD/ PCDF, PCBs	T2 - EMEP EEA guidebook (2019) factors
2C6 Zinc production	SOx, PM2.5, PM10, TSP, Pb, Hg, Cd, As, Zn, PCDD/ PCDF, PCBs	T1 - EMEP EEA guidebook (2019) factors
2C7a Copper production	-	
2C7b Nickel production	-	
2C7c Other metal production (please specify in the IIR)	-	
2C7d Storage, handling and transport of metal products (please specify in the IIR)	-	
2D3a Domestic solvent use including fungicides	NMVOC	T3 - plant specific factors
2D3b Road paving with asphalt	NMVOC, PM2.5, PM10, BC, TSP	T2 - EMEP EEA guidebook (2019) factors
2D3c Asphalt roofing	NMVOC, PM2.5, PM10, BC, TSP, CO	T1 - EMEP EEA guidebook (2019) factors
2D3d Coating applications	NMVOC	T2 - EMEP EEA guidebook (2019) factor; T3- plant specific factors
2D3e Degreasing	NMVOC	T1 - EMEP EEA guidebook (2019) factor
2D3f Dry cleaning	NMVOC	T2 - EMEP EEA guidebook (2019) factor
2D3g Chemical products	NMVOC, TSP, Cd, As, Cr, Ni, Se	T1, T2 - EMEP EEA guidebook (2019) factors; T3 - measured emissions
2D3h Printing	NMVOC	T3 (measured emissions)
2D3i Other solvent use (please specify in the IIR)	NMVOC	T2 - EMEP EEA guidebook (2019) factor; T3 - measured emissions
2G Other product use (please specify in the IIR)	All CLRTAP pollutants (except Se, HCB, PCBs)	T2 - EMEP EEA guidebook (2019) factors; T3- measured emissions
2H1 Pulp and paper industry	NOx, NMVOC, SOx, PM2.5, PM10, BC, TSP, CO	T1 - EMEP EEA guidebook (2019) factors
2H2 Food and beverages industry	NMVOC	T2 - EMEP EEA guidebook (2019) factors
2H3 Other industrial processes (please specify in the IIR)	-	

NFR	Pollutants Reported	Emission Factor tier and source
2I Wood processing	TSP	T1 - EMEP EEA guidebook (2019) factors
2J Production of POPs	-	
2K Consumption of POPs and heavy metals (e.g. electrical and scientific equipment)	-	
2L Other production, consumption, storage, transportation or handling of bulk products (please specify in the IIR)	-	

Information on which source sectors include the condensable component of PM_{10} and $PM_{2.5}$, as provided by the Guidebook 2019:

For NFR 2C.1, 2.C.2, 2.C.3, 2.C.5 and 2.C.6, all tables of emission factors used in the actual estimation of particulate matter note that: “These PM factors represent filterable PM emissions only (excluding any condensable fraction).”

For NFR 2.D.3.b, is specified in a note below the table with emissions factors used: ”The TSP, PM_{10} and $PM_{2.5}$ emission factor represents filterable PM emissions. Note that US EPA (2004) includes condensable PM emission factors and factors for controlled plant”.

4.1 NFR 2.A.1 Cement production

This activity covers emissions from cement manufacture process. The present chapter only considers emissions of particulate matter from cement plants. According to the 2019 EMEP/EEA Guidebook emissions from the kiln are a combination of combustion and process emissions but the emissions of the main pollutants — NOx, sulphur oxides (SOx), CO, non-methane volatile organic compounds (NMVOC) and NH_3 — as well as heavy metals and persistent organic pollutants (POPs) are assumed to originate mainly from the combustion of the fuel. These emissions are therefore treated under NFR 1.A.2, which addresses combustion in cement production.

The methodology for estimating emissions of particulate matter is based on the use of the 2019 EMEP/EEA Guidebook, Chapter 3.2.2 Table 3.1 - Tier 1 default approach, for the time series 1990-2017, and Chapter 3.3.2 - Tier 2, Table 3.2 Abatement efficiencies applied to emission factors, for 2018-2022 time period.

The methodology for estimating emissions from cement production applies the general equation:

Epollutant = ARproduction× Efpollutant, where:

- $E_{pollutant}$ is the emission of the specified pollutant
- $AR_{production}$ is the activity rate for the cement production
- $EF_{pollutant}$ is the emission factor for this pollutant.

The activity data used for emission calculations is the annual national total clinker production from the “PRODROM” statistics, provided by the N.I.S.

Table 4.1.1. Activity data trends (kt product) for NFR 2.A.1. Cement production

Year	kt product
1990	8379
1991	6037
1992	5488
1993	5349
1994	5232
1995	5938
1996	6038
1997	5669
1998	5497
1999	4971
2000	5006
2001	5218
2002	4984
2003	4996
2004	5661
2005	6007
2006	6916
2007	7670
2008	7780
2009	5841
2010	5202
2011	5751
2012	5874
2013	5062
2014	5467
2015	6203
2016	5933
2017	6190
2018	6587
2019	7208
2020	7542
2021	7765
2022	7046

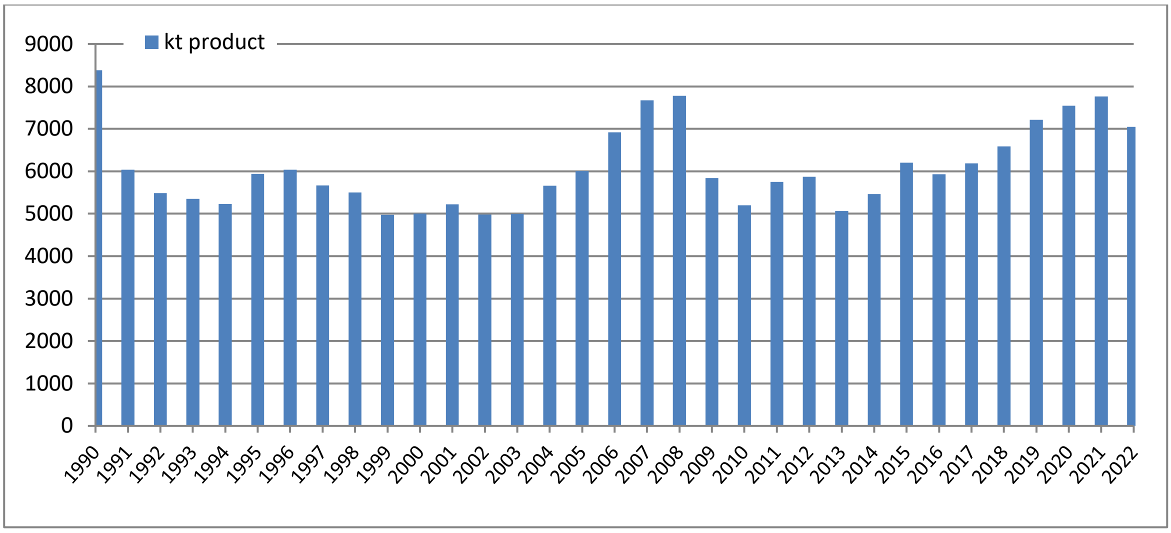


Figure 4.1.1. Activity data trend (kt product) for NFR 2.A.1. Cement production

The emissions trends for particles from the cement production are shown in the following table and figure.

Table 4.1.2. Emission Trends (kt) for NFR 2.A.1 Cement Production

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
1990	1.089	1.961	2.179
1991	0.785	1.413	1.570
1992	0.713	1.284	1.427
1993	0.695	1.252	1.391
1994	0.680	1.224	1.360
1995	0.772	1.389	1.544
1996	0.785	1.413	1.570
1997	0.737	1.327	1.474
1998	0.715	1.286	1.429
1999	0.646	1.163	1.292
2000	0.651	1.171	1.302
2001	0.678	1.221	1.357
2002	0.648	1.166	1.296
2003	0.649	1.169	1.299
2004	0.736	1.325	1.472
2005	0.781	1.406	1.562
2006	0.899	1.618	1.798
2007	0.997	1.795	1.994
2008	1.011	1.821	2.023
2009	0.759	1.367	1.519
2010	0.676	1.217	1.352
2011	0.748	1.346	1.495
2012	0.764	1.374	1.527
2013	0.658	1.184	1.316
2014	0.711	1.279	1.421
2015	0.806	1.452	1.613
2016	0.771	1.388	1.543

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
2017	0.805	1.448	1.609
2018	0.514	1.021	1.133
2019	0.562	1.117	1.240
2020	0.588	1.169	1.297
2021	0.606	1.204	1.336
2022	0.550	1.088	1.212

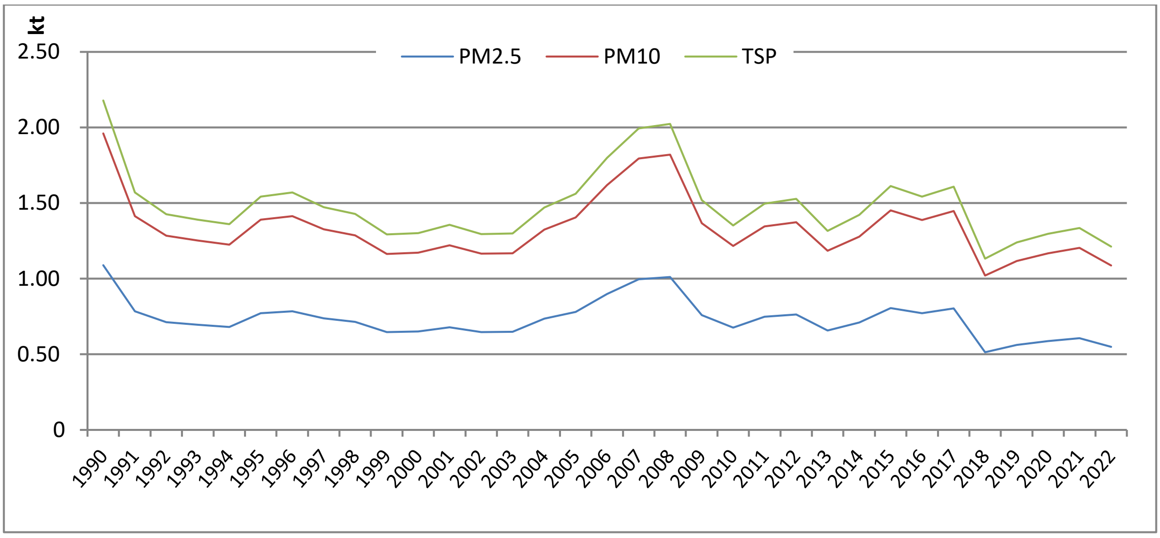


Figure 4.1.2. Emission Trends (kt) for NFR 2.A.1 Cement Production

The particulate matter emissions from this activity followed the activity data trend: for the 2000-2004 time period emissions recorded lower values, increasing from 2005 to 2008 when it recorded a peak and decreasing afterwards until 2010. For the 2010-2022 time period emissions recorded variations related to clinker production activity.

Recalculations and improvements:

- Improvement of emissions estimation from Tier 1 to Tier 2 methodology was performed for the recent years, when the BAT rules published in 04.2013 were implemented. There has been an interval of four years for transition, therefore, we have considered to apply the Tier 2 method for the years 2018-2022.

4.2 NFR 2.A.2 Lime production

The production of lime causes emissions from both processes and combustion. Emissions from combustion activities are treated under NFR 1.A.2. This chapter covers only emissions for particulate fractions.

The emissions are calculated based on Tier 1 and Tier 2 methodology for this process applying the general equation:

$E_{pollutant} = AR_{production} \times EF_{pollutant}$, where:

- $E_{pollutant}$ is the emission of the specified pollutant

- $AR_{production}$ is the activity rate for the lime production
- $EF_{pollutant}$ is the emission factor for this pollutant.

The emission factors used to calculate the emissions from lime production are from 2019 EMEP/EEA Guidebook:

- chapter NFR 2.A.2 Lime production, Table 3.1 for 1990-2017;

- chapter NFR 2.A.2 Lime production, Table 3.3 for 2018-2022.

Lime production is taken from the Statistical Yearbook provided by the N.I.S. and from the Romania's Greenhouse Gas Inventory - N.I.R., improving the consistency between data for NFR and CRF. These data are structured by type of lime: calcium quicklime and dolomitic lime. For the period 2000-2008 calcium quicklime production is taken from the Statistical Yearbook provided by the N.I.S applying a correction factor value. For the period 2009-2022 calcium quicklime production is taken from the economic operators. For dolomitic lime produced, the N.I.S. activity data are used for the 2000-2022 period.

Table 4.2.1. Activity data trend (kt product) for NFR 2.A.2. Lime production

Year	kt product
1990	2025
1991	1551
1992	1295
1993	1162
1994	1087
1995	1179
1996	1164
1997	1124
1998	1396
1999	1250
2000	1260
2001	1439
2002	1358
2003	1357
2004	1468
2005	1278
2006	1430
2007	1748
2008	1505
2009	1073
2010	1171
2011	1161
2012	1001
2013	964
2014	1233
2015	1050
2016	1062
2017	1125
2018	1165

Year	kt product
2019	1024
2020	695
2021	783
2022	605

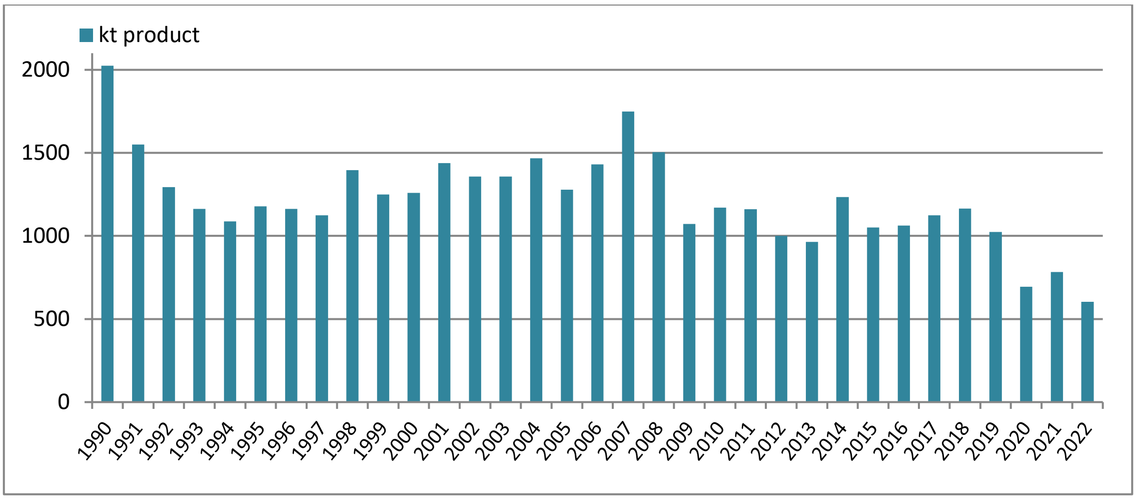


Figure 4.2.1. Activity data Trend (kt) for NFR 2.A.2. Lime production

The emission trends for particles from lime production are shown in the following table and figure.

Table 4.2.2. Emission Trends (kt) for NFR 2.A.2. Lime production

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
1990	1.418	7.088	18.225
1991	1.085	5.427	13.955
1992	0.906	4.532	11.654
1993	0.814	4.068	10.461
1994	0.761	3.804	9.782
1995	0.825	4.127	10.612
1996	0.814	4.072	10.472
1997	0.787	3.935	10.118
1998	0.977	4.885	12.561
1999	0.875	4.375	11.251
2000	1.031	5.157	13.260
2001	1.168	5.841	15.019
2002	1.123	5.614	14.435
2003	1.124	5.619	14.448
2004	1.205	6.026	15.496
2005	1.056	5.279	13.575
2006	1.175	5.877	15.112
2007	1.407	7.037	18.096
2008	1.249	6.243	16.054
2009	0.833	4.167	10.716
2010	0.937	4.686	12.051
2011	0.929	4.645	11.943
2012	0.814	4.071	10.467
2013	0.790	3.949	10.155

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
2014	0.863	4.314	11.094
2015	0.739	3.697	9.506
2016	0.743	3.717	9.557
2017	0.787	3.937	10.124
2018	0.035	0.233	0.466
2019	0.031	0.205	0.410
2020	0.021	0.139	0.278
2021	0.024	0.157	0.313
2022	0.018	0.121	0.242

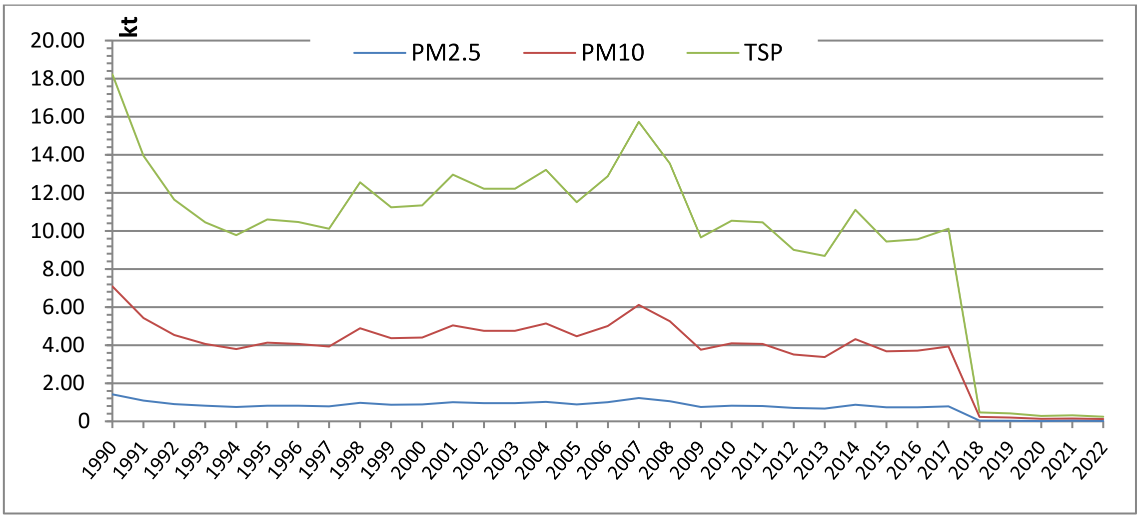


Figure 4.2.2. Emission Trends (kt) for NFR 2.A.2. Lime production

The emissions of $PM_{2.5}$, PM_{10} and TSP follow the activity data trends for lime production which varied substantially from year to year due to high variation of industry outputs.

Recalculations and improvements:

- Improvement of emissions estimation from Tier 1 to Tier 2 methodology was performed for the recent years, when the BAT rules published in 04.2013 were implemented. There has been an interval of four years for transition, therefore, we have considered to apply the Tier 2 method for the years 2018-2022.

4.3 NFR 2.A.3 Glass production

This activity covers emissions released during the production of the particular types of glass:

- Flat glass (SNAP 030314);
- Container glass (SNAP 030315);
- Glass wool (SNAP 0303156).

Emissions from combustion activities within the glass industry are treated under NFR 1.A.2.

NFR 2.A.3 is not a key source for any pollutant.

The emissions have calculated based on Tier 2 methodology for this process applying the general equation:

$$E_{pollutant} = \sum_{technologies} AR_{production,\ technology} \times EF_{technology,\ pollutant}$$

where:

- $AR_{production,\ technology}$ = the production rate within the source category, using this specific technology
- $EF_{technology,\ pollutant}$ = the emission factor for this technology and this pollutant

This equation is applied at the national level using annual national flat glass, container glass and glass wool production.

The emission factors used to calculate the emissions from glass production are from 2019 EMEP/EEA Guidebook, chapter 2.A.3 Glass production, Table 3.2, Table 3.3 and Table 3.5.

The glass production is taken from the Statistical Yearbook provided by the National Institute of Statistics (N.I.S.) and from the Romania's Greenhouse Gas Inventory – N.I.R., improving the consistency between data for NFR and CRF. The data and information on glass production was collected from economic operators. The glass quantity from the data collected from the economic operators is higher compared to the one provided by the N.I.S. due to the fact that data collected from the operators are the melted glass quantity and data from the N.I.S. represents the glass quantity sold. Since there are confidential data in some categories, only aggregated activity data are reported in the following table. There is no production of glass wool in 2016-2017.

Table 4.3.1. Activity data trend (kt product) for NFR 2.A.3. Glass production

Year	kt product
1990	925.88
1991	753.97
1992	621.27
1993	497.62
1994	545.88
1995	612.23
1996	651.43
1997	542.86
1998	482.54
1999	286.51
2000	389.05
2001	404.13
2002	404.13
2003	538.15
2004	385.63
2005	301.85
2006	284.04

Year	kt product
2007	461.81
2008	451.04
2009	358.02
2010	400.31
2011	386.43
2012	377.08
2013	373.58
2014	363.76
2015	394.66
2016	411.33
2017	401.93
2018	394.28
2019	358.70
2020	423.40
2021	463.70
2022	467.10

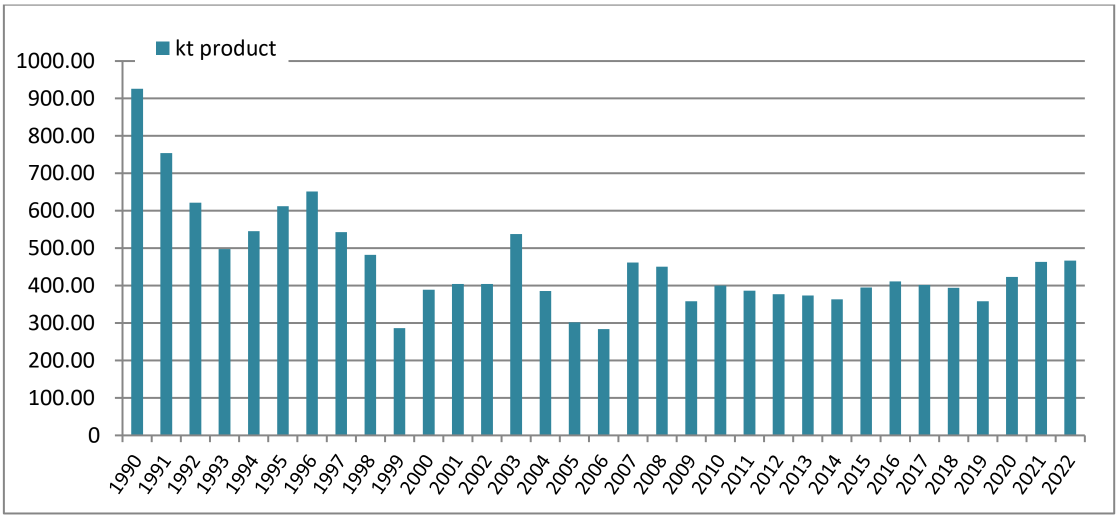


Figure 4.3.1. Activity data Trend (kt) for NFR 2.A.3. Glass production

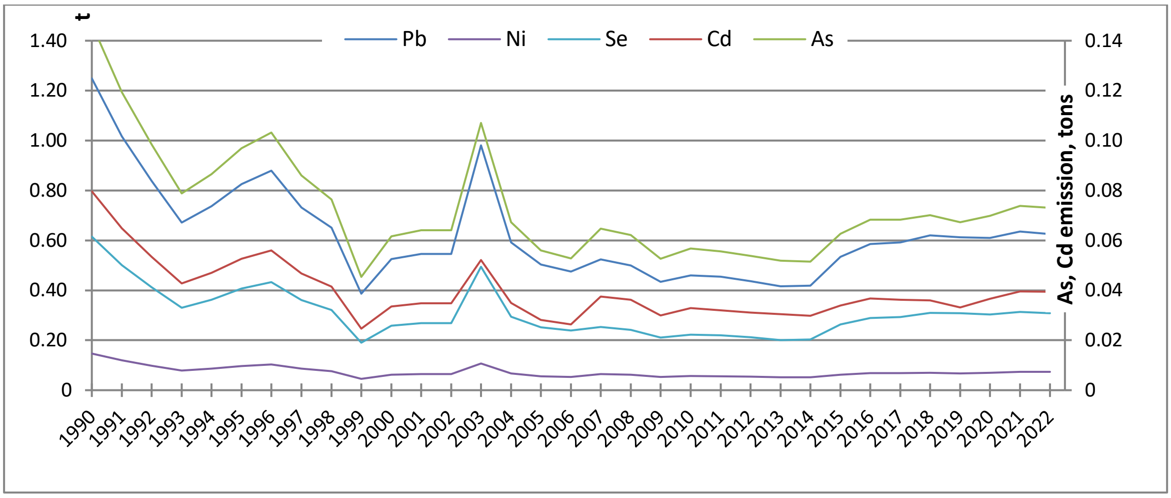
The emission trends for the glass production are shown in the following table and figure.

Table 4.3.2. Emission Trends (t) for NFR 2.A.3 Glass production

Year/Pollutant	Pb	Cd	As	Ni	Se
1990	1.249	0.080	0.147	0.488	0.615
1991	1.017	0.065	0.119	0.397	0.501
1992	0.838	0.053	0.098	0.327	0.413
1993	0.671	0.043	0.079	0.262	0.331
1994	0.736	0.047	0.086	0.288	0.363
1995	0.826	0.053	0.097	0.323	0.407
1996	0.879	0.056	0.103	0.343	0.433
1997	0.732	0.047	0.086	0.286	0.361
1998	0.651	0.042	0.076	0.254	0.321
1999	0.387	0.025	0.045	0.151	0.190
2000	0.525	0.033	0.062	0.205	0.258

Year/Pollutant	Pb	Cd	As	Ni	Se
2001	0.545	0.035	0.064	0.213	0.269
2002	0.545	0.035	0.064	0.213	0.269
2003	0.981	0.052	0.107	0.241	0.494
2004	0.592	0.035	0.067	0.193	0.295
2005	0.503	0.028	0.056	0.141	0.252
2006	0.476	0.026	0.053	0.131	0.239
2007	0.523	0.038	0.065	0.262	0.253
2008	0.500	0.036	0.062	0.255	0.241
2009	0.434	0.030	0.053	0.200	0.211
2010	0.460	0.033	0.057	0.228	0.223
2011	0.454	0.032	0.056	0.219	0.220
2012	0.437	0.031	0.054	0.214	0.212
2013	0.417	0.030	0.052	0.216	0.201
2014	0.419	0.030	0.052	0.206	0.203
2015	0.534	0.034	0.063	0.207	0.263
2016	0.586	0.037	0.068	0.220	0.289
2017	0.592	0.036	0.068	0.211	0.293
2018	0.621	0.036	0.070	0.192	0.310
2019	0.612	0.033	0.067	0.157	0.308
2020	0.610	0.037	0.070	0.207	0.303
2021	0.635	0.040	0.074	0.235	0.314
2022	0.625	0.039	0.073	0.238	0.308

Figure 4.3.2. Emission Trends (t) for NFR 2.A.3. Glass production



The emissions of Pb, Cd, As, Ni and Se follow the activity data trends for glass production.

Recalculations and improvements:

- There were no recalculations and improvements for this category.

4.4 NFR 2.A.5.a Quarrying and mining of minerals other than coal

The emissions of particulates are relevant for quarrying and mining of minerals other than coal. These emissions are generally fugitive in nature and it is difficult to quantify.

The methodology for estimating emissions of particulate matter is based on the use of the 2019 EMEP/EEA Guidebook, Chapter 3.2 - Tier 1 default approach, by multiplying the annual amount of minerals with emission factors from the Table 3.1.

NFR 2.A.5.a is key source category for PM_{10} and TSP pollutants (with a share of 3.5%, respectively 5.2% of the national total).

The activity data are provided by the N.I.S. and consist of production data for each product type: metalliferous ores of various kinds, stones, marble, granite, sandstone, limestone, clays, other minerals, other chemical and fertilizer minerals, etc. The annual quantity of extracted minerals is provided by the N.I.S., starting with 1993. From 1990-2003, the activity data for the metalliferous ores are provided by the N.I.S., and the quantity of minerals, other than the metalliferous, was estimated based on the production indices by industry, mining and quarrying.

The production of metalliferous ores has decreased heavily after 2000, and the other productions had variable increases. Since there are confidential data in some categories, only aggregated activity data are reported in the following table.

Table 4.4.1. Activity data trend (kt) for NFR 2.A.5.a Quarrying and mining of minerals other than coal

Year	Material quarried (kt)
1990	25448.15
1991	18620.62
1992	16069.24
1993	14107.11
1994	19997.79
1995	19745.21
1996	19674.72
1997	18188.54
1998	19859.53
1999	12171.58
2000	10743.95
2001	20488.47
2002	25294.18
2003	35296.49
2004	40419.96
2005	42586.00
2006	47544.97
2007	61606.59
2008	65103.74
2009	50510.80
2010	48843.36
2011	57046.19
2012	57290.47

Year	Material quarried (kt)
2013	57207.87
2014	59999.06
2015	73464.75
2016	75636.95
2017	64266.14
2018	68275.00
2019	88584.84
2020	100103.23
2021	99793.46
2022	100393.47

The emission trends for NFR 2.A.5.a are shown in the following table and figure.

Table 4.4.2. Emission Trends (kt) for NFR 2.A.5.a Quarrying and mining of minerals other than coal

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
1990	0.127	1.272	2.596
1991	0.093	0.931	1.899
1992	0.080	0.803	1.639
1993	0.071	0.705	1.439
1994	0.100	1.000	2.040
1995	0.099	0.987	2.014
1996	0.098	0.984	2.007
1997	0.091	0.909	1.855
1998	0.099	0.993	2.026
1999	0.061	0.609	1.242
2000	0.054	0.537	1.096
2001	0.102	1.024	2.090
2002	0.126	1.265	2.580
2003	0.176	1.765	3.600
2004	0.202	2.021	4.123
2005	0.213	2.129	4.344
2006	0.238	2.377	4.850
2007	0.308	3.080	6.284
2008	0.326	3.255	6.641
2009	0.253	2.526	5.152
2010	0.244	2.442	4.982
2011	0.285	2.852	5.819
2012	0.286	2.865	5.844
2013	0.286	2.860	5.835
2014	0.300	3.000	6.120
2015	0.367	3.673	7.493
2016	0.378	3.782	7.715
2017	0.321	3.213	6.555
2018	0.341	3.414	6.964
2019	0.443	4.429	9.036
2020	0.501	5.005	10.211
2021	0.499	4.990	10.179
2022	0.502	5.020	10.240

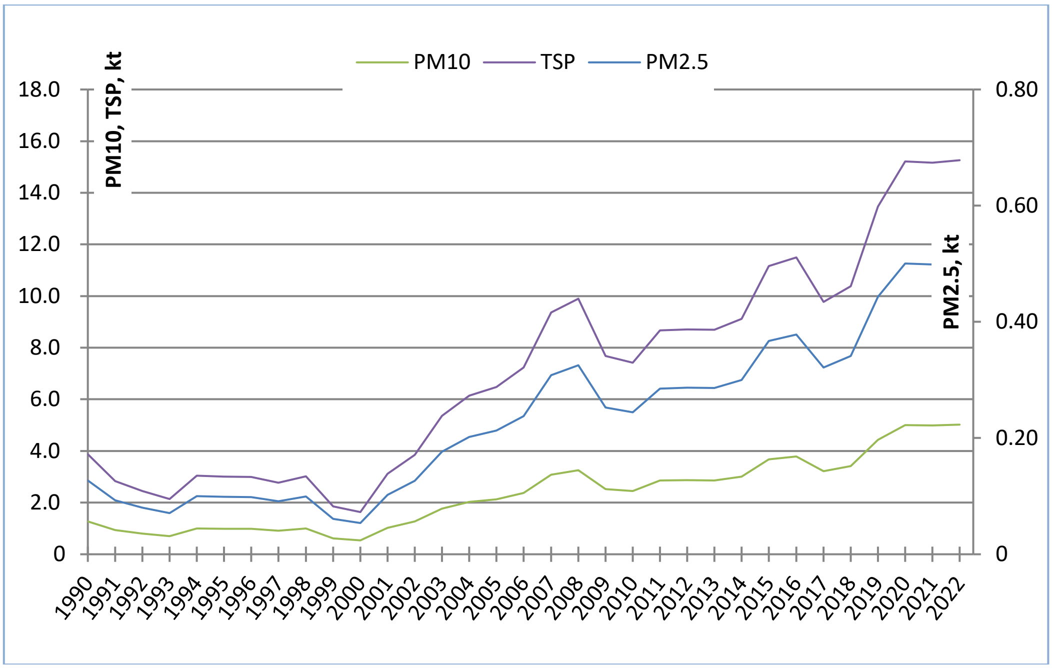


Figure 4.4.1. Emission Trends (kt) for NFR 2.A. 5.a Quarrying and mining of minerals other than coal

Recalculations and improvements:

- During the 2023 Review, the TERT noted in the question RO-2A5a-2023-0001 that a Tier 1 method is used for a key category, that using a Tier 1 method is not best practice and asked for a revised estimation for PM_{10} (and $PM_{2.5}$ and TSP) emissions from category 2A5a using a Tier 2 or Tier 3 method. In order to solve this issue, we have initiated the collection of information at national level. So far, the collected information is not sufficient for a reliable application of the Tier2 methodology provided by the Guidebook.

4.5 NFR 2.A.5.b Construction and demolition

Emissions of particulate matter are relevant for construction and are estimated using the default method given in the 2019 EMEP/EEA Guidebook, Chapter 2.A.5.b Construction and demolition.

The following equation is used:

- $EM = EF \cdot Aaffected \cdot d \cdot (1 – CE) \cdot (24/PE) \cdot (s/9\%)$

Where:

- EM = emission (kg)
- EF = the emission factor for pollutant emission (kg/[m² · year])
- A affected = area affected by construction activity (m²)
- d = duration of construction (year)
- CE = efficiency of emission control measures (-)

- PE = Thornthwaite precipitation-evaporation index (-)
- s = soil silt content (%)

The methodology for estimating emissions considers four main types of construction:

- Residential housing, single-or two family
- Residential housing, apartments
- Non-residential housing
- Road construction.

The activity data are required for each type of construction, but these activity data do not exist for Romania, so the activity data are estimate based on other statistics such as the total constructed utility floor area and the annually reported length of the road network, available from National Institute of Statistics (N.I.S.).
Regarding residential housing, the national statistics cover the total constructed utility floor area for both houses and apartments, and this is divided according to the percentage of houses and apartments, available from N.I.S.
In case of non-residential housing, the total constructed utility floor area is available from 2002, for the years 1990-2001 the same value was used as for year 2002.
The affected area is estimated using 0,8 m^2 footprint are per m^2 utility floor area, as it is suggested in the 2019 EMEP/EEA Guidebook.
The affected area for road construction is estimated from the total length of new road constructed (only new mains roads i.e. highways), which is available from national statistical using default width of exposed area from the guidebook.
The emission factors used are from the Table 3.1 to Table 3.4. The duration of construction (d) and the efficiency of emission control measures (CE) were used as presented in the guidebook. For the Thornthwaite precipitation-evaporation index (PE) the value of 120 is used and for soil silt content (s) 20% is used, as assumed for Germany.

Table 4.5.1. Area affected by construction activity (m^2) for NFR 2.A.5.b Construction and demolition

Year	Houses	Apartments	Non-residential housing	New roads
1990	1385503	2154539	1818487	0
1991	888996	1172977	1818487	0
1992	1259425	1095961	1818487	0
1993	1401366	886048	1818487	0
1994	1733890	1060748	1818487	0
1995	1763071	920922	1818487	0
1996	1662783	685040	1818487	0
1997	1789518	772254	1818487	0
1998	1860948	849686	1818487	0
1999	1882017	878743	1818487	0
2000	1842515	879575	1818487	0
2001	1988243	905585	1818487	0
2002	1990509	1043874	1818487	0

Year	Houses	Apartments	Non-residential housing	New roads
2003	2010389	1204296	2217350	0
2004	2057337	1437693	2447980	4140000
2005	2406446	1455091	3000996	0
2006	2963636	1732733	4267430	0
2007	3678925	2220658	5920100	1908000
2008	5088056	2811712	5456956	0
2009	4715579	2596564	3524523	1440000
2010	4187520	2035482	2779669	396000
2011	3986767	1810989	3513478	648000
2012	3787197	1758362	2833776	7200000
2013	3635093	1814922	2647615	3384000
2014	3377849	1872626	3215746	1404000
2015	3392603	1892046	2262618	2304000
2016	3707240	2112103	2004063	0
2017	3711782	2149530	2555798	576000
2018	3924517	2337276	2881797	2160000
2019	4320969	2727524	2950948	1548000
2020	4132112	2763589	2502332	1944000
2021	4597382	2823847	2649127	396000
2022	4930988	2849718	3080760	648000

NFR 2.A.5.b is key source for TSP pollutant in 2022 with 2.2% of the national total.
The emission trends for NFR 2.A.5.b are shown in the following table and figure.

Table 4.5.2. Emission Trends (kt) for NFR 2.A.5.b Construction and demolition

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
1990	0.058	0.577	1.914
1991	0.047	0.470	1.555
1992	0.047	0.469	1.553
1993	0.045	0.451	1.493
1994	0.047	0.475	1.572
1995	0.046	0.461	1.527
1996	0.044	0.436	1.442
1997	0.045	0.447	1.480
1998	0.046	0.456	1.510
1999	0.046	0.459	1.521
2000	0.046	0.459	1.519
2001	0.046	0.464	1.537
2002	0.048	0.478	1.583
2003	0.057	0.568	1.881
2004	0.275	2.751	9.186
2005	0.075	0.745	2.467
2006	0.102	1.017	3.366
2007	0.236	2.360	7.845
2008	0.138	1.385	4.587
2009	0.174	1.736	5.779
2010	0.100	0.999	3.318
2011	0.124	1.237	4.108

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
2012	0.445	4.451	14.875
2013	0.247	2.469	8.241
2014	0.156	1.563	5.202
2015	0.185	1.849	6.169
2016	0.065	0.652	2.163
2017	0.105	1.052	3.497
2018	0.194	1.944	6.482
2019	0.169	1.691	5.633
2020	0.181	1.810	6.037
2021	0.106	1.061	3.528
2022	0.128	1.279	4.252

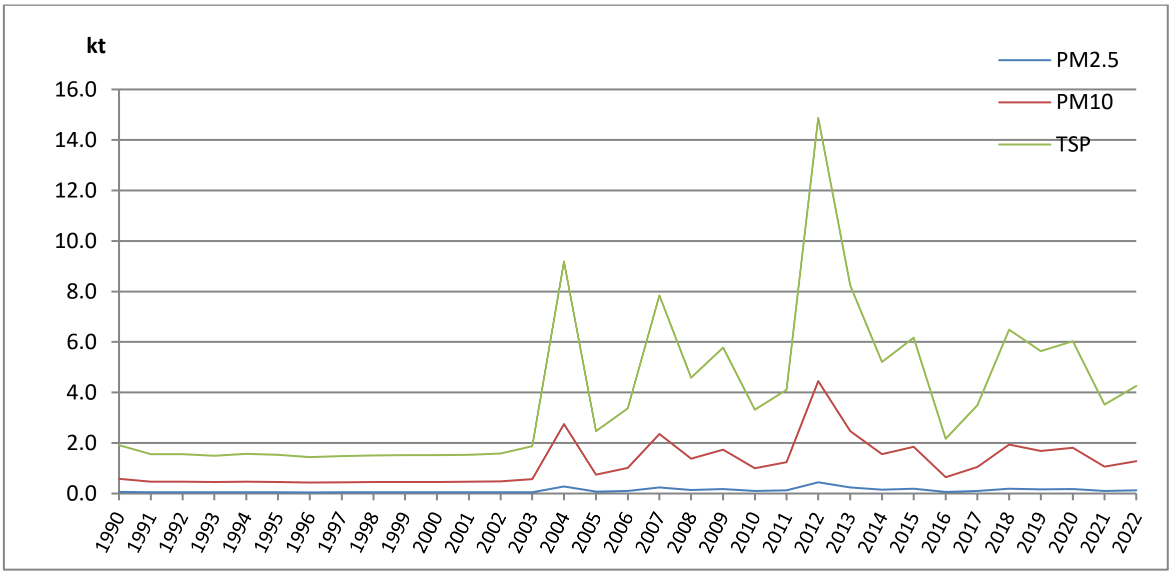


Figure 4.5.1. Emission Trends (kt) for NFR 2.A.5.b Construction and demolition

Particulate matter emissions followed the trend of activity data, with peaks in the years when new roads were built.

Recalculations and improvements:

- Recalculated 2021 due to a slight revision of the activity data by NIS.

4.6 NFR 2.B.1 Ammonia production

This activity covers emissions from ammonia manufacture process.

NFR 2.B.1 is not a key source for any pollutant.

The methodology for estimating emissions of NOx, NH_3 and CO is based on the use of the 2019 EMEP/EEA Guidebook, Chapter 2.B Chemical industry, by multiplying the annual amount of ammonia production with default emission factors.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from ammonia productions is not included.

The activity data used for emission calculations is the annual national total ammonia production from the Statistical Yearbook provided by the N.I.S. Since 2015 the ammonia production data are confidential.

Table 4.6.1. Activity data trend (kt) for NFR 2.B.1. Ammonia production

Year	kt production
1990	2178.00
1991	1375.00
1992	1733.00
1993	1620.00
1994	1443.00
1995	1809.00
1996	1841.00
1997	951.00
1998	467.53
1999	833.93
2000	1254.70
2001	1154.73
2002	1137.46
2003	1444.66
2004	1422.14
2005	1611.00
2006	1580.00
2007	1371.00
2008	1275.00
2009	1139.00
2010	1392.00
2011	1588.00
2012	1543.00
2013	1127.00
2014	1193.00

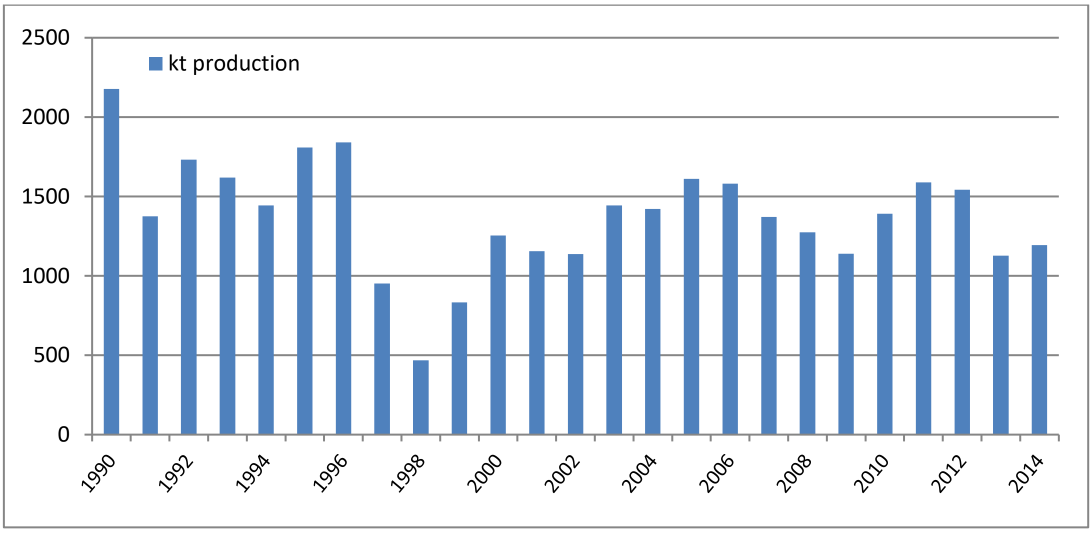


Figure 4.6.1. Activity data trend (t) for NFR 2.B.1. Ammonia production

The emission trends are shown below in the following table and figures.

Table 4.6.2 Total Emission Trends (kt) for NFR 2.B.1. Ammonia production

Year/Pollutant	NOx	NH_3	CO
1990	2.178	0.022	0.218
1991	1.375	0.014	0.138
1992	1.733	0.017	0.173
1993	1.620	0.016	0.162
1994	1.443	0.014	0.144
1995	1.809	0.018	0.181
1996	1.841	0.018	0.184
1997	0.951	0.010	0.095
1998	0.468	0.005	0.047
1999	0.834	0.008	0.083
2000	1.255	0.013	0.125
2001	1.155	0.012	0.115
2002	1.137	0.011	0.114
2003	1.445	0.014	0.144
2004	1.422	0.014	0.142
2005	1.611	0.016	0.161
2006	1.580	0.016	0.158
2007	1.371	0.014	0.137
2008	1.275	0.013	0.128
2009	1.139	0.011	0.114
2010	1.392	0.014	0.139
2011	1.588	0.016	0.159
2012	1.543	0.015	0.154
2013	1.127	0.011	0.113
2014	1.193	0.012	0.119
2015	0.607	0.006	0.061
2016	0.537	0.005	0.054
2017	0.628	0.006	0.063
2018	0.656	0.007	0.066
2019	0.570	0.006	0.057
2020	0.840	0.008	0.084
2021	0.439	0.004	0.044
2022	0.000	0.000	0.000

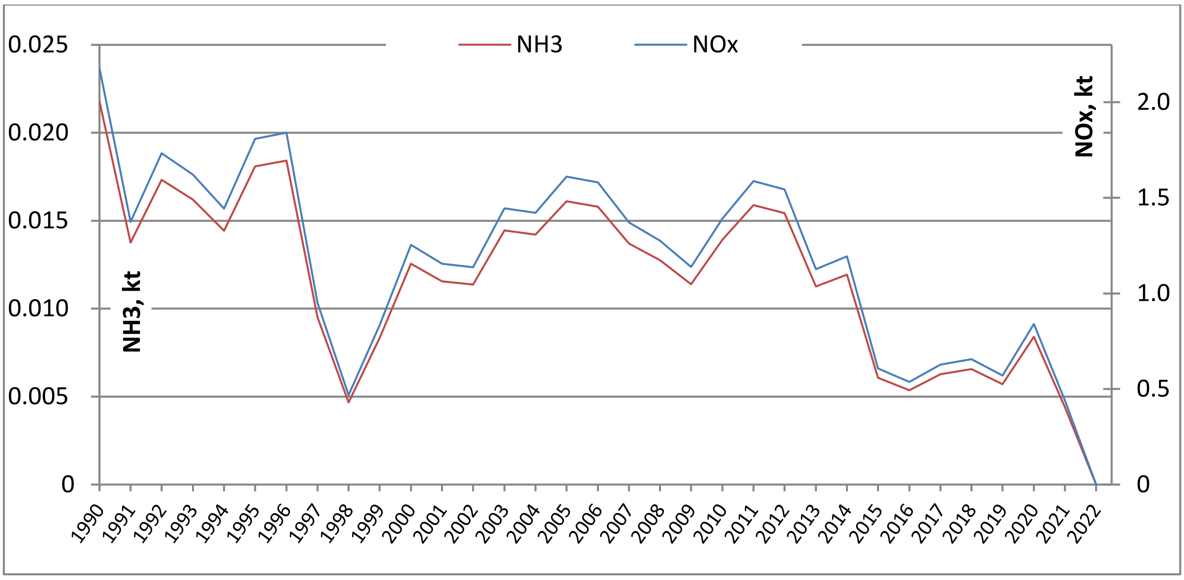


Figure 4.6.2a Total Emission Trends (kt) for NOx and NH_3 for NFR 2.B.1. Ammonia production

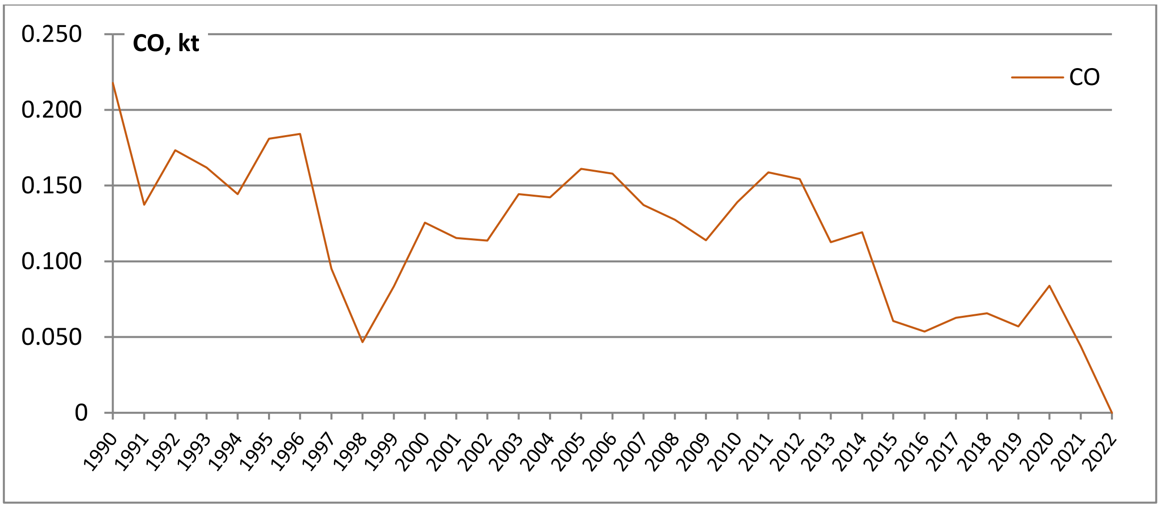


Figure 4.6.2b Total Emission Trends (kt) for CO for NFR 2.B.1. Ammonia production

The emissions of NOx, NH_3 and CO follow the activity data trends for ammonia production which varies substantially from year to year due to high variation of industry outputs.

Recalculations and improvements:

- There were no recalculations and improvements for this category.

4.7 NFR 2.B.2 Nitric acid production

This activity covers emissions from nitric acid manufacture process. At industrial scale, nitric acid is produced by synthesis, from ammonia, atmospheric air and water.

The methodology for estimating emissions of NOx is based on the use of the 2019 EMEP/EEA Guidebook, Chapter 2.B Chemical industry, using Tier 2 or Tier 3 approach. Approach Tier 2 was used for nitric acid production facilities that do not have continuous emission monitoring systems. Approach Tier 3 was used for nitric acid production facilities that have Continuous Emissions Monitoring Systems.

Emissions of nitrogen oxide were estimated by multiplying annual nitric acid production (tons 100% HNO_3 by each plant) by a default emission factor.

The nitric acid production is from the Romania's Greenhouse Gas Inventory – N.I.R., improving the consistency between data for NFR and CRF. Activity data and emissions are collected directly from nitric acid production plants for each facility and each year to use a higher Tier methodology. In Romania, in 1990 there were seven chemical plants with ten nitric acid production plants. In 2014 there were five chemical plants with six nitric acid production plants (medium and high pressure) and one old plant, without non-catalytic reduction (SNCR), erected before 1975. In 2017 there were only two chemical plants, where four nitric acid production facilities are in operation.

The nitric acid production submitted by operators were compared to the production acquired from the N.I.S. and it was discovered that the production registered by the N.I.S is constantly lower. This can be explained through the fact that certain operators do not report the production values, as they are confidential.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from nitric acid production is not included.

NFR 2.B.2 is not a key source for NOx pollutant.

The NOx emissions trends are shown below in the following table and figure.

Table 4.7.1. Emission trends (kt) for NFR 2.B.2. Nitric acid production

Year/Pollutant	NOx
1990	9.708
1991	5.667
1992	8.027
1993	7.826
1994	6.680
1995	7.726
1996	7.945
1997	4.923
1998	3.858
1999	4.141
2000	5.643
2001	5.101
2002	5.353
2003	3.470

Year/Pollutant	NOx
2004	2.248
2005	2.923
2006	2.304
2007	2.492
2008	2.176
2009	2.157
2010	3.695
2011	3.280
2012	1.925
2013	0.809
2014	0.827
2015	0.488
2016	0.401
2017	0.307
2018	0.365
2019	0.276
2020	0.346
2021	0.281
2022	0.037

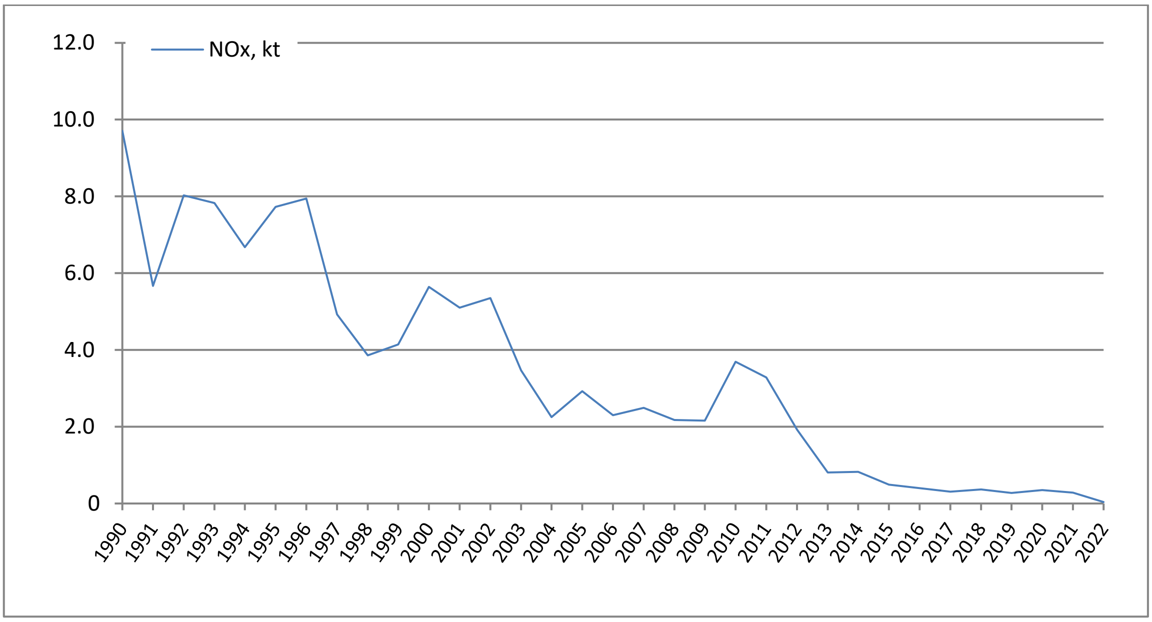


Figure 4.7.1. Emission trends (kt) for NOx for NFR 2.B.2. Nitric acid production

The emissions of NOx follow the activity data trends for nitric acid production which varied substantially from year to year due to high variation of industry outputs. In recent years, most nitric acid production facilities have been fitted with emission reduction and monitoring systems, leading to the drop of emissions.

Recalculations and improvements:

- There were no recalculations and improvements for this category.

4.8 NFR 2.B.3 Adipic acid production

This activity covers emissions from adipic acid manufacture process.

The methodology for estimating emissions of NOx and CO is based on the use of the 2019 EMEP/EEA Guidebook, Chapter 2.B Chemical industry, by multiplying the annual amount of adipic acid production with Tier 2 emission factors from the Table 3.16.

The activity data used for emission calculations is the annual national total adipic acid production from the "PRODROM" statistics, provided by the N.I.S. There is no adipic acid production since the year 2002.

NFR 2.B.3 is not key category for any pollutant.

NOx and CO emissions followed the activity data with peaks in the years 1998 and 2000.

Table 4.8.1. Activity data trend (kt adipic acid) for NFR 2.B.3 Adipic acid production

Year	kt production
1990	6.17
1991	5.25
1992	3.73
1993	5.88
1994	5.78
1995	6.37
1996	6.42
1997	8.97
1998	9.31
1999	7.46
2000	9.26
2001	5.32

Table 4.8.2. Emission trends (kt) for NFR 2.B.3 Adipic acid production

Year	NOx	CO
1990	0.04935	0.00247
1991	0.04202	0.00210
1992	0.02983	0.00149
1993	0.04703	0.00235
1994	0.04621	0.00231
1995	0.05095	0.00255
1996	0.05136	0.00257
1997	0.07173	0.00359
1998	0.07450	0.00372
1999	0.05969	0.00298
2000	0.07406	0.00370
2001	0.04258	0.00213

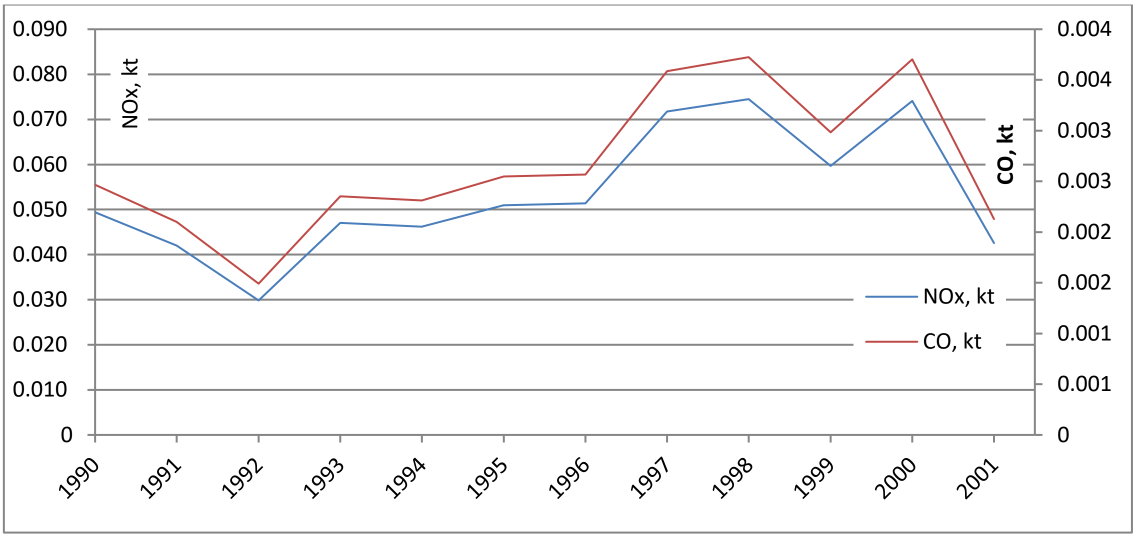


Figure 4.8.1. Emission trends (kt) for NFR 2.B.3 Adipic acid production

Recalculations and improvements:

- There were no recalculations and improvements for this category.

4.9 NFR 2.B.5 Carbide production

This activity covers emissions from carbide manufacture process.

The methodology for estimating emissions of TSP is based on the use of the 2019 EMEP/EEA Guidebook, Chapter 2.B Chemical industry, by multiplying the annual amount of carbide production with Tier 1 emission factors from the Table 3.5.

The activity data used for emission calculations is the annual national total calcium carbide production from the Statistical Yearbook provided by the N.I.S. There is no calcium carbide production in the 2007-2020 period.

NFR 2.B.5 is not a key source for TSP pollutant.

Table 4.9.1. Activity data trend (kt Carbide) for NFR 2.B.5 Carbide production

Year	kt production
1990	129
1991	94
1992	87
1993	82
1994	67
1995	90
1996	106
1997	91
1998	73
1999	54
2000	55

Year	kt production
2001	53
2002	53
2003	45
2004	63
2005	34
2006	20
2021	0.00067
2022	0.71

The emission trends are shown below in the following figure.

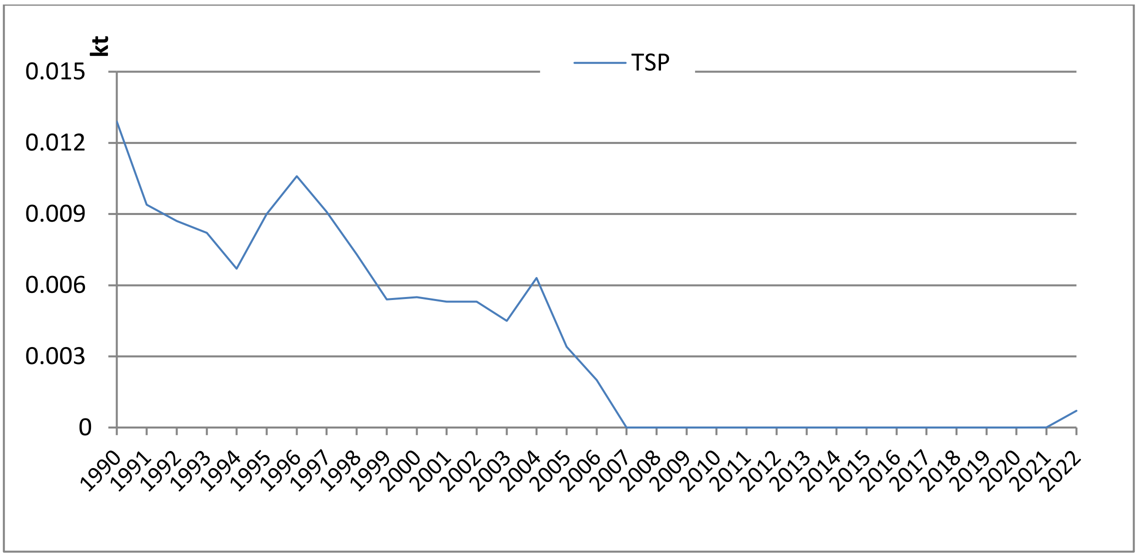


Figure 4.9.1. Total Emission trends (kt) for TSP for NFR 2.B.5 Carbide production

TSP emissions followed the activity data trend for carbide production, with a peak in 1996.

Recalculations and improvements:
- There were not recalculations since the previous submission.

4.10 NFR 2.B.7 Soda ash production

This activity covers emissions from soda ash manufacture process.

NFR 2.B.7 is not a key source for any pollutant.

The methodology for estimating emissions of NH_3, TSP and CO is based on the use of the 2019 EMEP/EEA Guidebook, Chapter 2.B Chemical industry, by multiplying the annual amount of soda ash production with default emission factors.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions for soda ash production is not included.

The activity data used for emission calculations is the annual national total soda ash production from the Statistical Yearbook provided by the National Institute of Statistics. These data are confidential since the year 2007. There is no soda ash production since year 2020.

The emission trends are shown below in the following table and figure.

Table 4.10.1. Emission trends (kt) for NFR 2.B.7 Soda Ash production

Year/Pollutant	NH_3	TSP	CO
1990	0.5688	0.0632	5.6880
1991	0.4239	0.0471	4.2390
1992	0.4068	0.0452	4.0680
1993	0.3339	0.0371	3.3390
1994	0.4041	0.0449	4.0410
1995	0.4536	0.0504	4.5360
1996	0.4824	0.0536	4.8240
1997	0.4923	0.0547	4.9230
1998	0.4155	0.0462	4.1548
1999	0.3733	0.0415	3.7329
2000	0.3519	0.0391	3.5195
2001	0.4029	0.0448	4.0292
2002	0.4089	0.0454	4.0886
2003	0.3653	0.0406	3.6534
2004	0.3584	0.0398	3.5836
2005	0.3114	0.0346	3.1140
2006	0.4077	0.0453	4.0770
2007	0.4068	0.0452	4.0680
2008	0.4446	0.0494	4.4460
2009	0.3681	0.0409	3.6810
2010	0.3393	0.0377	3.3930
2011	0.3753	0.0417	3.7530
2012	0.3852	0.0428	3.8520
2013	0.3825	0.0425	3.8250
2014	0.3771	0.0419	3.7710
2015	0.4545	0.0505	4.5450
2016	0.4644	0.0516	4.6440
2017	0.4860	0.0540	4.8600
2018	0.4824	0.0536	4.8240
2019	0.3087	0.0343	3.0870

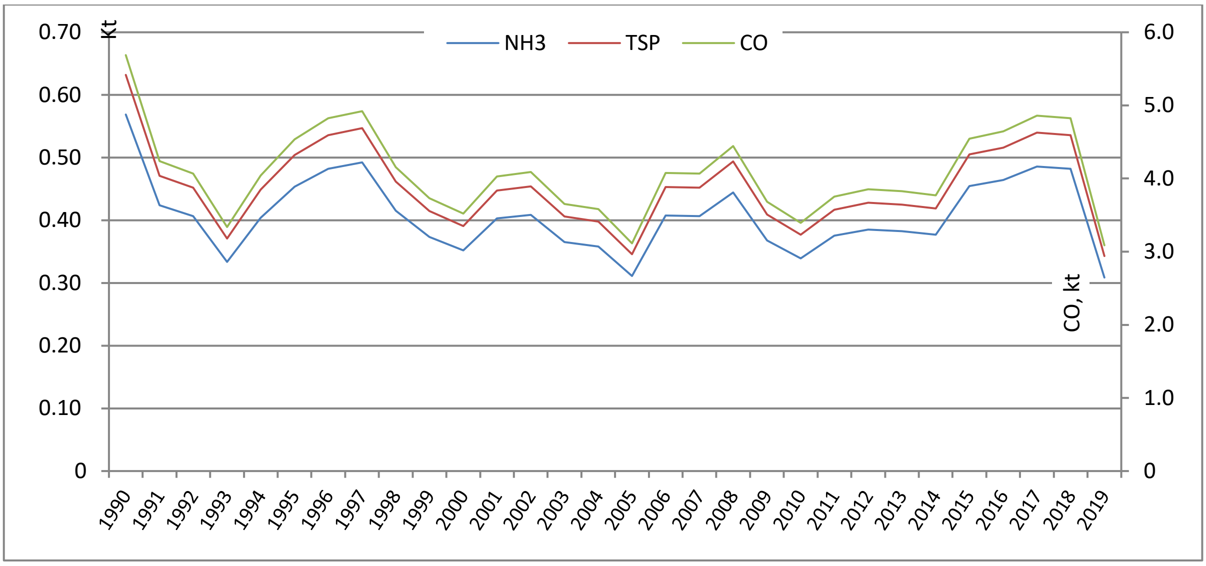


Figure 4.10.1. Emission trends (kt) for NFR 2.B.7 Soda Ash production

The emissions of NH_3 and TSP follow the activity data trends for soda ash production which varied substantially from year to year due to high variation of industry outputs.

Recalculations and improvements:

- There were not recalculations since the previous submission.

4.11 NFR 2.B.10.a Other chemical industry

This source includes a large collection of different chemical production processes, listed below with corresponding SNAP codes:

- 040407 NPK fertilisers;
- 040408 Urea (not available between 1990-1993);
- 040409 Carbon black (production stopping in year 2003);
- 040413 Chlorine (production using mercury cell technology stopping in year 2014);
- 040501 Ethylene (production stopping in year 2009);
- 040502 Propylene;
- 040506 Polyethylene Low Density (production starting in year 2001);
- 040507 Polyethylene High Density (production starting in year 2001);
- 040508 Polyvinylchloride
- 040509 Polypropylene (production starting in year 2003);
- 040511 Polystyrene (production starting in year 2001);
- 040514 Styrene-butadiene rubber (SBR) (production stopping in year 2014);
- 040516 Ethylene oxide (produced between 2003-2007).

The methodology for estimating emissions from chemical production applies the general equation:

$$Epollutant = \sum_{technologies} ARproduction, technology \times EFtechnology, pollutant$$

where:

- ARproduction, technology = the production rate within the source category, using this specific technology
- EFtechnology, pollutant = the emission factor for this technology and this pollutant

The activity data used for the emission calculations are the total productions of each product. These data are provided by N.I.S., with the exception of chlorine production provided by economic operators. These data are confidential.
Chlorine production was taken from economic operators and Hg emissions were estimated for the 1990-2013. Mercury emissions mainly come from the manufacture of chlorine using mercury cell technology. Chlorine production using this process stopped during 2013. Starting with 2014 in Romania, chlorine is produced only by membrane cell electrolysis. No emission factors are available for this in the 2019 EMEP/EEA Guidebook and the notation key NO is used for Hg emissions.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from other chemical industry production is not included.

NFR 2.B.10.a is not a key source for any pollutant.
The emission trends of NMVOC, $PM_{2.5}$, PM_{10} and TSP are shown below in the following table. Other pollutants such as NOx, SOx, NH_3, Hg and CO are estimated only for the period in which the chemicals that generated these pollutants were produced.

Table 4.11.1. Emission Trends of NMVOC, $PM_{2.5}$, PM_{10}, and TSP for NFR 2.B.10.a Other chemical industry

Year/Pollutant	NMVOC (kt)	$PM_{2.5}$ (kt)	PM_{10} (kt)	TSP (kt)
1990	14.772	0.015	0.031	87.258
1991	9.191	0.011	0.013	54.514
1992	11.519	0.007	0.016	69.932
1993	10.841	0.007	0.017	65.883
1994	9.624	0.065	0.098	58.291
1995	12.004	0.054	0.083	72.572
1996	12.100	0.072	0.106	73.348
1997	7.151	0.074	0.111	42.656
1998	3.917	0.096	0.138	22.723
1999	6.381	0.054	0.084	38.273
2000	8.740	0.059	0.090	52.819
2001	8.039	0.072	0.108	47.137
2002	7.893	0.074	0.114	46.147
2003	11.494	0.097	0.147	67.696
2004	10.606	0.199	0.287	61.608
2005	14.301	0.264	0.374	84.721

Year/Pollutant	NMVOC (kt)	$PM_{2.5}$ (kt)	PM_{10} (kt)	TSP (kt)
2006	10.009	0.147	0.217	57.540
2007	10.304	0.185	0.271	58.670
2008	15.334	0.201	0.288	89.886
2009	8.423	0.084	0.115	48.476
2010	10.143	0.028	0.040	59.678
2011	11.045	0.090	0.123	64.697
2012	8.769	0.141	0.189	50.825
2013	6.580	0.105	0.141	37.400
2014	6.919	0.056	0.076	39.485
2015	4.265	0.058	0.079	23.177
2016	3.604	0.022	0.031	18.674
2017	4.056	0.054	0.075	21.528
2018	4.749	0.060	0.082	25.278
2019	4.156	0.051	0.071	21.772
2020	5.669	0.072	0.098	31.423
2021	3.433	0.066	0.092	17.966
2022	1.090	0.001	0.004	2.773

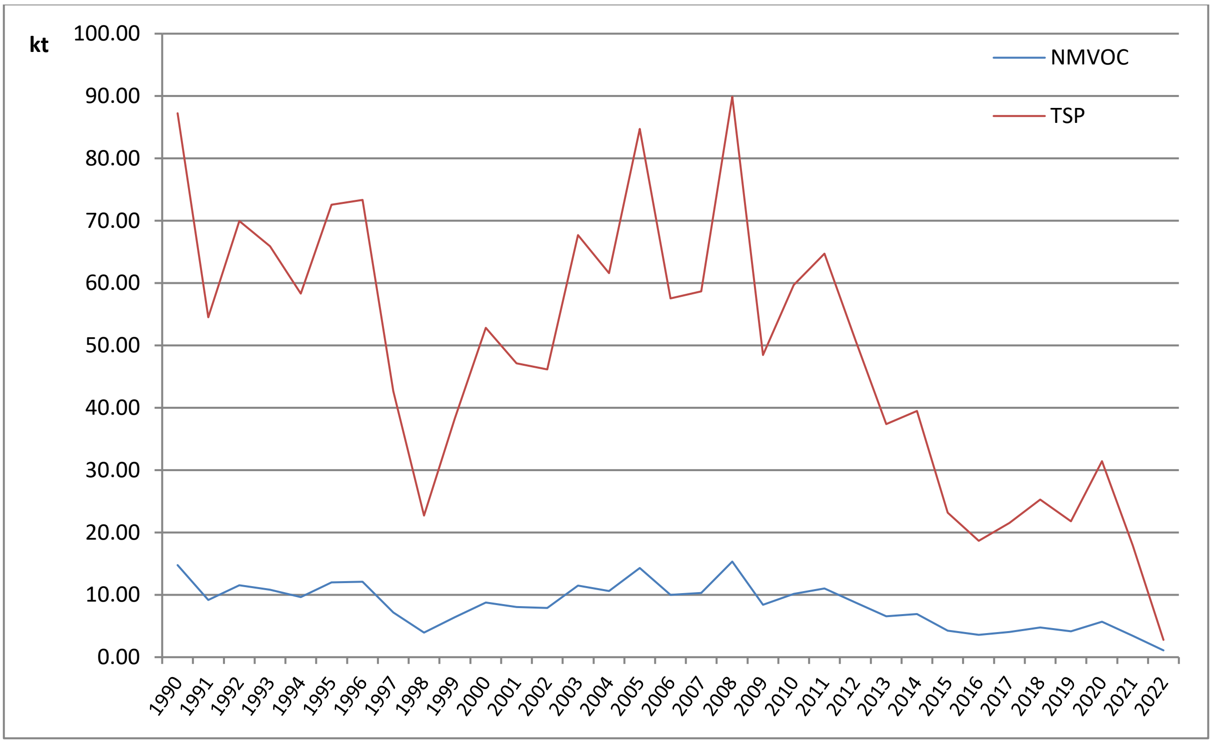


Figure 4.11.1 Emission Trends (kt) of NMVOC and TSP for NFR 2.B.10.a Other chemical industry

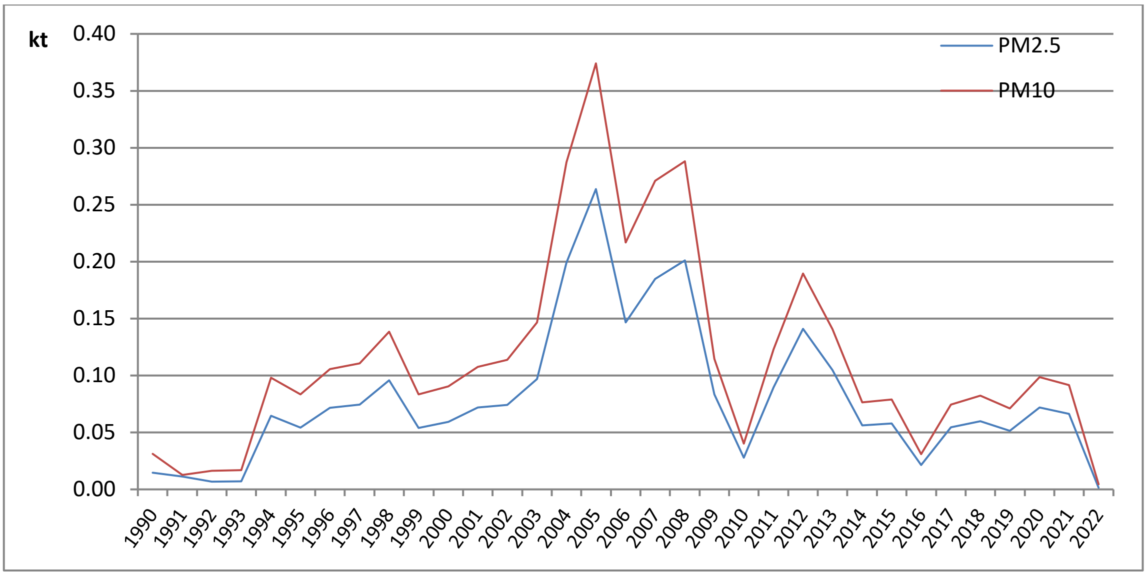


Figure 4.11.2 Emission Trends (kt) of $PM_{2.5}$ and PM_{10} for NFR 2.B.10.a Other chemical industry

The emissions of NMVOC, PM2.5, PM10 and TSP from those activities follow the activity data trends of other chemical industries which varied substantially from year to year due to high variation of industry outputs.

Recalculations and improvements:

- There were not recalculations since the previous submission.

4.12 NFR 2.C.1 Iron and steel production

This source category covers the following activities with corresponding SNAP codes:

- 040202 Blast furnace charging;
- 040205 Open hearth furnace steel plant;
- 040206 Basic oxygen furnace steel plant;
- 040207 Electric furnace steel plant;
- 040208 Rolling mills;
- 040209 Sinter and pelletizing plants.

In this sector are reported only the process emissions in iron and steel production. The emissions from combustion activities within the iron and steel industry are reported under NFR 1.A.2.a.

CLRTAP pollutants, except NH3, are estimated in this sector.

The methodology for estimating emissions from iron and steel production applies the general equation:

$$\text{Epollutant} = \sum_{\text{technologies}} \text{ARproduction, technology x EFtechnology, pollutant}$$

where:

- ARproduction, technology = the production rate within the source category, using this specific technology
- EFtechnology, pollutant = the emission factor for this technology and this pollutant

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from iron and steel production is not included.
The activity data used for emission calculations are represented by the total production of each product from the Statistical Yearbook provided by the National Institute of Statistics. These data are confidential since 2007.

NFR 2.C.1 is a key source for emissions of Pb (45.1%), Cd (10.5%), Hg (11.5%), As (22.9%), Cr (30.8%), Ni (9.7%), Zn (8.6%), PCDD/F (13.4%) and PCBs (69.5%) in 2022.

The emission trends for the key pollutants are shown below in the following table and figures.

Table 4.12.1. Emission Trends of key pollutants for NFR 2.C.1. Iron and steel production

Year	Pb (t)	Cd (t)	Hg (t)	As (t)	Cr (t)	Ni (t)	Zn (t)	PCDD/F (g I-TEQ)	PCBs (kg)
1990	696.218	2.560	0.605	65.798	17.377	24.388	47.818	89.011	35.878
1991	434.054	1.716	0.453	40.558	12.202	15.467	33.804	65.690	26.542
1992	301.439	1.255	0.351	27.952	8.802	10.913	25.039	50.001	19.476
1993	321.650	1.294	0.349	29.977	9.199	11.518	25.642	50.322	19.688
1994	340.045	1.353	0.365	31.708	10.101	12.098	27.334	53.280	21.240
1995	333.604	1.375	0.403	30.815	11.881	11.853	30.296	59.858	25.070
1996	321.158	1.291	0.369	29.778	11.232	11.327	28.313	55.286	23.475
1997	325.161	1.317	0.393	30.008	12.845	11.375	30.791	60.179	26.341
1998	245.003	1.072	0.366	22.158	12.532	8.579	28.420	56.899	26.083
1999	127.691	0.661	0.262	11.105	8.319	4.645	19.039	39.914	17.988
2000	33.328	0.495	0.295	1.482	8.128	1.726	18.702	43.434	19.765
2001	35.258	0.518	0.310	1.579	8.665	1.802	19.771	45.801	20.890
2002	39.804	0.521	0.325	1.916	10.554	1.768	22.188	49.991	24.169
2003	41.086	0.557	0.343	1.937	10.655	1.908	22.951	52.132	24.997
2004	43.617	0.618	0.375	2.001	10.994	2.135	24.421	56.049	26.348
2005	44.623	0.681	0.403	1.943	10.650	2.391	25.088	58.672	26.510
2006	44.342	0.697	0.408	1.889	10.340	2.460	24.969	58.842	26.094
2007	44.352	0.699	0.409	1.885	10.318	2.469	24.978	58.909	26.047
2008	35.420	0.583	0.337	1.453	7.940	2.075	19.996	47.713	20.445
2009	19.422	0.328	0.188	0.781	4.260	1.170	10.980	26.371	11.124
2010	25.506	0.495	0.272	0.889	4.811	1.808	14.555	36.374	13.943
2011	25.873	0.528	0.286	0.848	4.572	1.940	14.812	37.585	13.853

Year	Pb (t)	Cd (t)	Hg (t)	As (t)	Cr (t)	Ni (t)	Zn (t)	PCDD/F (g I-TEQ)	PCBs (kg)
2012	23.240	0.470	0.255	0.771	4.161	1.724	13.298	33.638	12.515
2013	21.416	0.373	0.212	0.836	4.552	1.341	12.127	29.401	11.962
2014	22.151	0.397	0.223	0.840	4.571	1.434	12.569	30.716	12.347
2015	23.996	0.402	0.231	0.970	5.293	1.436	13.560	32.517	13.713
2016	23.619	0.396	0.227	0.954	5.205	1.414	13.346	32.017	13.531
2017	23.805	0.436	0.244	0.884	4.802	1.579	13.531	33.254	13.335
2018	24.584	0.430	0.243	0.957	5.213	1.544	13.930	33.780	13.950
2019	24.080	0.393	0.227	0.996	5.442	1.396	13.585	32.338	13.888
2020	20.114	0.298	0.178	0.895	4.913	1.039	11.285	26.197	11.902
2021	23.983	0.378	0.221	1.019	5.579	1.335	13.504	31.852	13.943
2022	18.367	0.313	0.179	0.732	3.994	1.119	10.389	25.015	10.471

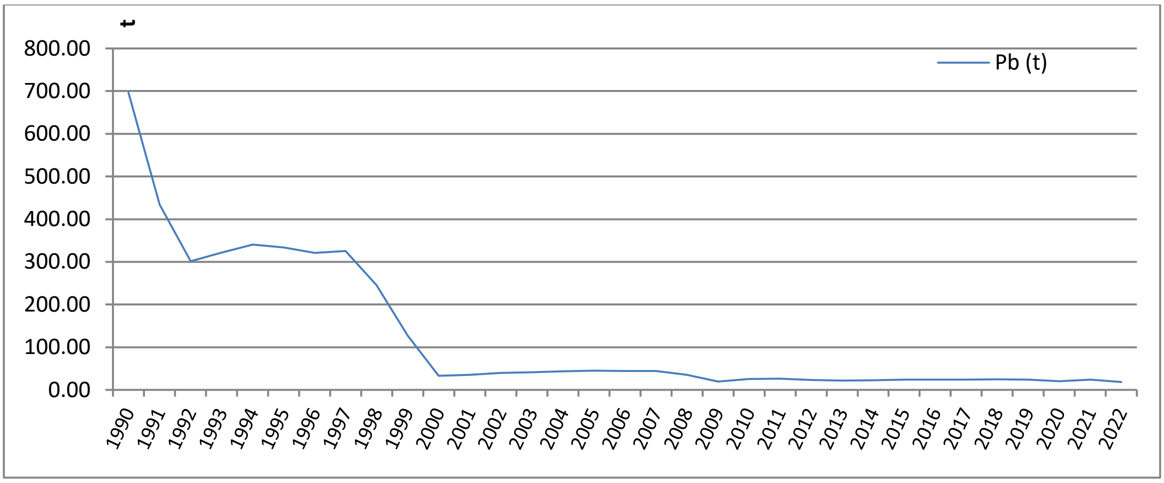


Figure 4.12.1.a Emission Trends of Pb (t) for NFR 2.C.1. Iron and steel production

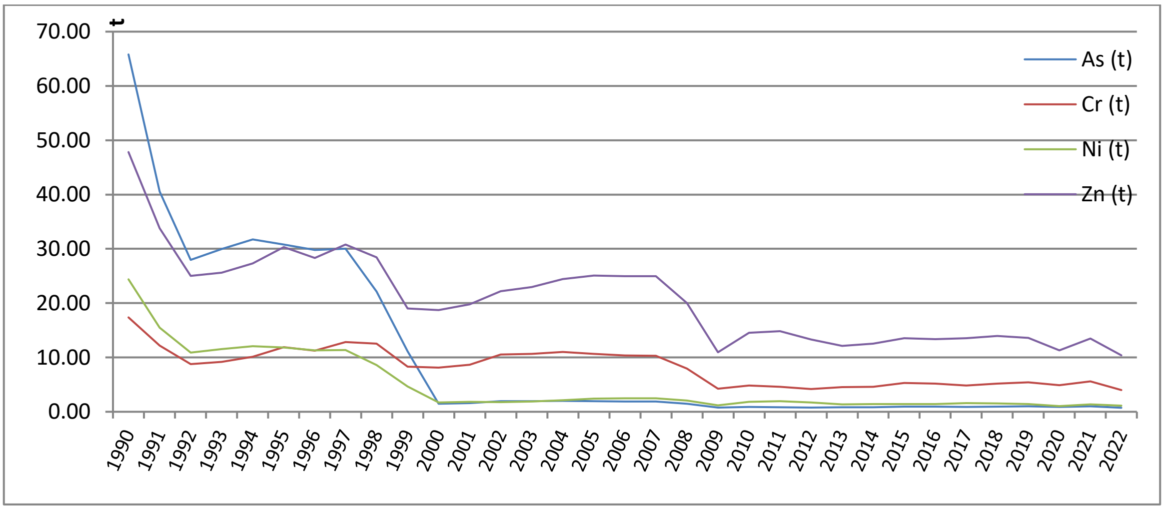


Figure 4.12.1.b Emission Trends of As, Cr, Ni and Zn (t) for NFR 2.C.1. Iron and steel production

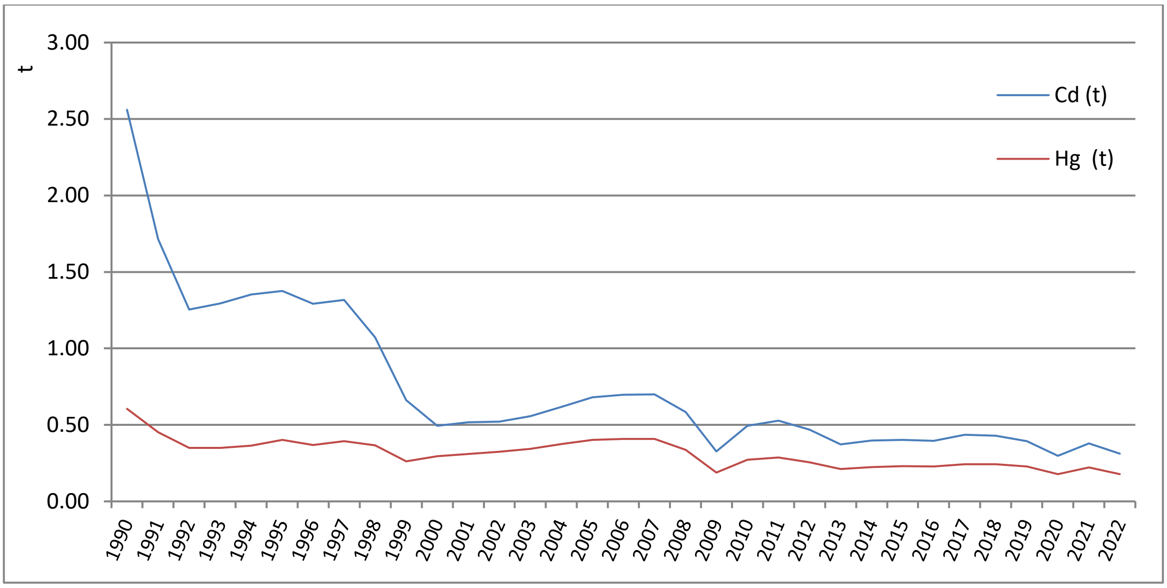


Figure 4.12.1.c Emission Trends of Cd, Hg (t) for NFR 2.C.1. Iron and steel production

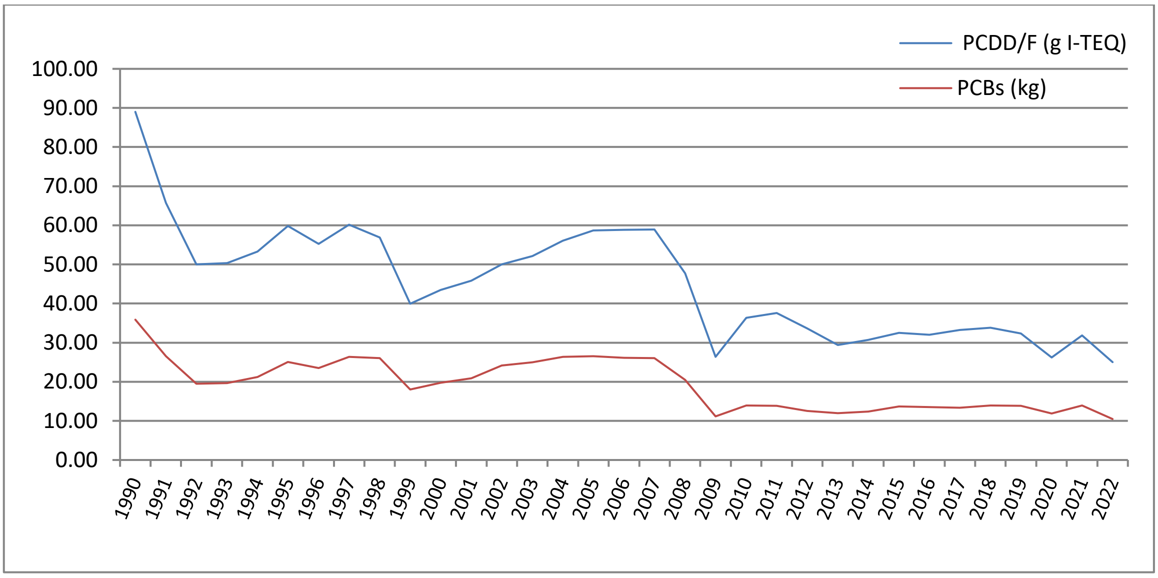


Figure 4.12.1.d Emission Trends of PCDD/F (g I-TEQ) and PCBs (kg) for NFR 2.C.1. Iron and steel production

The emissions from iron and steel production follow the activity data trends which varied substantially from year to year due to high variation of industry outputs. There has been a sudden decrease in emissions for year 2009, according to the decrease in activity data. The high emissions of Pb, As and Ni from 1990-1999 are the result of the steel produced in the open-hearth furnace steel plant. The manufacture of steel by this technology stopped in 2000.

Recalculations and improvements:

- There were not recalculations since the previous submission.

4.13 NFR 2.C.2 Ferroalloys production

This chapter only covers the process emissions of particulate matter from ferroalloys production. The combustion-related emissions are addressed in chapter 1.A.2.b.

The methodology for estimating emissions of particulate matter is based on the use of the 2019 EMEP/EEA Guidebook, Chapter 2.C.2 Ferroalloys production, by multiplying the annual amount of ferroalloys production with default emission factors.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from ferroalloys production is not included.

The activity data are represented by the total production of ferroalloys, from the “PRODROM” statistics, provided by the National Institute of Statistics. These data are confidential. There is no ferroalloys production since year 2013.

Emissions from the production of ferroalloys are not significant. The emission trends are shown below in the following table and figure.

Table 4.13.1. Total Emission Trends for $PM_{2.5}$, PM_{10} and TSP (kt) for NFR 2.C.2 Ferroalloys production

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
1990	0.0852	0.1207	0.1420
1991	0.0654	0.0927	0.1090
1992	0.0518	0.0734	0.0864
1993	0.0395	0.0560	0.0659
1994	0.0593	0.0840	0.0988
1995	0.0720	0.1019	0.1199
1996	0.0793	0.1124	0.1322
1997	0.0508	0.0719	0.0846
1998	0.0385	0.0546	0.0642
1999	0.0003	0.0005	0.0006
2000	0.0436	0.0617	0.0726
2001	0.0469	0.0664	0.0781
2002	0.0508	0.0720	0.0847
2003	0.0853	0.1208	0.1421
2004	0.1170	0.1657	0.1949
2005	0.0717	0.1016	0.1196
2006	0.0338	0.0480	0.0564
2007	0.0161	0.0228	0.0269
2008	0.0085	0.0120	0.0142
2009	0.0092	0.0131	0.0154
2010	0.0195	0.0277	0.0325

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
2011	0.0141	0.0200	0.0236
2012	0.0082	0.0116	0.0137

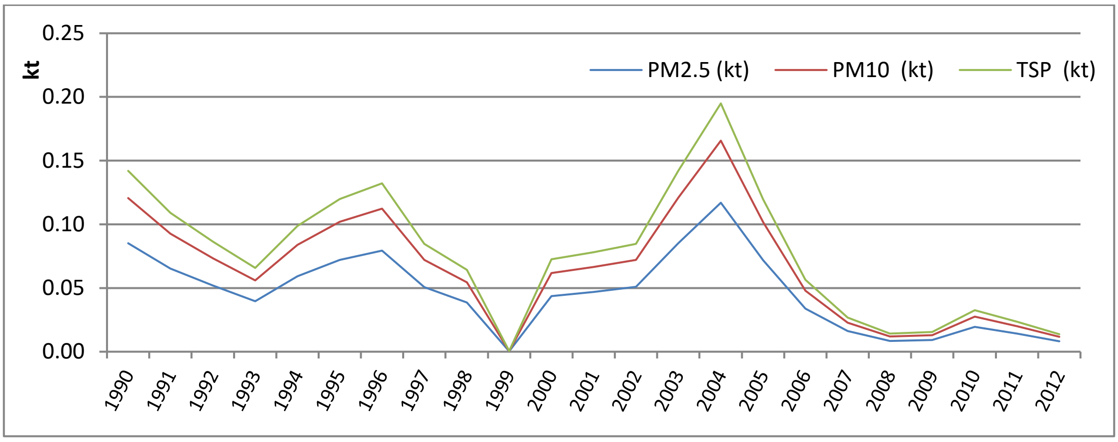


Figure 4.13.1. Total Emission Trends for NFR 2.C.2 Ferroalloys production for $PM_{2.5}$, PM_{10}, TSP (kt)

The emissions from ferroalloys production follow the activity data trends which varied substantially from year to year due to high variation of industry outputs. There has been a sudden decrease in emissions for year 1999 and a peak in year 2004, according to activity data.

Recalculations and improvements:

- There were not recalculations since the previous submission.

4.14 NFR 2.C.3 Aluminium production

The methodology for estimating emissions from aluminium production applies the general equation:

$$\text{Epollutant} = \sum_{\text{technologies}} \text{ARproduction, technology x EFtechnology, pollutant}$$

where:

- $AR_{production,\ technology}$ = the production rate within the source category, using this specific technology;
- $EF_{technology,\ pollutant}$ = the emission factor for this technology and this pollutant.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from aluminium production is not included.

For this category, emissions are derived from primary (SNAP 040301) and secondary aluminium production (SNAP 030310).

Primary aluminium is produced by the electrolysis process using the pre-baked anodes technology. Emissions are estimated based on activity data provided by N.I.S., using emission factors from the 2019 EMEP/EEA Guidebook.

Secondary aluminium has been produced since 2010, in Romania. HCB emissions result from the use of hexachloroethane in secondary aluminium production. The use of hexachloroethane for degassing purposes in secondary aluminium refining operations was banned in 2009, so emissions thereafter are considered zero. Emissions are estimated based on activity data and process information provided by the operator.

All these data are confidential.

The emission trends are shown below in the following table.

Table 4.14.1. Emission Trends for CO (kt) for NFR 2.C.3. Aluminium production

Year/Pollutant	CO (kt)
1990	20.128
1991	18.476
1992	12.863
1993	13.408
1994	14.184
1995	16.872
1996	16.828
1997	19.644
1998	20.965
1999	20.889
2000	20.793
2001	21.578
2002	22.391
2003	23.766
2004	25.831
2005	28.620
2006	32.023
2007	31.509
2008	37.494
2009	24.172
2010	24.902
2011	26.880
2012	24.304
2013	23.703
2014	23.495
2015	24.762
2016	24.909
2017	24.811
2018	25.335
2019	24.041
2020	23.137
2021	24.231
2022	9.769

The emissions of CO follow the activity data trends for aluminium production which varied substantially from year to year with a peak in 2008.

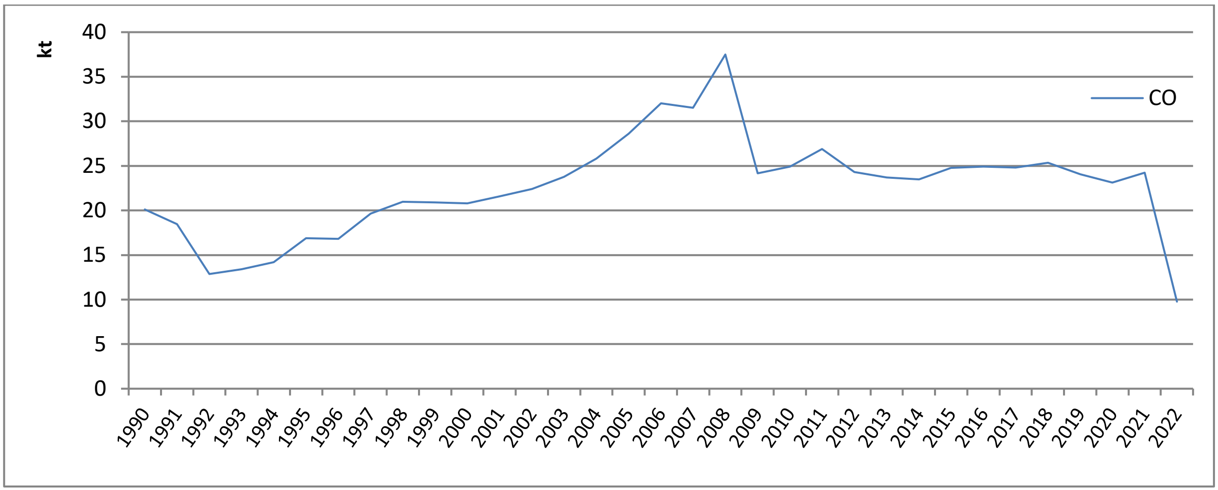


Figure 4.14.1. Emission Trends for CO (kt) for NFR 2.C.3. Aluminium production

Recalculations and improvements:
- No recalculations were made since the last submission.

4.15 NFR 2.C.4. Magnesium production

For this metal production category, emissions are from 2015 in accordance with the national production. The methodology for estimating emissions of SOx and TSP pollutants is based on the use of the 2019 EMEP/EEA Guidebook, Chapter 2.C.7.c Other metal production, with Tier 1's default emission factors. NFR 2.C.4 is not a key source for any pollutant.

The emission trends for the magnesium production are shown in the following table and figure.

Table 4.15.1. Emission Trends (kt) for NFR 2.C.4 Magnesium production

Year/Pollutant	SOx (kt)	TSP(kt)
2015	0.164	0.101
2016	0.234	0.144
2017	0.208	0.128
2018	0.214	0.132
2019	0.311	0.191
2020	0.203	0.125
2021	0.179	0.110
2022	0.159	0.098

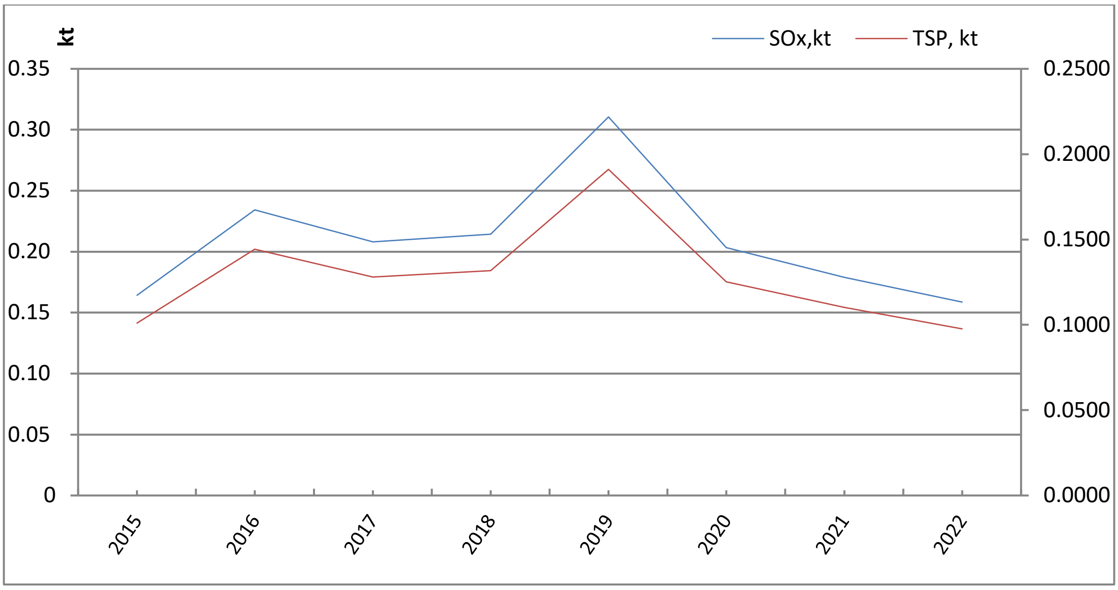


Figure 4.15.1. Emission Trends (kt) for NFR 2.C.4 Magnesium production

Recalculations and improvements:

- There were not recalculations since the previous submission.

4.16 NFR 2.C.5. Lead production

For this sub-category, emissions are derived from primary and secondary lead production.

The most important process emissions are sulphur oxides (SOx), nitrogen oxides (NOx), heavy metals (particularly lead), dust and PCDD.

The methodology for estimating emissions from lead production applies the general equation:

$$\text{Epollutant} = \sum_{\text{technologies}} \text{ARproduction, technology x EFtechnology, pollutant}$$

where:

- ARproduction,technology = the production rate within the source category, using this specific technology;
- EFtechnology,pollutant = the emission factor for this technology and this pollutant.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from lead production is not included.

The activity data used for emission calculations are represented by primary and secondary lead productions from the “PRODROM” statistics, provided by the N.I.S.

The emission trends are shown below in the following table and figure.

Table 4.16.1 Total Emission Trends for NFR 2.C.5 Lead production

Year/Pollutant	Pb (t)	Zn (t)
1990	0.053	0.0078
1991	0.041	0.0060
1992	0.037	0.0054
1993	0.049	0.0072
1994	0.062	0.0090
1995	0.074	0.0108
1996	0.053	0.0078
1997	0.053	0.0078
1998	0.061	0.0090
1999	0.055	0.0081
2000	0.084	0.0116
2001	0.092	0.0134
2002	0.093	0.0137
2003	0.115	0.0169
2004	0.101	0.0147
2005	0.120	0.0167
2006	0.093	0.0126
2007	0.118	0.0163
2008	0.117	0.0161
2009	0.020	0.0024
2010	0.025	0.0028
2011	0.016	0.0020
2012	0.002	0.0002
2013	0.005	0.0007
2014	0.005	0.0008
2015	0.005	0.0008
2016	0.016	0.0008
2017	0.019	0.0009
2018	0.016	0.0007
2019	0.017	0.0008
2020	0.017	0.0007
2021	0.015	0.0007
2022	0.015	0.0007

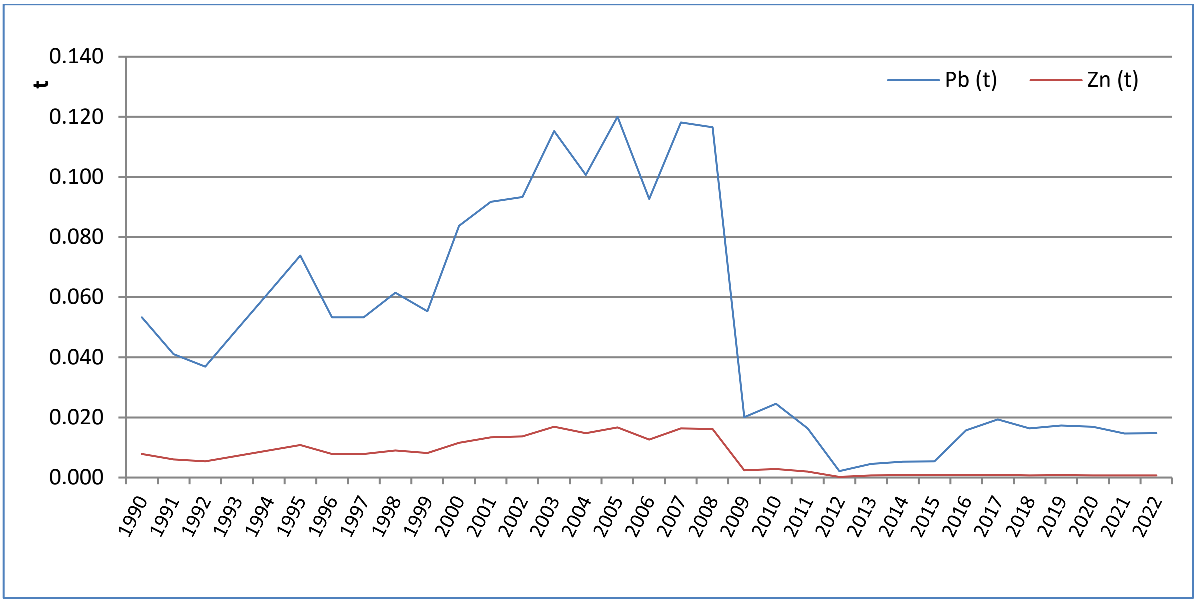


Figure 4.16.1 Total Emission Trends for NFR 2.C.5 Lead production

The emissions of Pb and Zn from those activities follow the activity data trends, which varied substantially from year to year due to high variation of industry outputs and with considerable decrease after 2008.

There were no recalculations and improvements for this category.

4.17 NFR 2.C.6 Zinc production

The main emissions to air from zinc production are sulphur oxides (SO_x), metals and their compounds and dust.

The methodology for estimating emissions from zinc production applies the general equation:

Epollutant = ARproduction× EFpollutant where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate for the zinc production;
- EFpollutant is the emission factor for this pollutant.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from zinc production is not included.

The activity data used for emission calculations is the annual national total zinc production, from the “PRODROM” statistics, provided by the N.I.S.

The emission trends are shown below in the following table and figure.

Table 4.17.1 Total Emission Trends (t) for NFR 2.C.6 Zinc production

Year/Pollutant	Pb (t)	Zn (t)
1990	0.00220	0.0550
1992	0.00240	0.0600
1993	0.00280	0.0700
1994	0.00380	0.0950
1995	0.00560	0.1400
1996	0.00560	0.1400
1997	0.00600	0.1500
1998	0.00580	0.1450
1999	0.00580	0.1450
2000	0.01040	0.2600
2001	0.00957	0.2393
2002	0.00761	0.1901
2003	0.01020	0.2550
2004	0.01055	0.2637
2005	0.01136	0.2840
2006	0.00874	0.2185
2007	0.01169	0.2922
2008	0.01240	0.3099
2009	0.00008	0.0019
2010	0.00005	0.0011
2011	0.00005	0.0013
2012	0.00007	0.0016
2013	0.00004	0.0011
2014	0.00002	0.0004
2015	0.00004	0.0010
2016	0.00006	0.0016
2017	0.00017	0.0042
2018	0.00012	0.0029
2019	0.00008	0.0021
2020	0.00006	0.0015
2021	0.00009	0.0023
2022	0.00021	0.0052

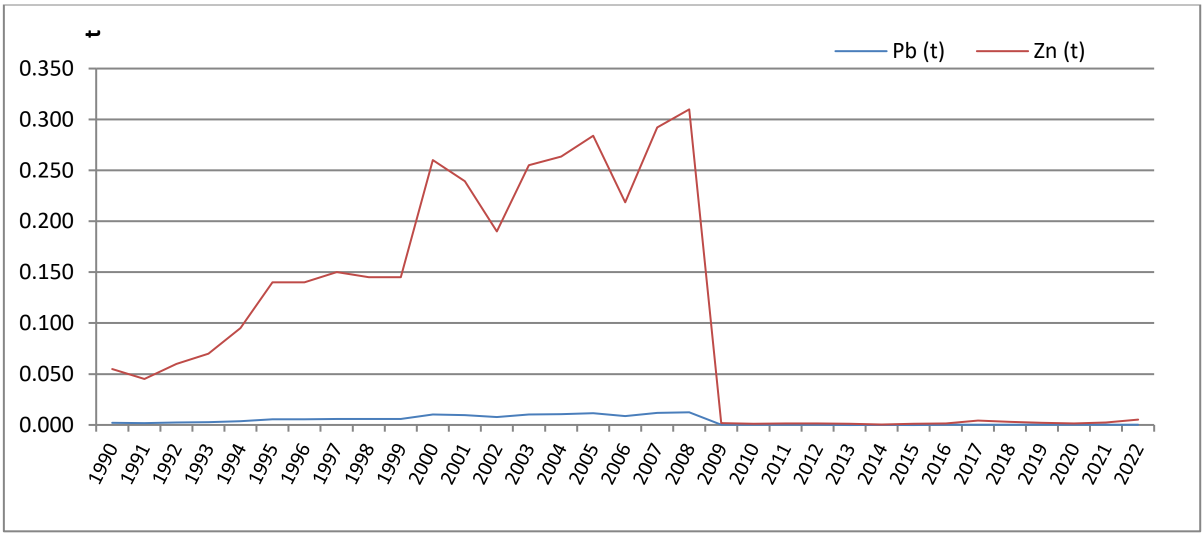


Figure 4.17.1 Total Emission Trends (t) for NFR 2.C.6 Zinc production

The 2022 emissions of Pb and Zn from zinc production decreased by more than 99% compared to the emissions in the year 2000, after reaching a peak level in 2008. This decrease is due to a high and sudden decrease in activity data starting with year 2009.

There were no recalculations and improvements for this category.

4.18 NFR 2.C.7.a Copper production

The main emissions to air from copper production are particulate matter (PM), sulphur oxides (SOx), volatile organic compounds (NMVOC) and trace elements.

The activity data is represented by primary and secondary copper production, from the "PRODROM" statistics, provided by the N.I.S. The time series covers the years 1990-2008, when production stopped.

Due to the different confidentiality policy along the time series, the presentation of emission factors used to estimate emissions from copper production is not included.

There is no copper production since 2009.

Table 4.18.1 Emission Trends (t) for NFR 2.C.7a Copper production

Year/Pollutant	Pb (t)	Cu (t)	Cd (t)
1990	1.048	2.296	0.478
1991	1.072	2.324	0.480
1992	1.096	2.352	0.482
1993	1.016	2.182	0.448
1994	0.896	1.927	0.396
1995	0.896	1.927	0.396
1996	1.224	2.693	0.562
1997	0.952	2.069	0.428
1998	0.804	1.655	0.329
1999	0.888	1.956	0.408
2000	0.630	1.365	0.282
2001	0.567	1.006	0.175
2002	0.417	0.826	0.159
2003	0.473	0.724	0.106
2004	0.590	0.690	0.057
2005	0.498	0.581	0.048
2006	0.518	0.604	0.050
2007	0.439	0.512	0.042
2008	0.320	0.373	0.031

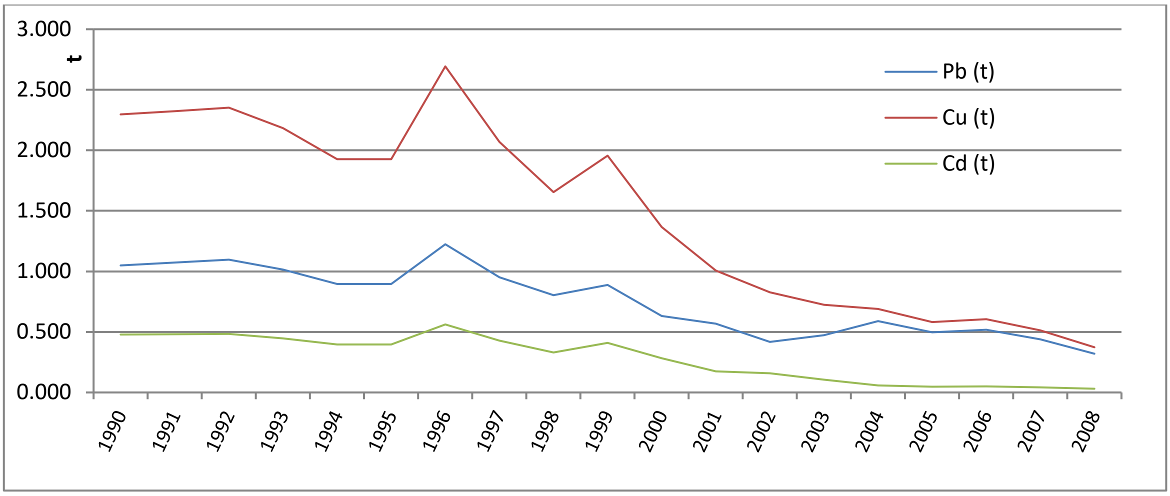


Figure 4.18.1 Total Emission Trends (t) for NFR 2.C.7a Copper production

4.19 NFR 2.D.3.a Domestic solvent use including fungicides

According to the 2019 EMEP/EEA Guidebook "*NMVOCs are used in a large number of products sold for use by the public*". The main categories in the domestic use of solvents are:

- Cosmetics and toiletries: products for the maintenance or improvement of personal appearance, health, or hygiene.
- Household products: products used to maintain or improve of household's durables.
- Construction/DIY: products used for improving the appearance or the structure of buildings.
- Car care products: products used for improving the appearance of vehicles, to maintain vehicles or winter products such as antifreeze.
- Pesticides: such as garden fungicides, herbicides and insecticides, and household insecticide sprays may be considered as consumer products.

The difficult issue in this sector is to collect activity data, because it needs data on consumption activity for a wide range of products that are currently not available directly in statistics.

For NFR 2.D.3.a, activity data is represented by the total population of Romania for time series 1990-2022 and is provided by EUROSTAT.

ESIG NMVOC per capita EFs were obtained during the review 2023, *RO-2D3a-2017-0001* There are provided in ESIG. These values were used to estimate NMVOC emissions for 2013 to 2021 (except 2014 which is not provided by ESIG). EF for the year 2014 was estimated as the average of 2013 years and 2015. The 2005 per capita NMVOC EF was derived by calculating the average of the ESIG NMVOC per capita EFs for 2013-2019. The value for 2020 was not included in this average because this is an exceptional year due to the use of solvents during the COVID pandemic. The NMVOC emissions were then corrected in line with the 2019 EMEP/EEA Guidebook that provides a correction factor of 1.11 for non-solvent

NMVOC emissions and a correction factor of 1.11 for solvents not considered in the ESIG methodology.

Table 4.19.1. ESIG NMVOC per capita EFs

year	1990-2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
EF ESIG	0.9435	1.2059	1.2021	1.1983	0.7891	0.7940	0.7582	0.9157	1.5842	1.2294	0.9805

The methodology for estimating emissions from this NFR applies the general equation:

Epollutant = ARproduction X EFpollutant where:

- Epollutant is the emission of the NMVOC
- ARproduction is the activity rate for the NFR 2D3a (total population)
- EFpollutant is the emission factor for NMVOC.

In 2022 NFR 2D3a was key source for NMVOC with 9.8% from national total.

Table 4.19.2. Activity data trends (caput) for NFR 2.D.3.a Domestic solvent use including fungicides

Year	AD (caput)
1990	23192274
1991	22810035
1992	22778533
1993	22748027
1994	22712394
1995	22656145
1996	22581862
1997	22526093
1998	22488595
1999	22455485
2000	22430457
2001	21833483
2002	21627509
2003	21521142
2004	21382354
2005	21257016
2006	21130503
2007	20635460
2008	20440290
2009	20294683
2010	20199059
2011	20095996
2012	20020074
2013	19947311
2014	19870647
2015	19760585

Year	AD (caput)
2016	19643949
2017	19533481
2018	19414458
2019	19328838
2020	19201662
2021	19042455
2022	19051562

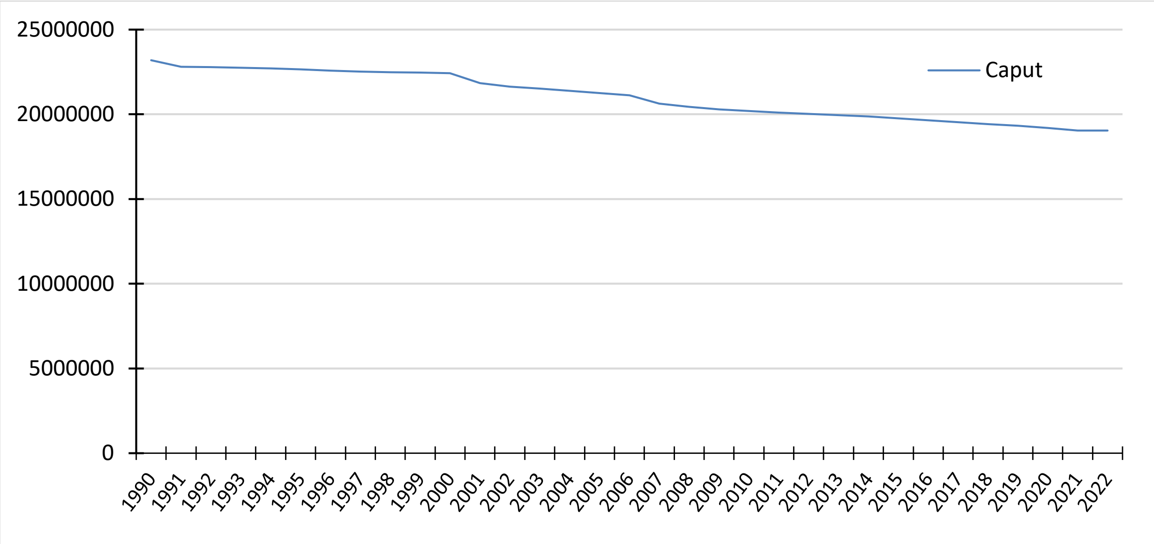


Figure 4.19.2. Activity data trends (caput) for NFR 2.D.3.a Domestic solvent use including fungicides

The emission trends are shown below in the following table and figure.

Table 4.19.3. Emission trends (kt) for NFR 2.D.3.a Domestic solvent use including fungicides

Year	NMVOC (kt)
1990	26.961
1991	26.517
1992	26.480
1993	26.445
1994	26.403
1995	26.338
1996	26.252
1997	26.187
1998	26.143
1999	26.105
2000	26.076
2001	25.382
2002	25.142
2003	25.019
2004	24.857
2005	24.712

Year	NMVOC (kt)
2006	24.564
2007	23.989
2008	23.762
2009	23.593
2010	23.482
2011	23.362
2012	23.274
2013	29.638
2014	29.430
2015	29.174
2016	19.099
2017	19.108
2018	18.137
2019	21.806
2020	37.479
2021	28.844
2022	23.015

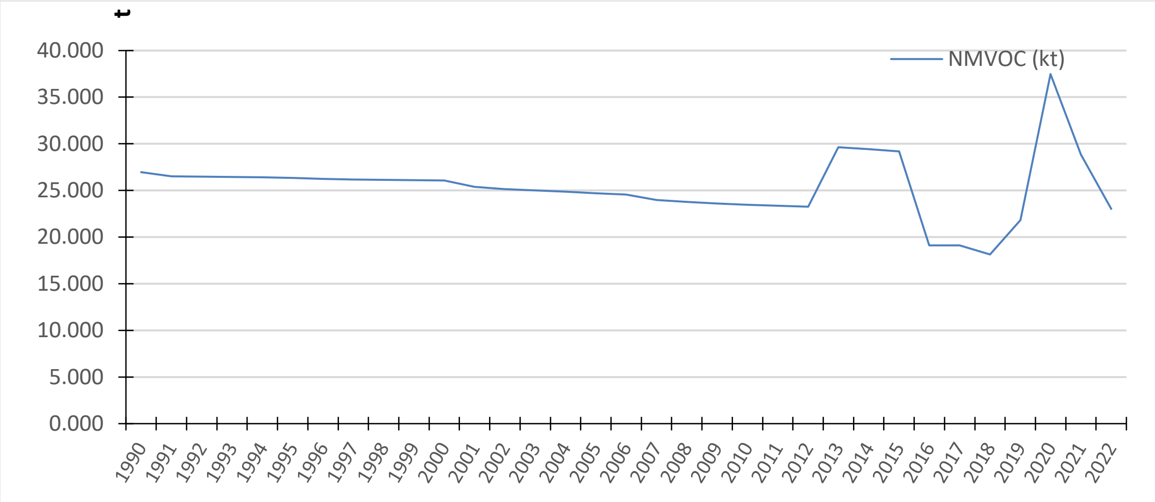


Figure 4.19.3. Emission trends (kt) for NFR 2.D.3.a Domestic solvent use including fungicides

Recalculations and improvement:

During the desk Review and according to the recommendations, *RO-2D3a-2017-0001*

- NMVOC emissions were recalculated using ESIG NMVOC EFs per capita for Romania for the period 1990-2021.

4.20 NFR 2.D.3.b Road Paving with Asphalt

This section covers emissions from asphalt paving operations, as well as subsequent releases from the paved surfaces. This was a key category in 2022, with a share of 11.2% from the national emissions of TSP.

The emissions to air from this sector are particulate matter (TSP, PM10, PM2.5), volatile organic compounds (NMVOC) and black carbon (BC).

After 2022 reviewing, Romania calculate the emissions from asphalt for roads using Tier 2 emission factors for "batch mix plants" from the 2019 EMEP Guidebook.

The methodology for estimating emissions from road paving with asphalt applies the general equation:

Epollutant = ARproduction× EFpollutant where:

- Epollutant is the emission of the specified pollutant
- ARproduction is the activity rate for the road paving with asphalt
- EFpollutant is the emission factor for this pollutant.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from road paving with asphalt is not included.

The activity data used for emission calculations is the annual national total bitumen production, from the “PRODROM” statistics, provided by the N.I.S.

The emission trends are shown below in the following table and figure.

Table 4.20.1. Total Emission Trends (kt) for NFR 2.D.3.b Road paving with asphalt

Year/Pollutant	TSP (kt)	PM 10(kt)
1990	6.210	0.828
1991	5.685	0.758
1992	5.505	0.734
1993	4.785	0.638
1994	5.094	0.679
1995	5.201	0.693
1996	5.254	0.701
1997	4.573	0.610
1998	2.885	0.385
1999	2.574	0.343
2000	3.348	0.446
2001	2.332	0.311
2002	2.338	0.312
2003	2.854	0.381
2004	14.282	1.904
2005	10.146	1.353
2006	14.241	1.899

Year/Pollutant	TSP (kt)	PM 10(kt)
2007	35.907	4.788
2008	7.994	1.066
2009	20.760	2.768
2010	24.672	3.290
2011	23.624	3.150
2012	27.055	3.607
2013	30.266	4.036
2014	31.377	4.184
2015	31.441	4.192
2016	22.187	2.958
2017	6.030	0.804
2018	16.725	2.230
2019	26.351	3.513
2020	27.002	3.600
2021	23.336	3.112
2022	22.134	2.951

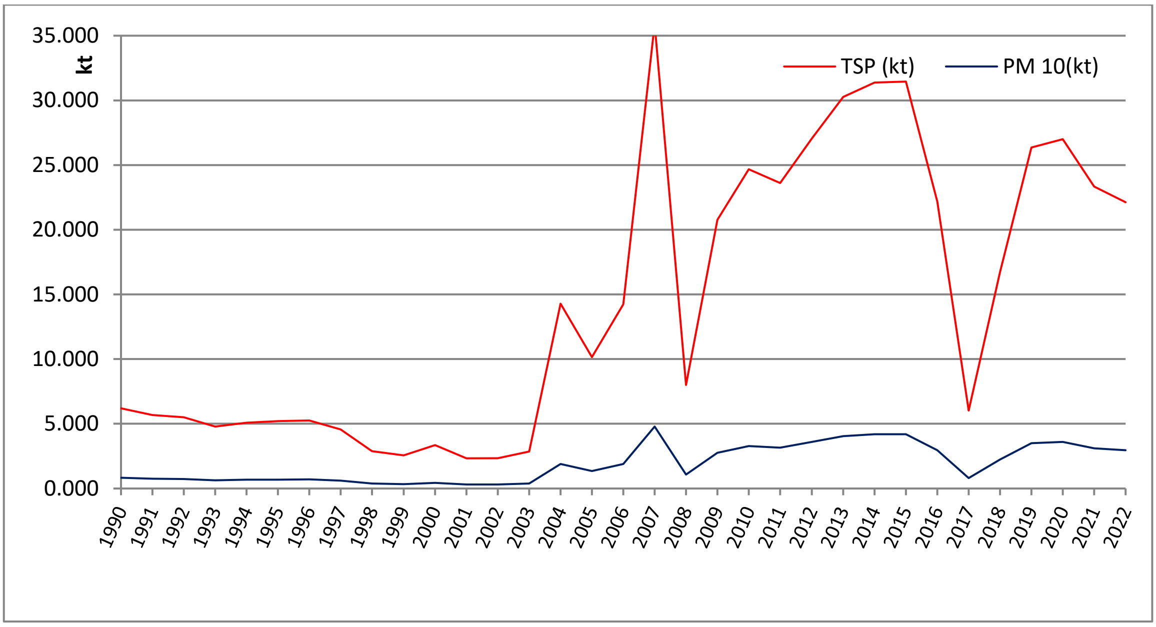


Figure 4.20.1. Total Emission Trends (kt) for NFR 2.D.3.b Road paving with asphalt

The emissions PM_{10} and TSP follow the fluctuations in activity data trend and the economic interest for this activity, with an important increase from 2005 to 2007, when it recorded a peak, a sudden decrease from 2007 to 2008, as in 2017.

4.21 NFR 2.D.3.c Asphalt Roofing

This activity covers emissions from the asphalt roofing industry.

The emissions to air from this sector are particulate matter (TSP, PM_{10}, $PM_{2.5}$), volatile organic compounds (NMVOC), carbon monoxide (CO) and black carbon (BC).

The methodology for estimating emissions from asphalt roofing industry applies the general equation:

$$E_{pollutant} = AR_{production} \times EF_{pollutant}$$

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate for the asphalt roofing;
- EFpollutant is the emission factor for this pollutant.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from asphalt roofing is not included.

The activity data used for emission calculations is the annual national total production of the asphalt roofing industry, from the "PRODROM" statistics provided by the N.I.S. These data are confidential for time series 2007-2021.

There was no production reported for 2022 year.

Table 4.21.1. Activity Data Trend (t asphalt) for NFR 2.D.3.c Asphalt Roofing

Year	t asphalt
1990	97500.0
1991	58500.0
1992	39000.0
1993	37500.0
1994	30000.0
1995	33000.0
1996	36000.0
1997	31500.0
1998	30838.5
1999	27360.0
2000	23317.5
2001	24000.0
2002	24000.0
2003	21000.0
2004	12000.0
2005	12144.0
2006	8790.0

The emission trends are shown below in the following table and figure.

Table 4.21.2. Total Emission Trends (kt) for NFR 2.D.3.c Asphalt Roofing

Year/Pollutant	NMVOC (kt)	TSP (kt)
1990	0.012675	0.15600
1991	0.007605	0.09360
1992	0.005070	0.06240

1993	0.004875	0.06000
1994	0.003900	0.04800
1995	0.004290	0.05280
1996	0.004680	0.05760
1997	0.004095	0.05040
1998	0.004009	0.04934
1999	0.003557	0.04378
2000	0.003031	0.03731
2001	0.003120	0.03840
2002	0.003120	0.03840
2003	0.002730	0.03360
2004	0.001560	0.01920
2005	0.001579	0.01943
2006	0.001143	0.01406
2007	0.000295	0.00363
2008	0.000186	0.00229
2009	0.000130	0.00160
2010	0.000029	0.00036
2011	0.000021	0.00026
2012	0.000023	0.00029
2013	0.000017	0.00021
2014	0.000016	0.00019
2015	0.000012	0.00015
2016	0.000008	0.00009
2017	0.000007	0.00009
2018	0.000004	0.00005
2019	0.000003	0.00004
2020	0.000002	0.00002
2021	0.000002	0.00002

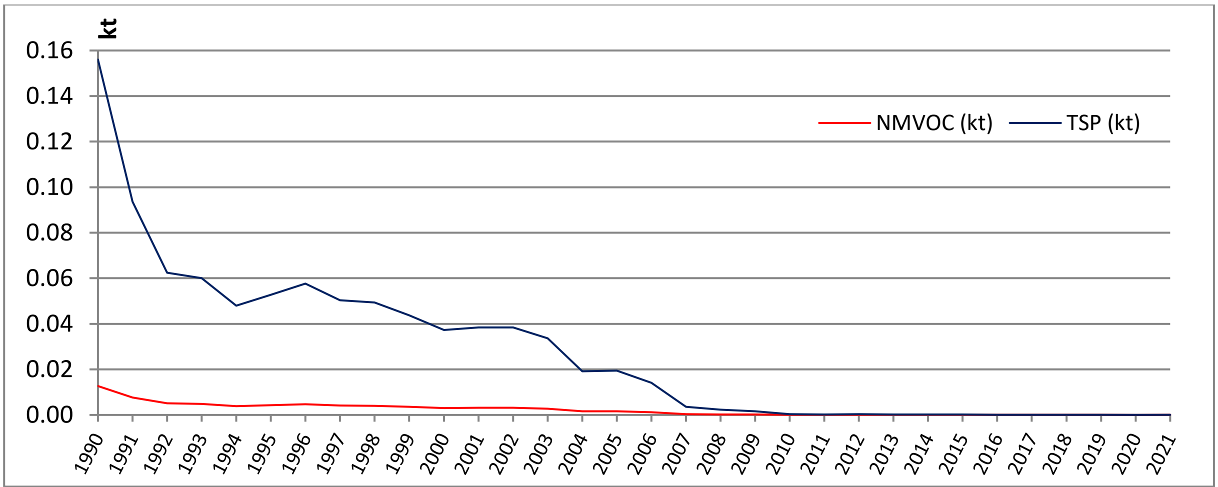


Figure 4.21.1. Total Emission Trends (kt) for NFR 2.D.3.c Asphalt Roofing

After 2009 there was a significant decrease in the asphalt roofing industry, and all emissions followed this trend.

There were no recalculations and improvements for this category.

4.22 NFR 2.D.3.d Coating applications

This NFR covers the emissions from the use of paints within the industrial and domestic sectors the use of paints.

The methodology for estimating emissions applies the general equation:

$$\text{Epollutant} = \sum_{\text{technologies}} \text{ARuse, technology x EFtechnology, pollutant}$$

where:

- $AR_{use,technology}$ = the use of paint within the source category, using this specific technology;
- $EF_{technology,pollutant}$ = the emission factor for this technology and this pollutant.

The use of paint is a major source of non-methane volatile organic compounds (NMVOC) emissions.

Table 4.22.1 Source description for NFR 2D3d sector

SNAP	SNAP name	Source activity data description
060101	Manufacture of automobiles	1990-2007 - numbers of automobiles provided by N.I.S. (PRODROM 291021001, PRODROM 291022301, PRODROM 291023301); 2008-2022 - the solvent consumption (kt) and the NMVOC emissions, are obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED).
060103 and 060104	Construction and buildings / Domestic use	2003-2022 the total paints provided by N.I.S. (PRODROM 243012300, PRODROM 243012500, PRODROM 243012700, PRODROM 243012902);
060105	Coil coating	2018-2022 the solvent consumption (kt) and the NMVOC emissions, are obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED).
060106	Boat building	1990-2007 the consumption of solvents and the NMVOC emission was estimated based on the gross domestic product (GDP), the annual values of the import and export of ships/boats; the GDP value (expressed in million USD) from the World Bank, and for the import/export value of boats, data provided by UN COMTRADE; 2008-2022 the solvent consumption (kt) and the NMVOC emissions, are obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED).
060107	Wood	2003-2007 the total paints provided by N.I.S. (PRODROM 243012250, PRODROM 243012290); 2008-2022 the solvent consumption (kt) and the NMVOC emissions, are obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED).

SNAP	SNAP name	Source activity data description
060108	Other industrial paint application	1990-2007 - numbers of other vehicle type (split by buses, trucks, other transport vehicle) provided by the N.I.S (IND 106A); 2008-2022 - the solvent consumption (kt) and the NMVOC emissions, are obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED). For the time series 1990-2007, EF determined was used to estimate the MNVOC emission.

Table 4.22.2 Emission factors references:

SNAP	Reported pollutants	Emission Factors tier and source
060101	Manufacture of automobiles	1990-2007 T2 factors Table 3-6 - EMEP EEA guidebook (2019)
060103 and 060104	NMVOC	2003-2022 T2 factors Table 3-4 and table 3-5 - EMEP EEA guidebook (2019)
060107	NMVOC	2003-2007 The EF determined is the average of the EF (total NMVOC emission/total solvent) for the years 2008-2011 – see table 4.22.3.
060108	NMVOC	1990-2007 The EF determined is the average of the EF (total NMVOC emission/total other vehicle type) for the years 2008-2011 - see table 4.22.4.

Table 4.22.3. Calculation for EF determined SNAP 060107 wood

SNAP 060107	year 2008	year 2009	year 2010	year 2011
total paints (t)	14783.81	12018.57	10714.22	12279.61
NMVOC emission (t)	1821.548	1178.749	1163.910	1130.318
EF/year	0.1232	0.0980	0.1086	0.0920

EF determined = ∑ emission NMVOC/ total paints time period 2008-2011 / 4
EF determined = 0.1054

Table 4.22.4. Calculation for EF determined SNAP 060108 other industrial coating applications

SNAP 060108	year 2008	year 2009	year 2010	year 2011
no. vehicle type	17304	27381	25260	11287
NMVOC emission(t)	2667.277	1873.364	1413.450	1764.661
EF/year	0.1541	0.0684	0.0559	0.1563

EF determined = ∑ emission NMVOC/ total other vehicle type time period 2008-2011 / 4
EF determined = 0.1087

Table 4.22.5. Emission and total solvents for SNAP 060106 boat building

Year	Solvent consumption (kt)	NMVOC(kt)
1990	3.432	3.408
1991	3.477	3.453
1992	3.512	3.487
1993	3.545	3.520
1994	3.449	3.425
1995	3.362	3.339
1996	3.354	3.331
1997	3.408	3.385
1998	3.309	3.286
1999	3.284	3.261
2000	3.278	3.255
2001	3.269	3.246
2002	3.126	3.104
2003	3.016	2.994
2004	2.78	2.762
2005	2.435	2.418
2006	2.022	2.001
2007	1.379	1.376

The emission trends are shown below in the following table and figure.

Table 4.22.6. Emission trends (kt) for NFR 2.D.3.d Coating applications

Year/Pollutant	NMVOC (kt)
1990	6.241
1991	5.982
1992	5.287
1993	8.730
1994	7.941
1995	6.729
1996	7.190
1997	6.781
1998	6.746
1999	6.046
2000	5.372
2001	5.166
2002	5.204
2003	10.715
2004	11.590
2005	10.678
2006	11.262
2007	9.379
2008	10.217
2009	16.743
2010	14.822
2011	8.973
2012	8.707

Year/Pollutant	NMVOC (kt)
2013	8.643
2014	9.222
2014	10.265
2015	9.879
2016	9.175
2017	9.430
2018	9.539
2019	7.976
2020	7.155
2021	6.476
2022	6.241

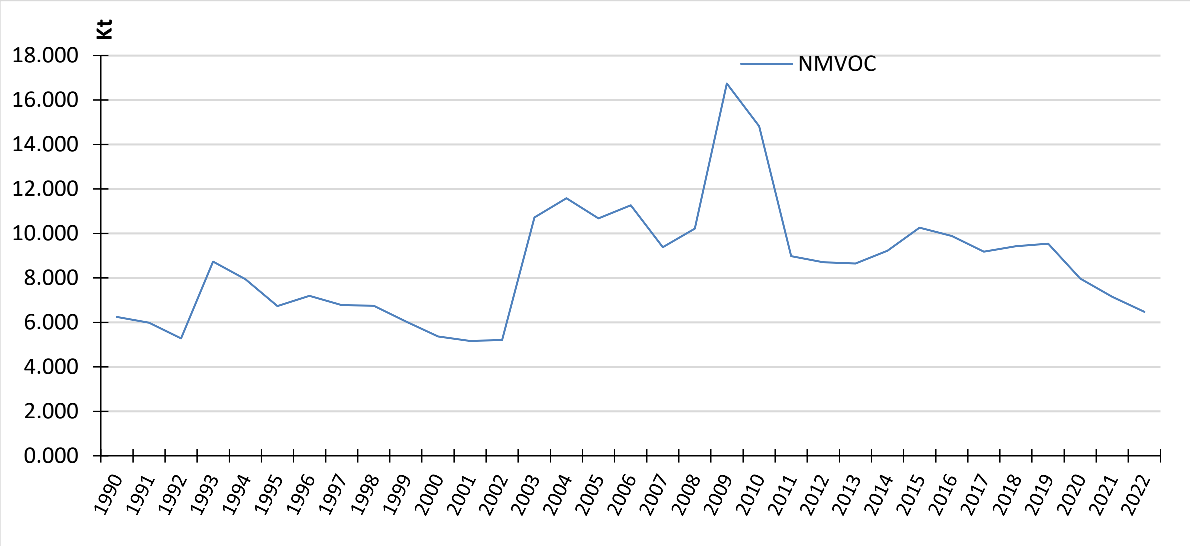


Figure 4.22.6. Emission trends (kt) for 2.D.3.d Coating applications

The emissions of NMVOC from the coating applications follow the activity data trends which varied substantially from year to year due to high variation of industry outputs.

Table 4.22.7. Activity data trends (kt solvent consumption) for NFR 2.D.3.d Coating applications

Year	Solvent consumption (kt)	no. auto	Total paints
1990	3.43	104794	
1991	3.48	91815	
1992	3.51	75847	
1993	3.55	98872	
1994	3.45	88783	
1995	3.36	91401	
1996	3.35	121656	
1997	3.41	129438	
1998	3.31	127137	
1999	3.28	107300	
2000	3.28	78235	
2001	3.27	83454	
2002	3.13	79677	

Year	Solvent consumption (kt)	no. auto	Total paints
2003	3.02	95099	27.65
2004	2.78	121998	33.32
2005	2.43	195270	26.54
2006	2.02	214491	37.19
2007	1.38	241767	32.39
2008	13.34		17.53
2009	10.62		50.55
2010	11.80		45.33
2011	10.87		18.50
2012	10.65		16.67
2013	10.76		14.49
2014	10.54		16.77
2015	11.54		18.05
2016	10.51		18.39
2017	10.60		19.26
2018	11.22		20.88
2019	11.32		21.22
2020	10.15		18.44
2021	11.04		14.49
2022	12.26		12.41

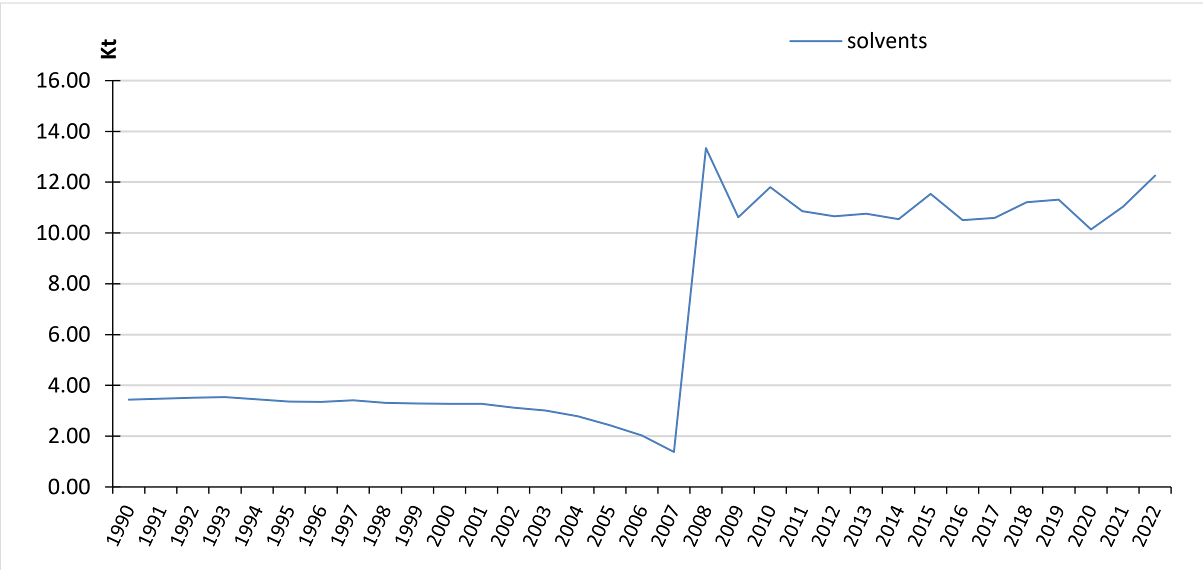


Figure 4.22.7.a Activity data trends (kt solvent consumption) for NFR 2.D.3.d Coating applications

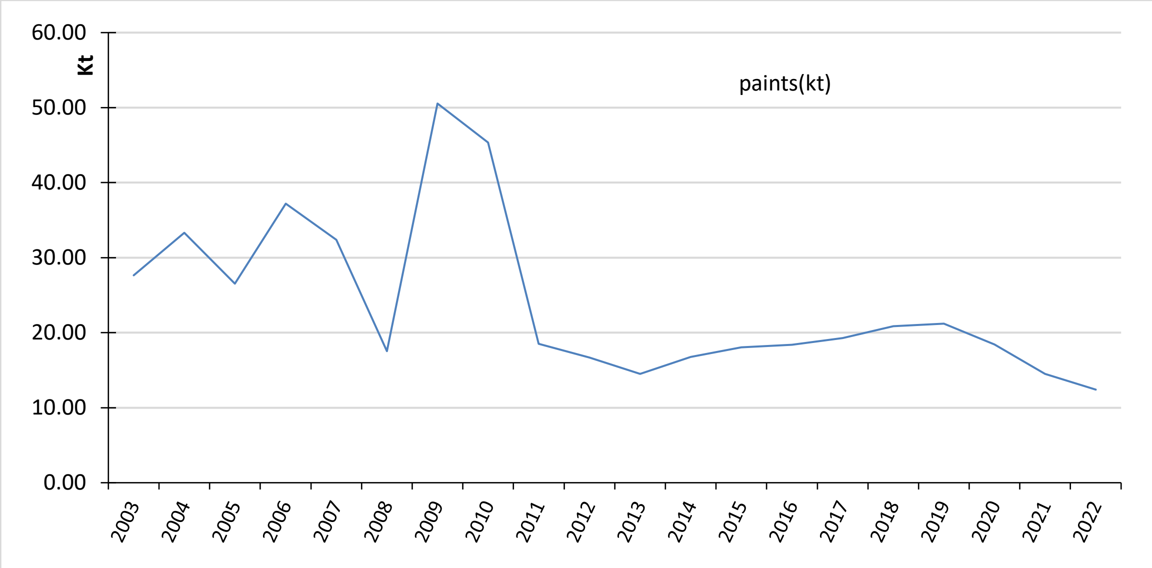


Figure 4.22.7.b. Activity data trends (kt paints) for NFR 2.D.3.d Coating applications

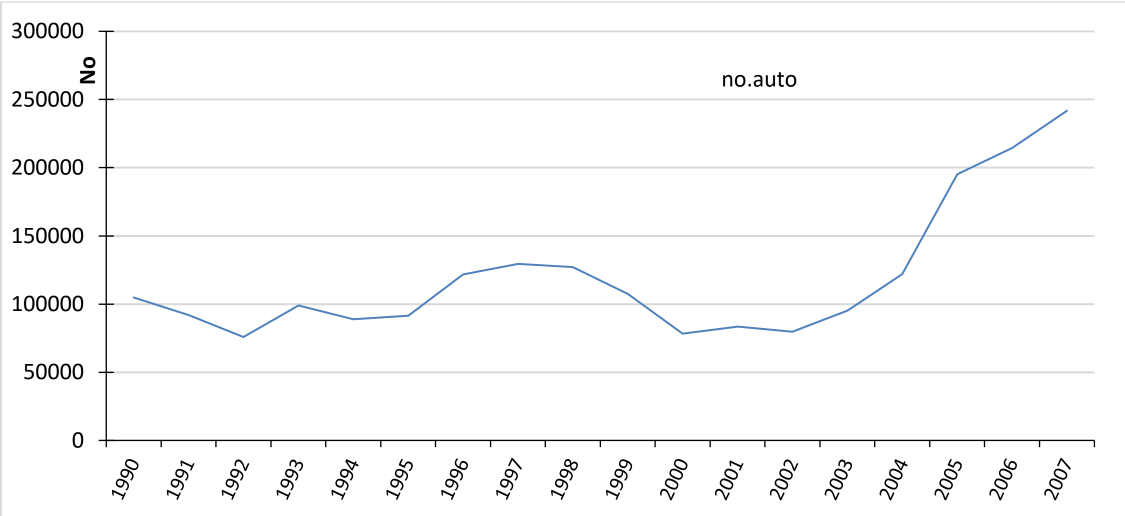


Figure 4.22.7.c. Activity data trends (no.auto) for NFR 2.D.3.d Coating applications

The emissions of NMVOC from the coating applications follow the activity data trends which varied substantially from year to year due to high variation of industry outputs.

In 2022 NFR 2D3d was key source for NMVOC with 2.8% from national total.

Recalculations and improvement:

During the desk Review and according to the recommendations, *RO-2D3d-2020-0001*:

- Correction of activity data (total solvents) time period 2018-2021;
- New SNAP 060105 coil coating (time period 2018-2022);
- SNAP 060106 boat building - calculation AD and NMVOC emission for time period 1990-2007;
- New SNAP 060103+060104 domestic and building application (time period 2003-2022).

4.23 NFR 2.D.3.e Degreasing

In the 2019 EMEP/EEA Guidebook this source category is defined as: "Degreasing is a process for cleaning products from water-insoluble substances such as grease, fats, oils, waxes, carbon deposits, fluxes and tars. In most cases the process is applied to metal products, but also plastic, fibreglass, printed circuit boards and other products are treated by the same process."

The methodology for estimating emissions from this source applies the general equation:

$$Epollutant = ARproduction \times EFpollutant,$$

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate for TRI and XYLEN;
- EFpollutant is the emission factor for this pollutant.

The consumption of trichlorethylene (TRI) and XYLEN as solvents used for degreasing was considered as activity data.

AD = Consumption = Production + Imports – Exports.

Production/import/export data were provided by N.I.S. (PRODROM 201413741, PRODROM 29024100, PRODROM 29024300, PRODROM 29024200). For the years 1990-1993 no data were available, so the 1994 data were used. The default emission factor to calculate the emissions is from 2019 EMEP/EEA Guidebook, chapter 2.D.3.e Degreasing, Tier 1 (Table 3-1).

The emission trends are shown below in the following table and figure.

Table 4.23.1. Activity data trends (kt) for NFR 2.D.3.e Degreasing

Year	Consumption of solvents (kt)
1990	53.9640
1991	53.9640
1992	53.9640
1993	53.9640
1994	53.9640
1995	64.1120
1996	25.0090
1997	6.1010
1998	6.4960
1999	10.8512
2000	6.6571
2001	4.5183
2002	2.6468
2003	0.9662
2004	12.0648
2005	11.7922
2006	9.7838

Year	Consumption of solvents (kt)
2007	14.4836
2008	16.6759
2009	13.1648
2010	16.5137
2011	11.4563
2012	3.6373
2013	2.3682
2014	1.0992
2015	0.2102
2016	0.1685
2017	0.1269
2018	0.0852
2019	0.0435
2020	0.0018
2021	0.0003
2022	0.0036

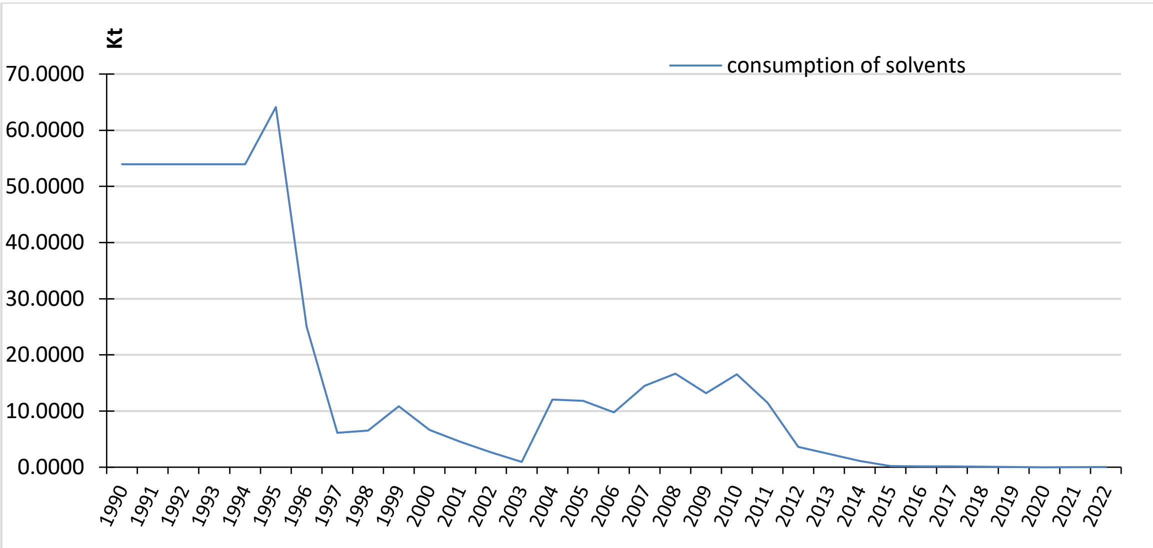


Figure 4.23.1. Activity data trends (kt consumption of solvents) for NFR 2.D.3.e Degreasing

Table 4.23.2. Emission trends (kt) for NFR 2.D.3.e Degreasing

Year	NMVOC (kt)
1990	24.8234
1991	24.8234
1992	24.8234
1993	24.8234
1994	24.8234
1995	29.4915
1996	11.5041
1997	2.8065
1998	2.9882
1999	4.9915
2000	3.0623

Year	NMVOC (kt)
2001	2.0784
2002	1.2175
2003	0.4445
2004	5.5498
2005	5.4244
2006	4.5006
2007	6.6624
2008	7.6709
2009	6.0558
2010	7.5963
2011	5.2699
2012	1.6731
2013	1.0894
2014	0.5056
2015	0.0967
2016	0.0775
2017	0.0584
2018	0.0392
2019	0.0200
2020	0.0008
2021	0.0001
2022	0.0017

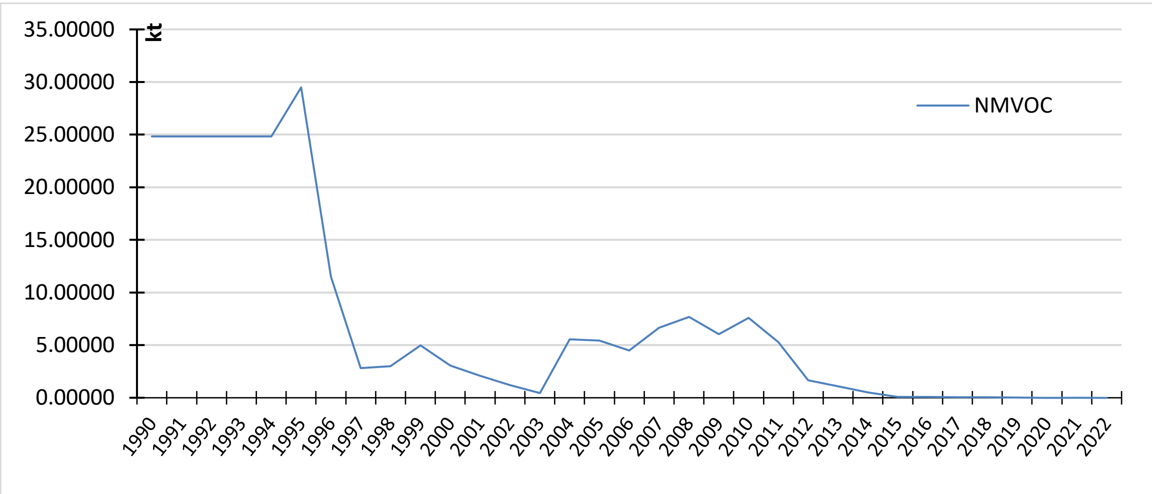


Figure 4.23.2. Emission trends (kt) for NFR 2.D.3.e Degreasing

The emissions of NMVOC from degreasing activities follow the activity data trends which varied substantially from year to year due to high variation of industry outputs.
Recalculations and improvement:

During the desk Review and according to the recommendations, *RO-2D3e-2023-0002*, XYLEN consumption was included in the AD and NMVOC emissions were recalculated using the new AD for entire period 1990-2021.

4.24 NFR 2.D.3.f. Dry cleaning

This source category refers to NMVOC emissions from processes using organic solvents to remove contamination furs, leather, down leathers, textiles, or other objects made of fibres.

As activity data was considered perchlorethylene (PER) as a solvent used for dry cleaning. We assumed the entire amount of perchlorethylene (PER) as a solvent used for dry cleaning. PER consumption was calculated with:

AD = Consumption = Production + Imports – Exports (kg).

Production/import/export data were provided by N.I.S.

The second paragraph of section 3.2.1 Dry cleaning from 2019 GB explains "solvent emissions directly from the cleaning machine into the air represent little more than 40% for a closed-circuit machine". Romania used in dry cleaning branch closed-circuit equipment following the European Solvents Directive. So, has been calculated an emission factor for NMVOC, expressed in g NMVOC/kg solvent which is 400 g NMVOC/kg PER. The activity data and emission trends are shown below in the following tables and figure.

Table 4.24.1. Activity data trends (kt) for NFR 2.D.3.f Dry cleaning

Year	Consumption of PER (kt)
1990	3.11
1991	3.11
1992	3.11
1993	3.11
1994	3.11
1995	4.33
1996	1.71
1997	3.10
1998	3.98
1999	4.85
2000	5.75
2001	2.16
2002	2.17
2003	2.18
2004	2.19
2005	1.34
2006	2.96
2007	1.87
2008	0.78
2009	0.64
2010	0.45
2011	0.42
2012	0.34
2013	0.32
2014	0.34
2015	0.40
2016	0.32
2017	0.43
2018	0.44
2019	0.42
2020	0.35

Year	Consumption of PER (kt)
2021	0.44
2022	0.45

Table 4.24.2. Emission trends (kt) for NFR 2.D.3.f Dry cleaning

Year	NMVOC (kt)
1990	1.242
1991	1.242
1992	1.242
1993	1.242
1994	1.242
1995	1.734
1996	0.686
1997	1.240
1998	1.590
1999	1.940
2000	2.298
2001	0.864
2002	0.868
2003	0.873
2004	0.878
2005	0.537
2006	1.183
2007	0.747
2008	0.311
2009	0.255
2010	0.181
2011	0.168
2012	0.135
2013	0.130
2014	0.137
2015	0.159
2016	0.128
2017	0.171
2018	0.174
2019	0.169
2020	0.140
2021	0.174
2022	0.179

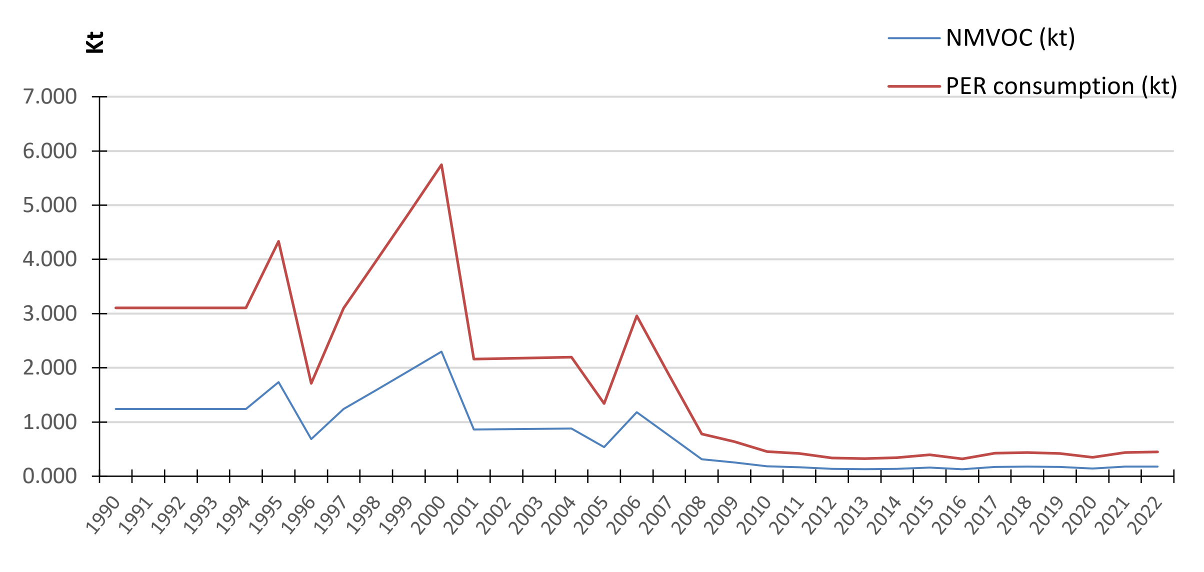


Figure 4.24.1. Emission trends (kt) for NFR 2.D.3.f Dry cleaning

The NMVOC emission trends follow the activity data trend with varied substantially from year to year due to variations in PER consumption.

There were no recalculations and improvements for this category.

4.25 NFR 2.D.3.g Chemical products

This NFR covers the emissions from the use of chemical products.

The methodology for estimating emissions from chemical products applies the general equation:

$$\text{Epollutant} = \sum_{\text{technologies}} \text{ARuse, technology x EFtechnology, pollutant}$$

where:

- ARuse,technology = the use of a specific chemical product,
- EFtechnology,pollutant = the emission factor for this technology and this pollutant.

Table 4.25.1 Source description for NFR 2D3g sector

SNAP	SNAP name	Source activity data description
060301	Polyester processing	1993-2022 – Polyester provided by N.I.S. (IND106A/106C, cod PRODROM 201640700);
060302	Polyvinylchloride processing	1990-2022 - Polyvinylchloride provided by N.I.S (cod PRODROM 201630250)
060303	Polyurethane foam processing	2000-2022 - Polyurethane provided by EUROSTAT (cod PRODCOM 20165670)

SNAP	SNAP name	Source activity data description
060304	Polystyrene foam processing	1993-2022 - Polystyrene provided by N.I.S (IND106A/106C); EUROSTAT (cod PRODCOM 201620350)
060305	Rubber processing	1990-2022 - Rubber provided by N.I.S (IND106A/106); EUROSTAT (COD PRODCOM 22191000)
060306	Pharmaceutical products manufacturing	1990-2007 the consumption of solvents and the NMVOC emission was estimated based on the gross domestic product (GDP), the annual values of the import and export; the GDP value (expressed in million USD) from the World Bank, and for the import/export value of pharmaceutical products, data provided by UN COMTRADE; For the calculation of NMVOC emissions, the average value of the national emission factor was used for the years 2008 and 2009, respectively 0,4133 t NMVOC/t solvents consumed; 2008-2022 the solvent consumption (kt) and the NMVOC emissions, are obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED).
060307	Paints manufacturing	1990-2022 - Paints provided by N.I.S (IND106A/106C)
060308	Inks manufacturing	2003-2022 - Inks provided by N.I.S (cod PRODROM 203024700)
060309	Glues manufacturing	1993-2022 - Glues provided by N.I.S (ND106A/106C)
060310	Asphalt blowing	1990-2022 - Asphalt provided by N.I.S (ND106A/106C)
060313	Leather tanning	2008-2022 the total solvents used and were obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED), as well as NMVOC emissions.

Table 4.25.2 Emission factors references for NFR 2D3g sector:

SNAP	Reported pollutants	Emission Factors tier and source
060301	NMVOC	T1 factors Table 3-1 - EMEP EEA guidebook (2019)
060302	NMVOC	T1 factors Table 3-1 - EMEP EEA guidebook (2019)
060303	NMVOC	T2 factors Table 3-3 - EMEP EEA guidebook (2019)
060304	NMVOC	T2 factors Table 3-4 - EMEP EEA guidebook (2019)
060305	NMVOC	T2 factors Table 3-5 - EMEP EEA guidebook (2019)
060307	NMVOC	T2 factors Table 3-11 - EMEP EEA guidebook (2019)
060308	NMVOC	T2 factors Table 3-11 - EMEP EEA guidebook (2019)
060309	NMVOC	T2 factors Table 3-11 - EMEP EEA guidebook (2019)
060310	NMVOC, TSP, Cd, As, Cr, Ni, Se, PAH	T2 factors Table 3-8 - EMEP EEA guidebook (2019)

The emissions of NMVOC from the NFR 2.D.3.g Chemical products follow the activity data trends which varied substantially from year to year due to high variation of industry outputs.

NMVOC emissions from this category are the key source, representing 6.6% of the total national emissions of NMVOC in 2022.

Table 4.25.3. Activity data trends (kt solvents; kt product) for NFR 2.D.3.g Chemical products

Year	kt solvents	kt product
1990	0.55	1165.00
1991	0.55	1001.00
1992	0.54	845.00
1993	0.54	601.95
1994	0.54	643.20
1995	0.54	673.42
1996	0.54	639.02
1997	0.54	609.45
1998	0.54	498.39
1999	0.54	424.88
2000	0.54	489.53
2001	0.54	453.32
2002	0.54	453.22
2003	0.55	527.46
2004	0.55	593.38
2005	0.54	537.84
2006	0.55	620.95
2007	0.57	617.40
2008	0.67	797.37
2009	0.61	521.75
2010	0.92	466.92
2011	0.84	479.92
2012	0.98	623.03
2013	0.98	668.23
2014	1.10	716.47
2015	1.11	755.44
2016	0.85	739.95
2017	1.11	684.09
2018	1.11	684.12
2019	0.95	681.88
2020	1.12	695.69
2021	0.80	772.05
2022	0.89	660.34

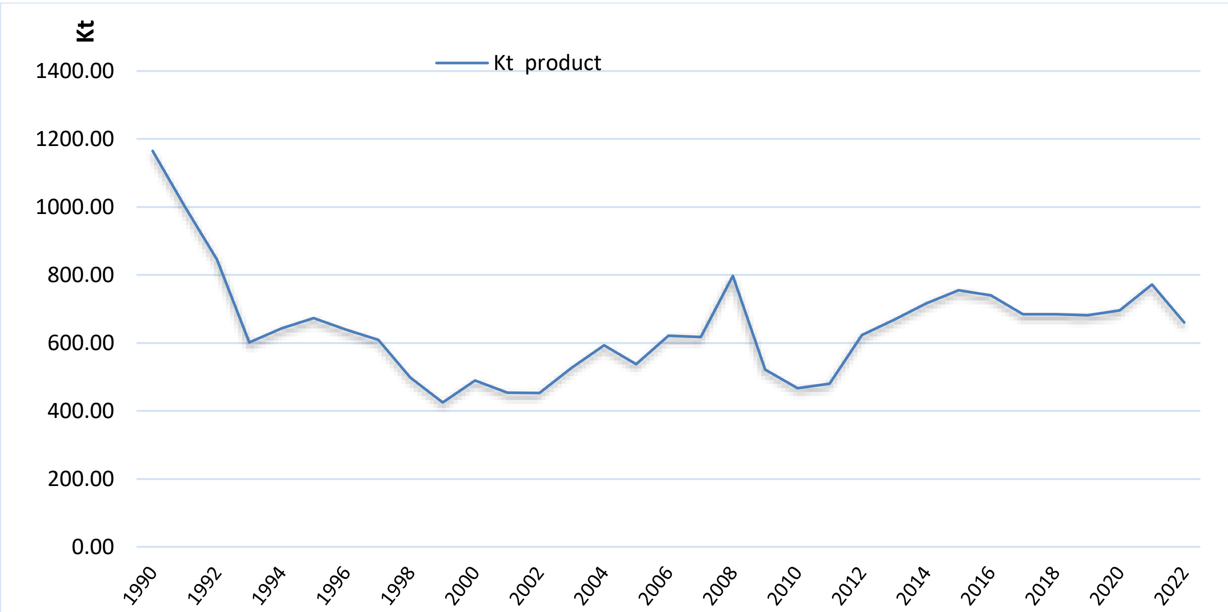


Figure 4.25.3.a Activity data trends Kt products for NFR 2.D.3.g Chemical products

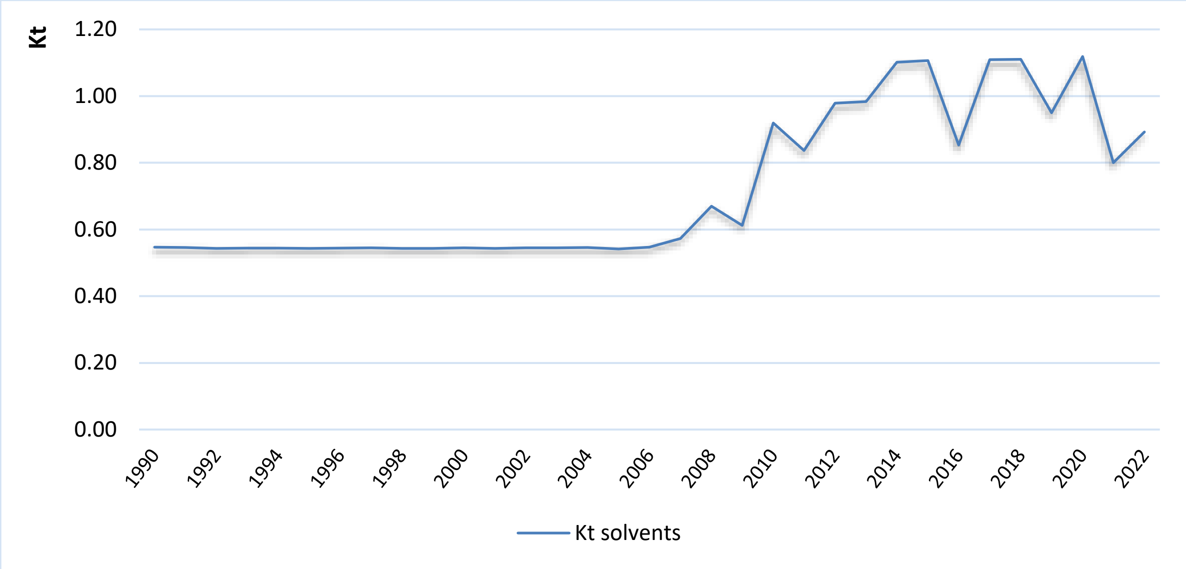


Figure 4.25.3.b Activity data trends Kt solvents for NFR 2.D.3.g Chemical products

Table 4.25.4. Emission trends (kt) for NFR 2.D.3.g Chemical products

Year/Pollutant	NMVOC
1990	19.287
1991	17.098
1992	15.266
1993	12.104
1994	12.791
1995	13.177
1996	12.859
1997	11.784
1998	9.505
1999	8.055
2000	9.998
2001	8.541
2002	8.395
2003	10.024
2004	10.992
2005	9.915
2006	12.369
2007	11.175
2008	15.086
2009	10.619
2010	9.210
2011	10.124
2012	12.039
2013	11.844
2014	13.483
2015	14.502
2016	15.563
2017	14.444
2018	14.629
2019	14.878

Year/Pollutant	NMVOC
2020	15.125
2021	16.802
2022	15.499

The emission trends are shown below in the following table and figure.

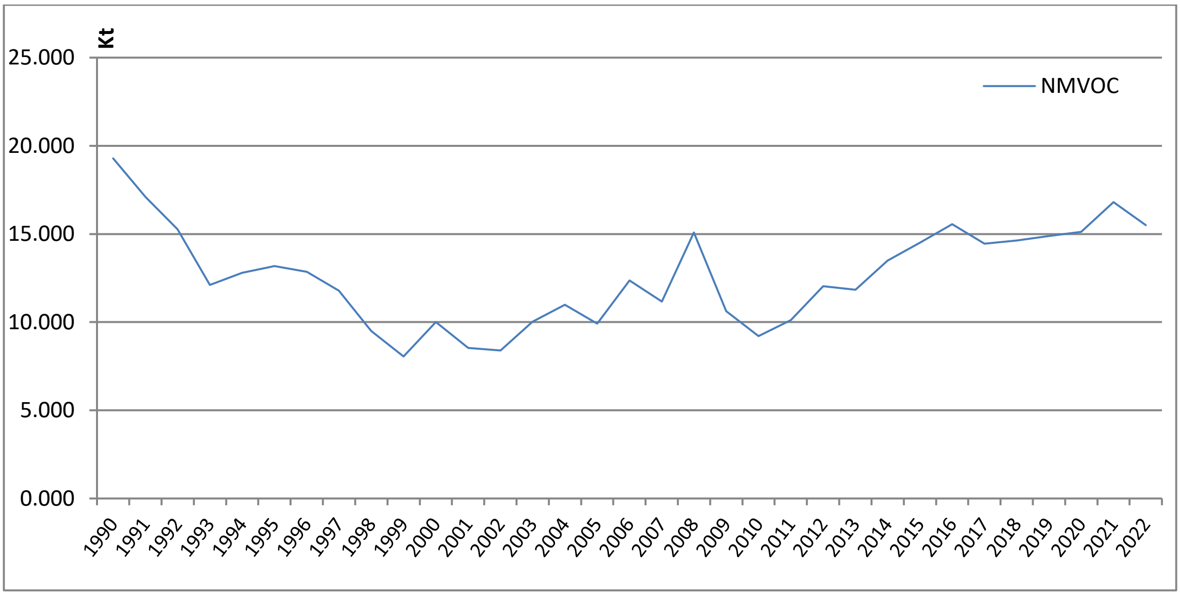


Figure 4.25.4. Emission trends (kt) for NFR 2.D.3.g Chemical products

Recalculations and improvement:
During the desk Review and according to the recommendations, *RO-2D3g-2019-0001*
- update AD and recalculation NMVOC emissions for time period 1990-2007 (SNAP 060306 pharmaceutical products manufacturing was estimated on the period 1990-2007)

4.26 NFR 2.D.3.h Printing

This chapter covers emissions from printing industry.

The methodology for estimating emissions applies the general equation:

Epollutant = ARproduction× EFpollutant where:

- Epollutant is the emission of the specified pollutant
- ARproduction is the activity rate
- EFpollutant is the emission factor for this pollutant.

The estimation emissions for NFR 2.D.3.h Printing was performed in accordance with the method proposed by TERT during the review of national air pollutant emission inventory 2023, *RO-2D3h-2023-0001*

The TERT proposes to readjust the 2005 emissions using extrapolation of activity data from 2008 to 2021 for 2005. The emissions are estimated with the same emission factor as in 2008 (for years 2003, 2004, 2006, 2007 the activity data and total emissions of NMVOC are estimated using extrapolation of year 2005; same calculation).

For 2008-2022 time period, the activity data represent the total solvents used, the emissions were obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED) as well as NMVOC emissions. For time period 1990-2002 there is no information.

Table 4.26.1. Activity data trends (kt solvents) for NFR 2.D.3.h Printing

Year	kt solvents
2003	2.11
2004	2.18
2005	2.25
2006	2.32
2007	2.39
2008	2.46
2009	2.41
2010	3.03
2011	3.24
2012	3.32
2013	3.38
2014	3.25
2015	3.82
2016	3.31
2017	3.75
2018	3.46
2019	3.85
2020	3.40
2021	3.82
2022	4.15

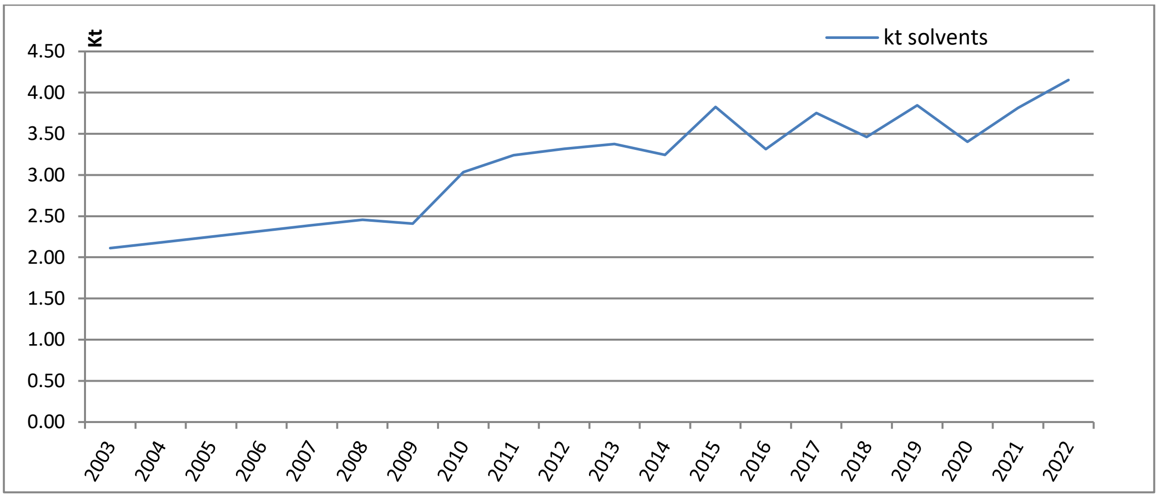


Figure 4.26.1. Activity data trends (kt solvents) for NFR 2.D.3.h Printing

Table 4.26.2. Emission trends (kt) for NFR 2.D.3.h Printing

Year/Pollutant	NMVOC
2003	1.132
2004	1.169
2005	1.206
2006	1.242
2007	1.279
2008	1.316
2009	0.989
2010	1.151
2011	1.232
2012	0.669
2013	0.572
2014	0.685
2015	0.655
2016	0.534
2017	0.667
2018	0.643
2019	0.493
2020	0.564
2021	0.607
2022	0.696

Figure 4.26.2. Emission trends (kt) for NFR 2.D.3.h Printing

The emissions of NMVOC follow the activity data trends from printing industry which varied from year to year and total solvents used in printing industry.

Recalculations and improvement:
- estimated total solvents and emissions NMVOC in accordance with the method proposed by TERT during the review of national air pollutant emission inventory 2023, *RO-2D3h-2023-0001* for 2005 year and time period 2003-2004 and 2006-2007.

4.27 NFR 2.D.3.i Other solvent use

This chapter covers emissions from “Other solvent use”

The methodology for estimating emissions applies the general equation:

Epollutant = ARproduction× EFpollutant where:

- Epollutant is the emission of the specified pollutant
- ARproduction is the activity rate
- EFpollutant is the emission factor for this pollutant.

Table 4.27.1 Source description for NFR 2D3i sector

SNAP	SNAP name	Source activity data description
060404	Fat, edible and non-edible oil extraction	1990-2007 The EF determined is the average of the EF (total solvents /total products) for the years 2008-2013 – see table 4.27.3. 2008-2022 - the solvent consumption (kt) and the NMVOC emissions, are obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED).
060405	Application of glues and adhesives	2008-2022 the solvent consumption (kt) and the NMVOC emissions, are obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED).
060406	Preservation of wood	2008-2022 the solvent consumption (kt) and the NMVOC emissions, are obtained from the economic operators by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED).
060407	Underseal treatment and conservation of vehicles	1990-2022 the total population provided by N.I.S and EUROSTAT

Table 4.27.2 Emission factors for NFR 2D3i sector

SNAP	Reported pollutants	Emission Factors tier and source
060407	NMVOC	1990-2022 T2 factors Table 3-10 - EMEP EEA guidebook (2019)

Table 4.27.3 Calculation for EF determined SNAP 060404 Fat, edible and non-edible oil extraction

SNAP 060404	year 2008	year 2009	year 2010	year 2011	year 2012	year 2013
total edible oils(t)	157764	184789	225285	203804	193208	192548
total solvents(t)	1754.96	1205.47	1391.05	1126.56	949.66	1161.14
NMVOC emission(t)	905.557	831.664	1043.623	958.335	861.727	1072.361
solvent/product	0.0057	0.0045	0.0046	0.0047	0.0044	0.0055

EF determined = ∑ solvent/product for 2008-2013 time period / 6

EF determined = 4.9341 kg NMVOC/t product

Table 4.27.4. Activity data trends (kt solvents, total population)
for NFR 2.D.3.i. Other solvent use

Year/Pollutant	Kt products	kt solvents	Population [caput]
1990	270.00		23192274
1991	236.00		22810035
1992	216.00		22778533
1993	213.00		22748027
1994	194.00		22712394
1995	224.00		22656145
1996	236.00		22581862
1997	246.00		22526093
1998	173.32		22488595
1999	244.60		22455485
2000	253.35		22430457
2001	295.96		21833483
2002	228.38		21627509
2003	243.50		21521142
2004	258.08		21382354
2005	264.31		21257016
2006	337.60		21130503
2007	219.92		20635460
2008		2.27	20440290
2009		1.80	20294683
2010		2.09	20199059
2011		1.72	20095996
2012		1.59	20020074
2013		1.76	19947311
2014		1.70	19870647
2015		1.76	19760585
2016		1.29	19643949
2017		1.54	19533481
2018		1.17	19414458
2019		1.82	19328838
2020		1.16	19201662
2021		1.21	19042455
2022		1.63	19051562

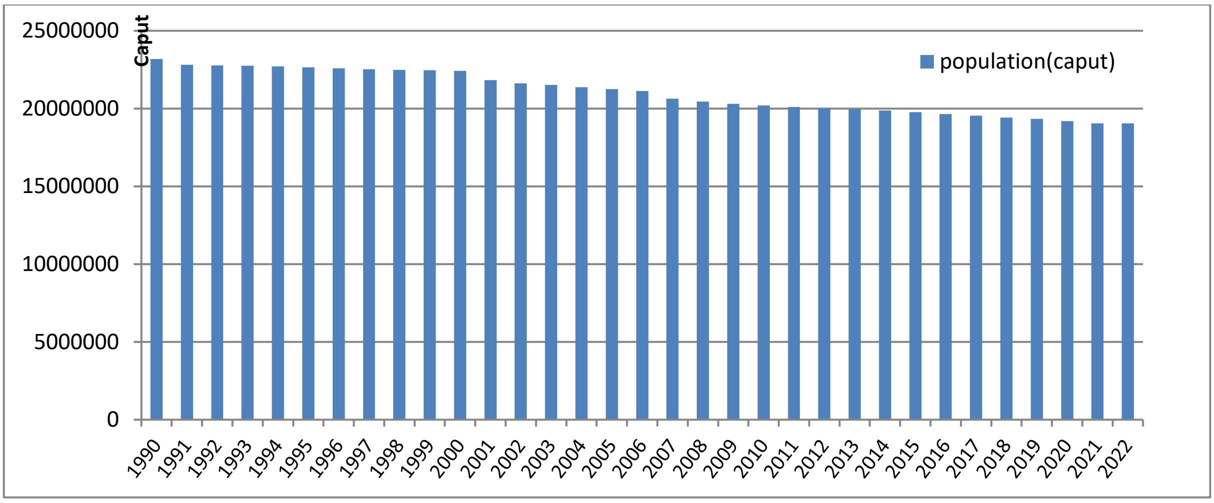


Figure 4.27.4.a Activity data trends (total population) for NFR 2.D.3.i. Other solvent use

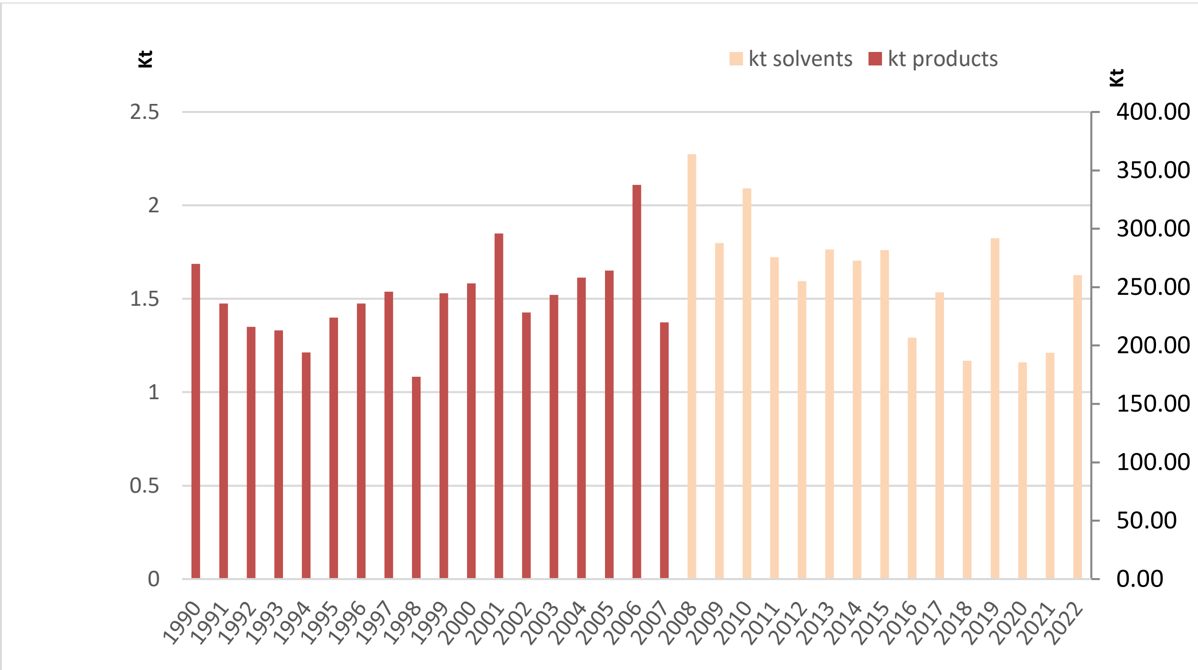


Figure 4.27.4.b Activity data trends (kt solvents and kt products) for NFR 2.D.3.i. Other solvent use

Table 4.27.5. Emission trends (kt) for NFR 2.D.3.i Other solvent use

Year/Pollutant	NMVOC
1990	5.971
1991	5.726
1992	5.621
1993	5.601
1994	5.500
1995	5.636
1996	5.681
1997	5.719
1998	5.353

Year/Pollutant	NMVOC
1999	5.698
2000	5.736
2001	5.827
2002	5.452
2003	5.506
2004	5.550
2005	5.556
2006	5.892
2007	5.212
2008	5.256
2009	5.057
2010	5.288
2011	5.164
2012	5.239
2013	5.371
2014	5.175
2015	5.173
2016	4.653
2017	4.867
2018	4.510
2019	5.174
2020	4.557
2021	4.585
2022	4.870

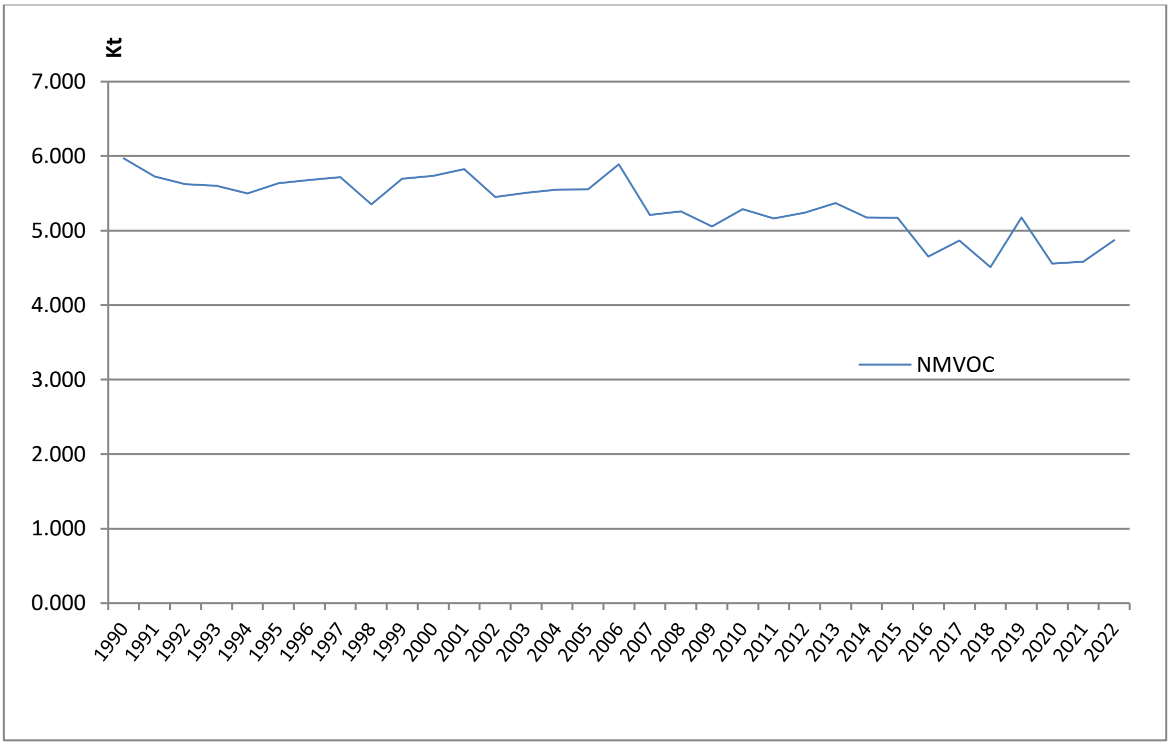


Figure 4.27.5. Emission trends (kt) for NFR 2.D.3.i Other solvent use

The emissions of NMVOC follow the activity data trends from NFR 2.D.3.i Other solvent use.

The NMVOC pollutant is the key source for NFR 2.D.3.i Other solvent use and represents 2.1% of total national NMVOC emissions for the year 2022.

Recalculations and improvement:

- recalculation NMVOC emissions for 2021 year (for the SNAP 060407 (preservation of wood) activity data (total population) was update for 2021 year).

During the desk Review and according to the recommendations, *RO-2D-2022-0001*, in order to assess the uncertainty of 2D category NMVOC emissions, the uncertainty associated with the activity data was considered to be 2% for data from economic operators and 3% for data provided by national statistics, as indicated in Table 2-1 of the EMEP Guidebook 2019. The uncertainty associated with the emission factors was calculated based on the Excel file, as a result of the NECD Capacity Building Project - Uncertainty workshop. The average of the upper and lower estimates of the 95% confidence interval was taken into account.

4.28 NFR 2.G Other product use

The emissions due to the use of fireworks, smoking tobacco and use of shoes are reported here.

The main emissions to air from this sector comprise a wide range of pollutants, the most important being the carbon monoxide (CO), particulate matter ($PM_{2.5}$, PM_{10}, TSP), volatile organic compounds (NMVOC) and heavy metals (Pb, Cd, Cu, Ni, Zn).

The emissions due to use of fireworks are calculated using Tier 2 approach, by multiplying the fireworks consumption and the emission factor from 2019 EMEP/EEA Guidebook, chapter 2D3i, 2.G, Other solvent and product use, Table 3-14 - Consumption of fireworks = Production + Import – Export (the amount used equals the production amount plus the imported amount minus the exported amount).

No activity data are available for production in Romania, the import-export data are available since 1992.

The emissions from the combustion (smoking) of tobacco are calculated using Tier2 approach, by multiplying the tobacco consumption and the emission factor from 2019 EMEP/EEA Guidebook, chapter 2.G, Table 3-15 - Consumption of tobacco = Production + Import – Export.

The emissions from the use of shoes are reported as measured NMVOC emissions, reported by economic operators, from 2008-2022 period, by drawing up a solvent management plan according to Annex VII part 7 of the Directive 2010/75/EU on industrial emissions (IED).

The production, import and export data of tobacco and of fireworks are provided by the N.I.S.

Table 4.28.1. Activity data trend (t) for NFR 2.G Other product use

Year	Tobacco (t)	Fireworks (t)
1990	27000.00	0
1991	39570.00	0
1992	42670.00	8.00
1993	37204.00	31.00
1994	35224.00	33.00
1995	45281.00	6.00
1996	33690.00	8.00
1997	31431.00	17.00
1998	31277.00	22.00
1999	32828.93	41.23
2000	36788.78	138.03
2001	42037.65	402.58
2002	37288.89	715.48
2003	40034.45	940.11
2004	43648.88	1574.32
2005	43856.45	1592.65
2006	40534.33	846.95
2007	31444.26	70.88
2008	33998.31	624.52
2009	30510.81	260.92
2010	18957.80	792.29
2011	24879.21	651.49
2012	25013.45	498.31
2013	22870.60	735.46
2014	20124.44	623.84
2015	21959.88	795.50
2016	26902.60	296.41
2017	22949.89	640.94
2018	27847.12	915.25
2019	24786.13	1543.93
2020	20111.63	1471.33
2021	24797.12	1108.76
2022	25806.37	2229.70

The emission trends are shown below in the following tables and figures.

Table 4.28.2. Emission Trends (kt) for NFR 2.G Other product use

Year/Pollutant	NMVOC	PM 2.5	PM10	TSP	CO
1990	0.131	0.729	0.729	0.729	1.488
1991	0.192	1.068	1.068	1.068	2.180
1992	0.207	1.153	1.153	1.153	2.351
1993	0.180	1.006	1.008	1.008	2.050
1994	0.170	0.953	0.954	0.955	1.941
1995	0.219	1.223	1.223	1.223	2.495
1996	0.163	0.910	0.910	0.911	1.856
1997	0.152	0.850	0.850	0.851	1.732
1998	0.151	0.846	0.847	0.847	1.724
1999	0.159	0.889	0.891	0.891	1.809
2000	0.178	1.001	1.007	1.008	2.028
2001	0.203	1.156	1.175	1.179	2.319

Year/Pollutant	NMVOC	PM 2.5	PM10	TSP	CO
2002	0.180	1.044	1.078	1.085	2.060
2003	0.194	1.130	1.175	1.184	2.213
2004	0.211	1.260	1.336	1.351	2.416
2005	0.212	1.267	1.343	1.359	2.428
2006	0.196	1.138	1.179	1.187	2.240
2007	0.152	0.853	0.856	0.857	1.733
2008	1.025	0.950	0.980	0.987	1.878
2009	0.951	0.837	0.850	0.852	1.683
2010	0.902	0.553	0.591	0.599	1.050
2011	1.079	0.706	0.737	0.743	1.376
2012	1.056	0.701	0.725	0.730	1.382
2013	1.047	0.656	0.691	0.698	1.265
2014	0.908	0.576	0.606	0.612	1.113
2015	1.059	0.634	0.672	0.680	1.216
2016	0.807	0.742	0.756	0.759	1.485
2017	0.807	0.653	0.684	0.690	1.269
2018	0.513	0.799	0.843	0.852	1.541
2019	0.477	0.730	0.804	0.819	1.337
2020	0.315	0.619	0.690	0.705	1.119
2021	0.427	0.727	0.780	0.791	1.374
2022	0.501	0.812	0.920	0.942	1.438

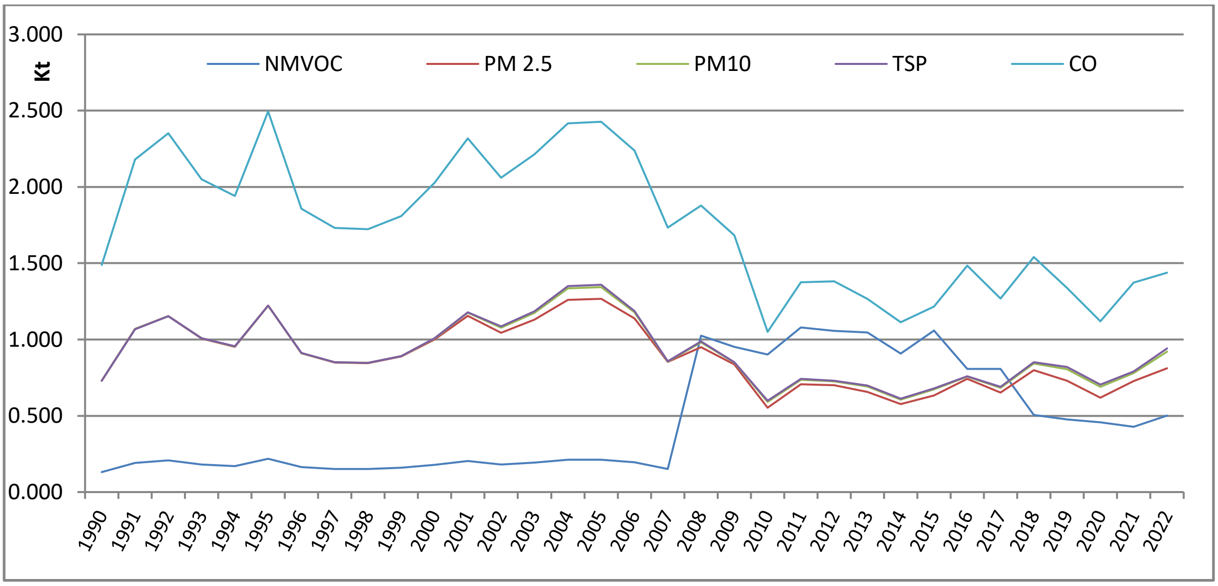


Figure 4.28.1. Emission Trends for NFR 2.G Other product use (kt)

The emissions of all pollutants vary for the time series together with the variation of the activity data, less the NMVOC trend, which is obtained by summing the emissions with the use of shoes category.

Recalculation: The NMVOC emissions for SNAP 060603 - Use of shoes, has been recalculated for the period 2008-2022, as a result of the reviewing the solvent consumption from economic operators, so the NMVOC emissions for this category has been recalculated for this period.

4.29 NFR 2.H.1 Pulp and paper industry

The activity data is represented by the total pulp and paper production from the Statistical Yearbook, provided by the N.I.S. and are confidential.

After 2008, only from 2020 was a small pulp production resumed.

The main emissions in the manufacturing of pulp and paper are carbon monoxide (CO), particulate matter ($PM_{2.5}$, PM_{10}, TSP), volatile organic compounds (NMVOC) and nitrogen oxides (NOx).

The methodology for estimating emissions from pulp and paper production applies the general equation:

$$Epollutant = ARproduction \times EFpollutant,$$

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate for the pulp and paper production;
- EFpollutant is the emission factor for this pollutant.

Due to the confidentiality purposes, that varying along the years, the presentation of emission factors used to estimate emissions from this production is not included.

The activity data used for emission calculations is the annual national total paper and pulp production, from the "PRODROM" statistics, provided by the N.I.S.

The emission trends are shown below in the following table and figure.

Table 4.29.1. Emission Trends for NFR 2.H.1 Pulp and paper industry (kt)

Year/Pollutant	NMVOC (kt)	CO (kt)
1990	0.7600	2.0900
1991	0.4700	1.2925
1992	0.3420	0.9405
1993	0.2640	0.7260
1994	0.2560	0.7040
1995	0.3880	1.0670
1996	0.3540	0.9735
1997	0.3080	0.8470
1998	0.2589	0.7118
1999	0.2877	0.7913
2000	0.3735	1.0272
2001	0.3441	0.9462
2002	0.3982	1.0951
2003	0.4232	1.1638
2004	0.3733	1.0267
2005	0.2060	0.5665
2006	0.1600	0.4400
2007	0.1720	0.4730
2008	0.0440	0.1210
2020	0.0002	0.0005
2021	0.0005	0.0014
2022	0.0011	0.0031

4.30 NFR 2.H.2 Food and beverages industry

The following products from food and beverages manufacturing are included:

- Bread;
- Wine;
- Beer;
- Spirits;
- Sugar;
- Margarine;
- Coffee roasting;
- Pastry and cakes;
- Meat, poultry and cans.

The NMVOC emissions from food and beverages manufacturing are taken into account for this subcategory.
Manipulation of cereals - grains for flour production and grains for beer production, was added as a new category to calculate the PM10 emissions.
This was a key source category for emissions of NMVOC in 2022, sharing 3.4% from the total national emissions of this pollutant.
The methodology for estimating emissions applies the general equation:

$$\text{Epollutant} = \sum_{\text{technologies}} \text{ARproduction, technology x EFtechnology, pollutant}$$

where:

- ARproduction,technology = the production rate within the source category, using this specific technology;
- EFtechnology,pollutant = the emission factor for this technology and this pollutant.

Due to the confidentiality purposes, the presentation of emission factors used to estimate emissions from foods and beverages industry is not included.

The activity data is taken from the Statistical Yearbook, from the "PRODROM" statistics, provided by the N.I.S. and from Eurostat statistics. The activity data was refined to correlate with the values of the GHG (UNFCCC) - CRF database, for SNAP 060617 - Margarine and solid cooking fats.
For food and beverages industry the activity data are confidential for different subcategory since 2010.
The emission trends are shown below in the following table and figure.

Table 4.30.1. Emission trends (kt) for NFR 2.H.2 Food and beverages industry

Year/Pollutant	NMVOC	PM10
1990	10.009	0.0595
1991	7.920	0.0757
1992	7.145	0.0704
1993	6.016	0.0666
1994	7.063	0.0687
1995	8.076	0.0759
1996	9.614	0.0839

Year/Pollutant	NMVOC	PM10
1997	8.015	0.0908
1998	8.332	0.0743
1999	7.385	0.0703
2000	9.361	0.0592
2001	10.118	0.0377
2002	10.496	0.0353
2003	11.274	0.0433
2004	10.938	0.0491
2005	10.426	0.0473
2006	11.413	0.0499
2007	9.765	0.0495
2008	10.419	0.0504
2009	9.640	0.0473
2010	8.247	0.0506
2011	9.413	0.0426
2012	9.942	0.0429
2013	10.296	0.0402
2014	10.363	0.0421
2015	11.413	0.0434
2016	10.685	0.0450
2017	10.799	0.0441
2018	7.628	0.0434
2019	8.739	0.0424
2020	7.354	0.0423
2021	8.260	0.0414
2022	7.958	0.0400

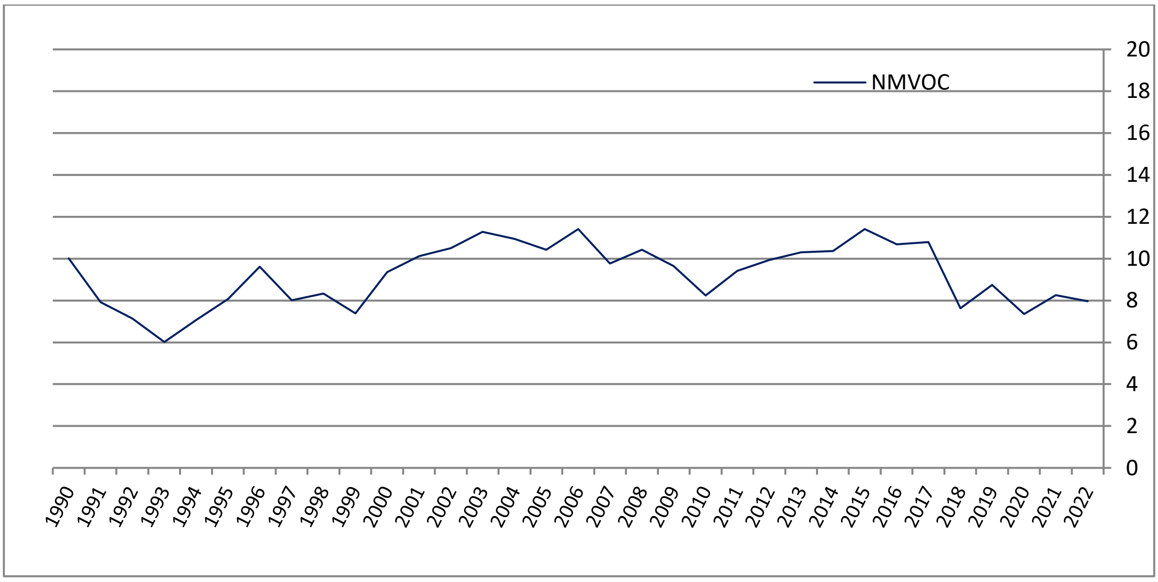


Figure 4.30.1. Emission trends (kt) for NFR 2.H.2 Food and beverages industry

The emissions of NMVOC from food and beverages industry follow the activity data trends, which varied substantially from year to year due to high variation of industry outputs.

Recalculation: The emissions from margarine category was recalculated to correlate with GHG values of the activity data for 2018-2021.
New category, manipulation of cereals, was added and emissions of PM10 were calculated for the entire series, 1990-2022.

4.31 NFR 2.I Wood Processing

This category refers to the manufacture of wood and products, manufacture of plywood, reconstituted wood products and engineered wood products and is important for particulate emissions only.

The TSP emissions from wood processing are taken into account for this subcategory.

The methodology for estimating emissions from wood processing applies the general equation:

Epollutant = ARproduction× EFpollutant where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate for the wood processing;
- EFpollutant is the emission factor for this pollutant.

The emission factors used to calculate the emissions from wood production are from 2019 EMEP/EEA Guidebook, chapter 2.I Wood processing, Table 3.1.

The activity data used for emission calculations is the annual national total timber production from the Statistical Yearbook, provided by the N.I.S. The activity data is multiplied with the density 0.883 t per m^3.

Table 4.31.1. Activity data (1000 m^3) for NFR 2.I Wood Processing

Year/Activity data	1000 m^3 product
1990	2932.00
1991	2443.00
1992	2094.00
1993	1876.00
1994	1723.00
1995	1636.00
1996	1767.00
1997	1738.00
1998	1617.57
1999	1448.92
2000	1404.65
2001	2530.00
2002	2706.00
2003	2568.00
2004	2987.00
2005	3018.00
2006	3126.00
2007	3369.00
2008	3509.00
2009	3913.00
2010	4416.00
2011	5145.00
2012	5175.00
2013	5836.00

Year/Activity data	1000 m³ product
2014	5909.00
2015	5868.00
2016	5452.00
2017	5140.00
2018	5143.00
2019	5144.21
2020	5452.99
2021	5373.32
2022	4793.24

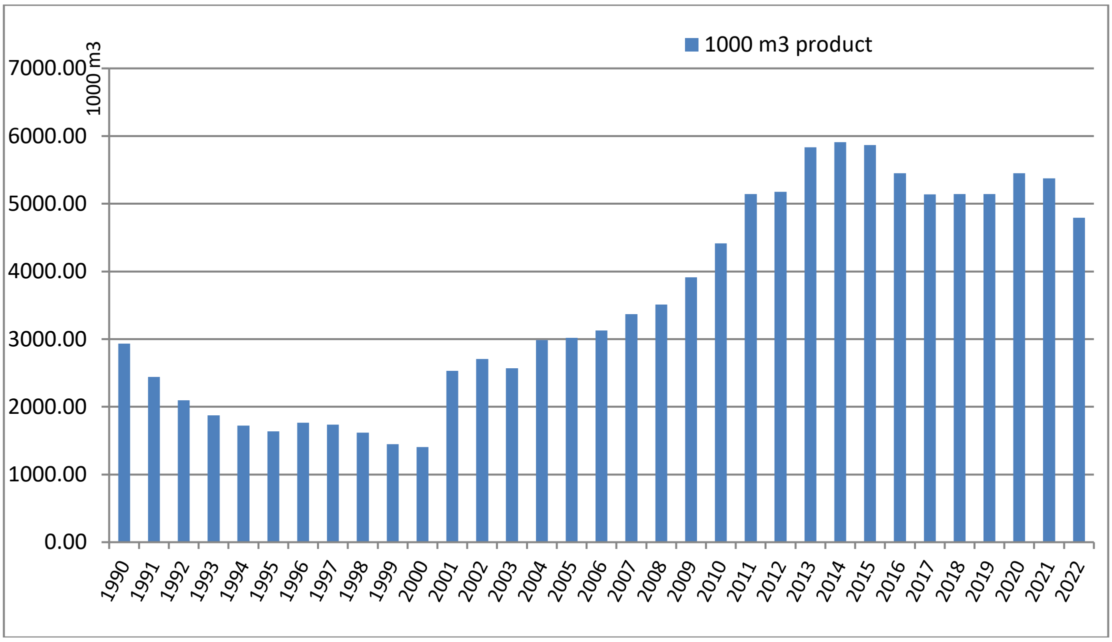


Figure 4.31.1. Activity data trend for NFR 2.I Wood Processing

The emission trends are shown below in the following table and figure.

Table 4.31.2. Emission trends (kt) for NFR 2.I Wood Processing

Year/Pollutant	TSP (kt)
1990	2.589
1991	2.157
1992	1.849
1993	1.657
1994	1.521
1995	1.445
1996	1.560
1997	1.535
1998	1.428
1999	1.279
2000	1.240
2001	2.234
2002	2.389
2003	2.268

2004	2.638
2005	2.665
2006	2.760
2007	2.975
2008	3.098
2009	3.455
2010	3.899
2011	4.543
2012	4.570
2013	5.153
2014	5.218
2015	5.181
2016	4.814
2017	4.539
2018	4.541
2019	4.542
2020	4.815
2021	5.088
2022	4.232

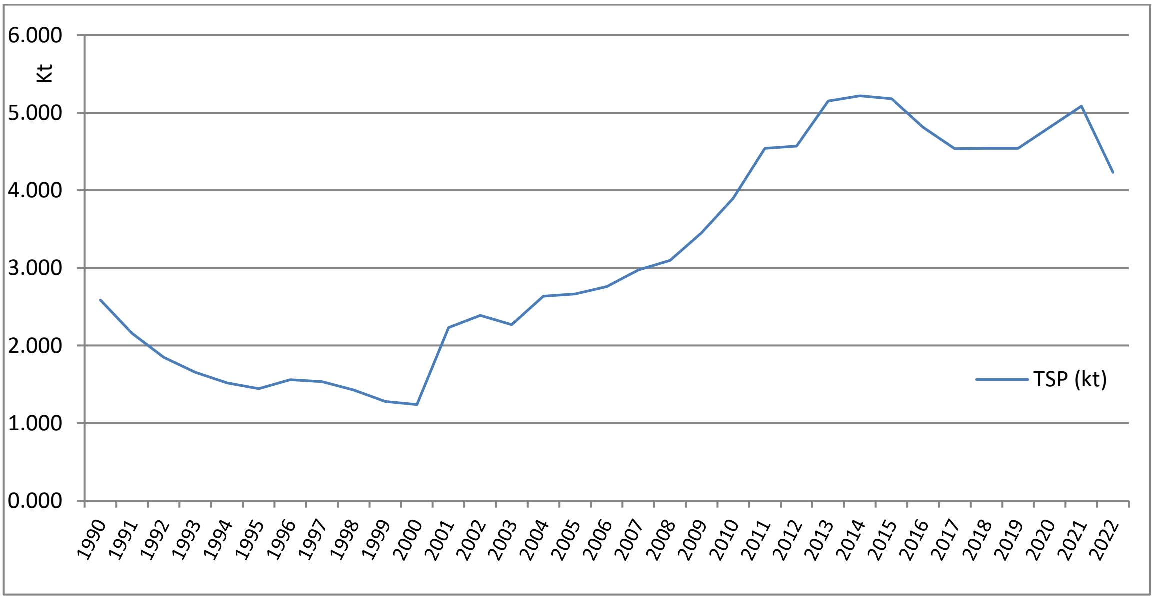


Figure 4.31.2. Emission trends (kt) for NFR 2.I Wood Processing

The emissions of TSP from wood processing activities follow the activity data trends which varied substantially from year to year due to high variation of industry outputs, with increasing interest in this industry over the last years.

There were no recalculations and improvements for this category.

5. AGRICULTURE (NFR sector 3)

The agricultural sector includes emissions from manure management (NFR 3.B), agricultural soils (NFR 3.D) and fields burning of agricultural residue (NFR 3.F).

The emission calculation is based on the methodologies provided in the 2019 EMEP/EEA Guidebook.

Animal populations, data on fertilizers usage and crop productions were taken from the Statistical Yearbook provided by the N.I.S. and from the Romania's Greenhouse Gas Inventory – N.I.R., improving the consistency between data for NFR and CRF, considering that many of the agricultural activities data for estimation of air pollutants are the same as for greenhouse gas emissions (TERT recommendations).

The emission from the agricultural activities covers a range of pollutants.

Table 5.1 Overview of sources and pollutants in agricultural activities

NFR codes	Long name	Main pollutants				Particulate matter				Other pollutants		
		NOx (as NO_2)	NMVOC	SOx (as SOx)	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO	HM [a)]	POPs[b)]
3B	Manure Management	x	x		x	x	x	x				
3Da	Agricultural soils	x	x		x							
3Dc	Farm-level agricultural operations					x	x	x				
3De	Cultivated crops		x									
3F	Field burning of agricultural residu	x	x	x	x	x	x	X	x	x	x	x

[a)] *As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn*
[b)] *Dioxins and furans (PCDD/F) and polycyclic aromatic hydrocarbons (PAH – benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoran-thene and indeno(1,2,3-cd)pyrene*

Table 5.2 - The agricultural contribution of total national emissions in 2022

	NH_3	NOx	SOx	NMVOC	$PM_{2.5}$	PM_{10}	TSP
National total (kt)	149.84	202.90	46.60	235.34	107.46	143.13	197.14
Agriculture total (kt)	134.37	29.00	0.00150	54.02	1.28	21.10	31.63
Weight percentage (%)	89.68%	14.29%	0.0032%	22.95%	1.19%	14.74%	16.04%

For the year 2022, the main part of the NH_3 emission (89.68%) from the national total is related to the agricultural sector, while the contribution of NMVOC share from agriculture accounts for 22.95% of the national total. The TSP, PM_{10} and $PM_{2.5}$ emissions from manure management are 16.04%, 14.74% and 1.19%, respectively, of the national total. The inventory also includes the NOx emissions from application of inorganic fertilizers and animal manure, which results in 14.29% of the national total. The total SOx emissions from agriculture is lower, 0.0032% from the national total.

Table 5.3 – Key Sources Categories for Agricultural Sector – NFR 3

Key Sources	**NFR Codes**	**Long name Category**
NOx	*3Da1*	*Inorganic N-fertilizers*
	3Da2a	*Animal manure applied to soils*
NMVOC	*3Da2a*	*Animal manure applied to soils*
	3B1a	*Manure management - Dairy cattle*
	3De	*Cultivated crops*
	3B1b	*Manure management – Non-dairy cattle*
NH3	*3Da2a*	*Animal manure applied to soils*
	3Da1	*Inorganic N-fertilizers*
	3Da3	*Urine and dung deposited by grazing animals*
	3B3	*Manure management - Swine*
	3B1a	*Manure management - Dairy cattle*
	3B1b	*Manure management – Non-dairy cattle*
PM10	*3Dc*	*Farm-level agricultural operations*
TSP	*3Dc*	*Farm-level agricultural operations*
	3B4gi	*Manure management - Laying hens*

Information on which source sectors include the condensable component of particulate matter, as provided by the Guidebook 2019 (pg. 8) is presented in the sector 3D Crop production and agricultural soils: "*The processes which result in particulate emissions are largely low-temperature mechanical activities, and emissions are unlikely to include substantial quantities of condensable particulate material*".

Table 5.4. Pollutants and Emission factors for Sector 3

NFR	Pollutants Reported	Emission Factor tier and source
3B1a Manure management - Dairy cattle	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP T2 – NH3, NMVOC
3B1b Manure management - Non-dairy cattle	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP T2 – NH3, NMVOC
3B2 Manure management - Sheep	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10,TSP, NMVOC T2 – NH3
3B3 Manure management - Swine	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP, NMVOC T2 – NH3
3B4a Manure management - Buffalo	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10,TSP, NMVOC, NH3
3B4d Manure management - Goats	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP, NMVOC, NH3
3B4e Manure management - Horses	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP, NMVOC, NH3
3B4gi Manure management - Laying hens	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP T2 – NH3, NMVOC
3B4gii Manure management - Broilers	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP, NH3 T2 – NMVOC
3B4giii Manure management - Turkeys	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP, NMVOC, NH3
3B4giv Manure management - Other poultry	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP, NMVOC, NH3
3B4h Manure management - Other animals (rabbits)	NOx, NMVOC, NH3, PM2.5, PM10, TSP	T1 – NOx, PM2.5, PM10, TSP, NMVOC, NH3
3Da1 Inorganic N-fertilizers (includes also urea application)	NOx, NH3	T1 – NOx; T2 - NH3, EMEP EEA guidebook (2019) factors
3Da2a Animal manure applied to soils	NOx, NMVOC, NH3	T1 – NOx, EMEP EEA guidebook (2019) factors

NFR	Pollutants Reported	Emission Factor tier and source
		T2 – NMVOC, NH3, EMEP EEA guidebook (2019)
3Da2b Sewage sludge applied to soils	NOx, NH3	T1 - EMEP EEA guidebook (2019) factors
3Da3 Urine and dung deposited by grazing animals	NMVOC, NH3	T2 - EMEP EEA guidebook (2019) factors
3Dc Farm-level agricultural operations including storage, handling and transport of agricultural products	PM2.5, PM10, TSP	T1 - EMEP EEA guidebook (2019) factors
3De Cultivated crops	NMVOC	T1+T2 - EMEP EEA guidebook (2019) factors
3F Field burning of agricultural residues	All CLRTAP pollutants (except PCDD/ PCDF, HCB, PCBs)	T2 - EMEP EEA guidebook (2019) factors

Romania is one of the country that have benefited from the ‘Capacity building for Member States regarding the development of national emission inventories’ commissioned by the DG Environment of the European Commission, using the AgrEE Tool to calculate and verify the emissions for the sector of Agriculture, for 3B, 3D and 3F subsectors.

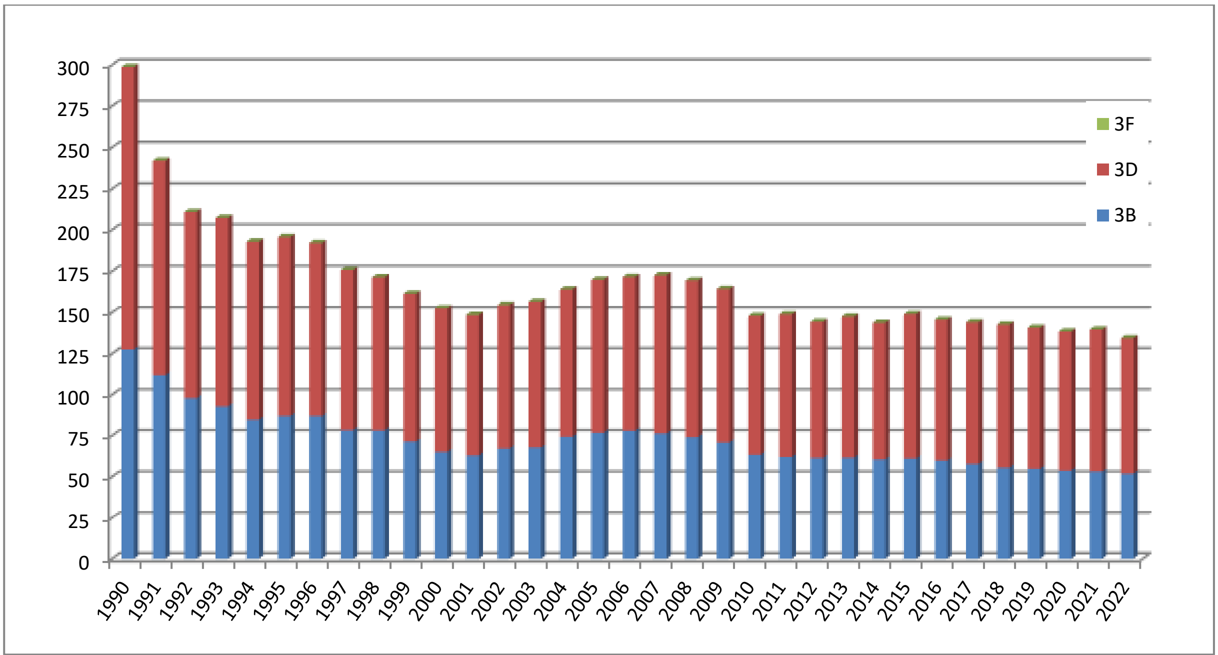


Figure 5.1 Distribution of the NH_3 emission by the agricultural sources for the 1990-2022 period

For the year 2022, the distribution of ammonia (NH_3) emissions by agriculture sources was as follows: 38.61% from manure management, 61.38% from manure applied to soils and only 0.0097% from burning fields.

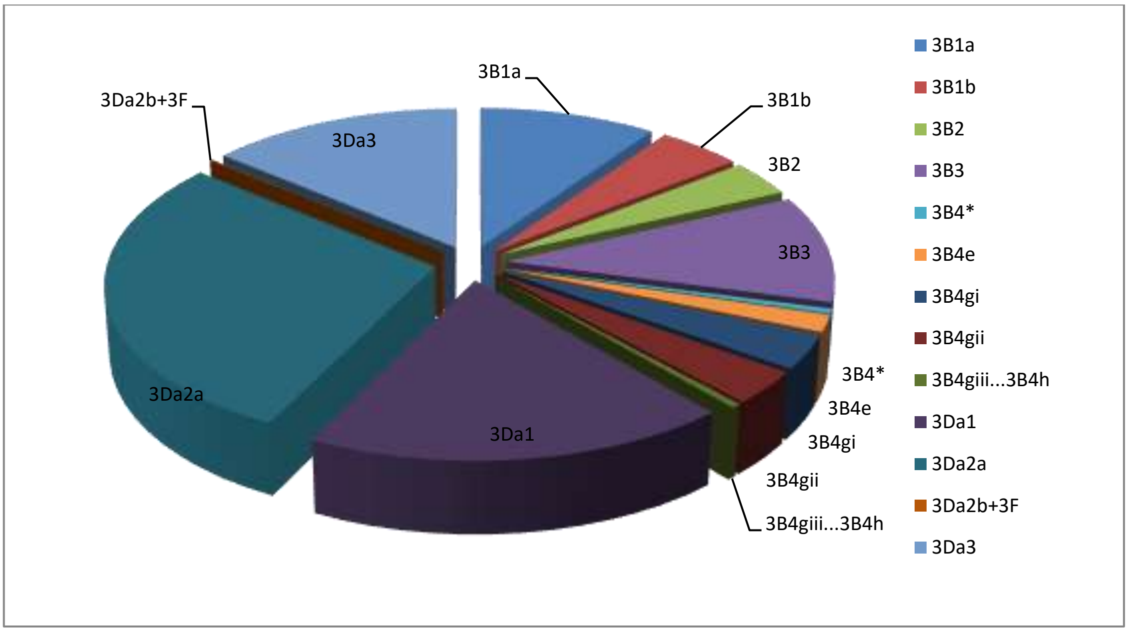


Figure 5.2 - Share of NH_3 emissions by the agriculture sector for 2022

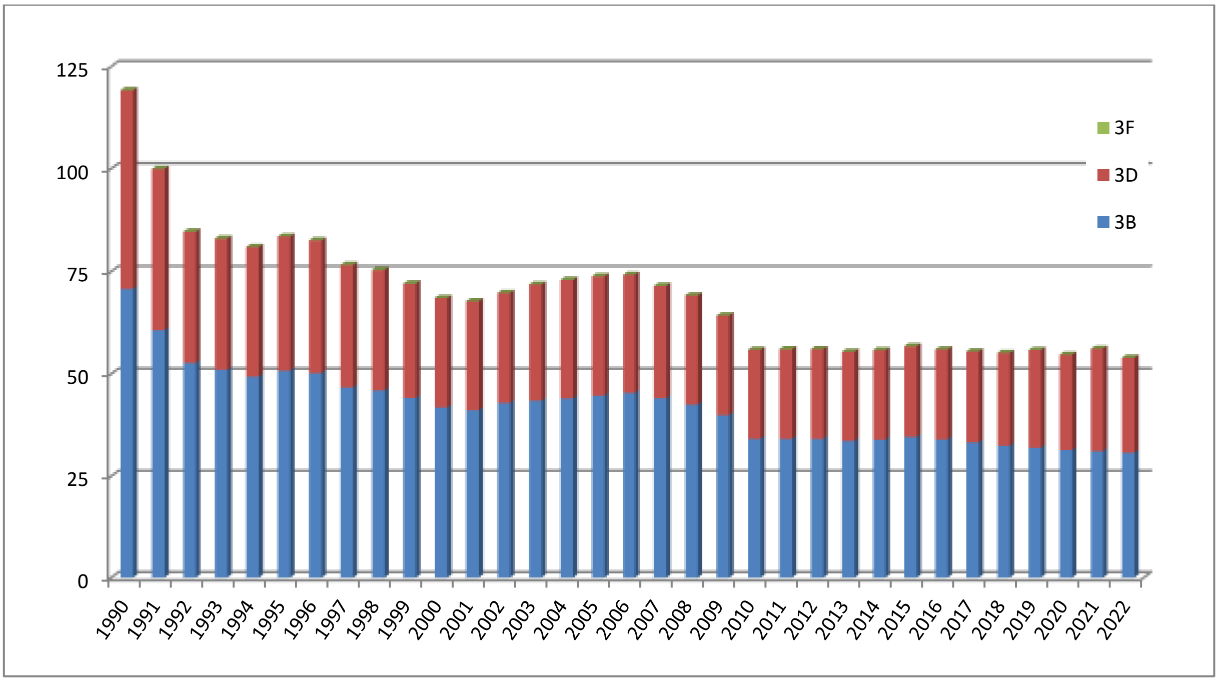


Figure 5.3 Distribution of the NMVOC emissions by the agricultural sources for 1990-2022 period

For the year 2022, the distribution of NMVOC emissions by agricultural sources was as follows: 56.9% from manure management, 43.1% from manure applied to soils and only 0.0378% from burning fields.

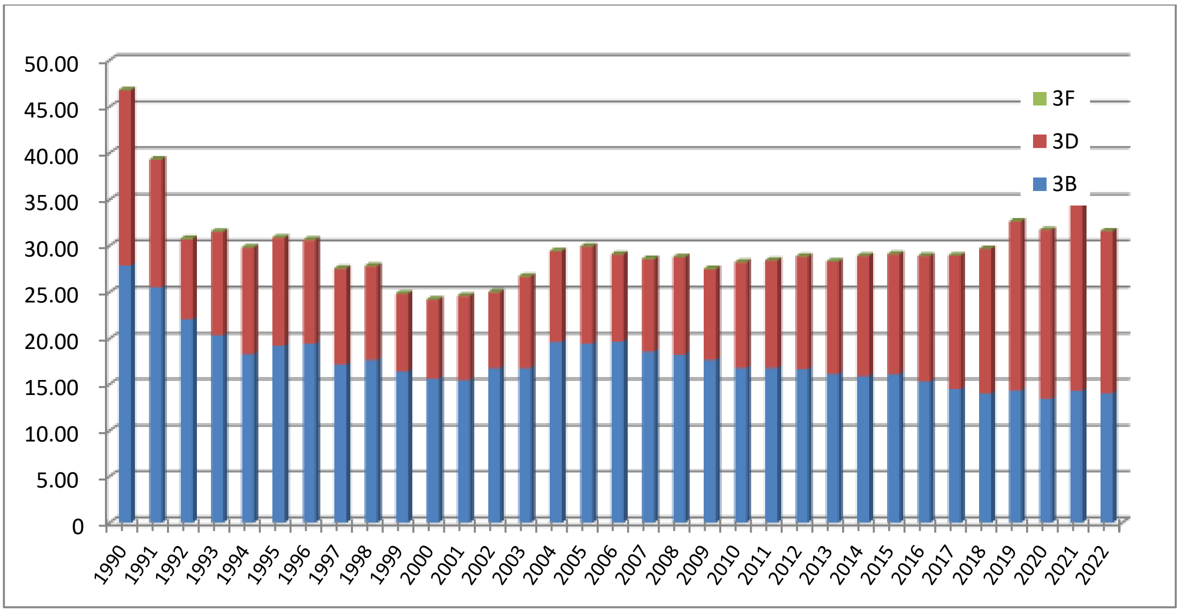


Figure 5.4 Distribution of TSP emissions by the agricultural sources for the 1990-2022 period

For the year 2022, the distribution of TSP emissions by the agricultural sources was as follows: 44.38% from manure management, 55.52% from manure applied to soils and only 0.107% from burning fields.

3B Manure Management

Description

This sector comprises emissions arising from the agricultural and zoo technical activities, including housing, manure storage and grazing, manure treatment and manure application.

The management of manure has to be considered as important source of pollutants of all agriculture emissions in 2022. This chapter contains emissions stemming from animal husbandry. This includes emissions from animal manure, except NFR categories 3.Da.2a - Animal manure applied to soils and 3.Da.3 - Urine and dung deposited by grazing animals.

In 2022, the majority of the emissions is generated by the production of cattle (dairy and non-dairy cattle) and swine (finishing pigs and sows categories).

For this sector, in 2022, the key categories were represented as percentage from total national emissions, as follow:
- NMVOC: dairy cattle (5.7%), non-dairy cattle (2.3%);
- NH_3: swine (9.8%), dairy cattle (8.8%), non-dairy cattle (4.2%);
- TSP: laying hens (4.1%).

After the period 2001÷2002, the species of animals raised in Romania recorded fluctuations in the number of animals due to the economic context, and led to the emergence of the various associative forms in a new transition economy and the interest shown by farmers for the growth of certain species. Therefore, the interest in dairy products, non-dairy cattle, sheep and goats manifested itself by increasing the number for these categories.

The livestock for these animal's categories have been taken from N.I.S. database and refined to correlate with the values of the GHG (UNFCCC) - CRF database. The activity data from NIS includes the categories of laying hens and other poultry, so the number of broilers was obtained as follows: Broilers = All other poultry except laying hens –Turkeys -Other poultry (geese, ducks etc.) (Annex A, Table1). The number of turkeys and other poultry (geese, ducks, etc.) was obtained from nationwide questionnaires. The national questionnaires were distributed to complete the entire series of years, 1990-2022, as the respective farms were established. Answers to the national questionnaires were received from all over the country, so that farms specialized in raising other poultry are found in 24% of the country, along the entire time series. For 2022 were reported only 19%, showing a decrease in the interest in raising these categories of poultry.

The national data on the proportions of the days that livestock spend in open yard areas are not available. In the absence of country-specific data, the used value of daily TAN deposited to yards by different categories was that provided by the 2019 EMEP/EEA Guidebook.

The pollutants from manure management were represented by NH_3, NMVOC, PM_{10}, TSP and $PM_{2.5}$ and the values were according to the 2019 EMEP/EEA Guidebook, part Manure Management.

Each emission factor reflects the sum of the emissions from animal housing and manure storage. The emissions resulting from the application of manure to soils and from grazing are reported separately under the NFR categories 3.Da.2.a and 3.Da.3.

In general, the AgrEE tool was used to calculate almost all the pollutants, following the 'Capacity building for Member States regarding the development of national emission inventories' commissioned by the DG Environment of the European Commission.

For **ammonia emissions** was used the Excel spreadsheet "Manure Management N-flow tool" for the subcategories calculated with Tier2 approach: dairy cattle (NFR 3.B.1a), non-dairy cattle (NFR 3.B.1b), swine (NFR 3.B.3- fattening pigs and sows), sheep (NFR 3.B.2) and laying hens (NFR 3.B.4.g.i), using the default parameters of the 2019 EMEP/EEA Guidebook were used (tables 3.7, 3.8, 3.9, 3.10), except where there were national values (average weight of animals, amount of solid/liquid stored) (Annex A Table 2, 3). For the rest of the subcategories, the values from Table 3.2 and Table 3.3, Tier 1 Methodology, EMEP/EEA Guide 2019 were used to calculate with the AgrEE Tool.

The proportion of livestock storage on slurry-based system was made available by the study *"Romanian Projections for Pollutants Emissions to 2030"* made available by the Ministry of the Environment, Waters and Forests – pages 118-119, as follow:

“Regarding the separate analysis of emissions according to the type of power supply (with or without silage), the percentages of the average annual population (AAP) that can be associated with feeding on the basis of silage were appreciated and assumed by the expert's opinion, taking into account the data presented in the Synthesis of indicators on the Animal Husbandry sector from 30.11.2017, offered by the Directorate of Policies and Strategies within Ministry of Agriculture and Rural Development.[…] Since, the production and management of silage is a function of the economic power of the holding, the percentages associated with the livestock on the structures were taken into account of property. Thus: in taurines, of the total livestock, 10% are companies or associations with capital private with high chances to produce and manage silage fodder. For other species, these percentages are: in sheep 3%, in goats 3%, in buffaloes 3%.

The types of waste management were established based on expert opinion, knowing the practices from the household systems that present the largest share of total and at the level of which an exact quantification of the pollutants cannot be made and cannot be measured the impact of environmental policies and emission reduction measures at the national level on animal husbandry sector.

Thus, at the level of the four years for which the estimates were made (2005, 2014, 2015 and 2016), the percentages distributed between waste management systems for each species and exploited category, was:

· Dairy cattle:

- Solid storage: 97% in 2005 and 70% since 2014;

- Sludge storage (slurry) 3% in 2005 and 30% from 2014;

· Other taurines:

- Solid storage: 97% in 2005 and 70% since 2014;

- Sludge storage (slurry) 3% in 2005 and 30% from 2014;

Pigs for fattening:

- Sludge: 40% in 2005 and 60% from 2014;

- Solid storage 60% in 2005 and 40% since 2014;

· Sows:

- Sludge: 30% in 2005 and 60% from 2014;

- Solid storage 60% in 2005 and 30% since 2014;

- Outdoor: 10%;

· Laying hens:

- Solid storage: 100%;

· Broilers:

- Solid storage: 100%;

· Sheep, goats, horses, buffaloes:

- Solid storage: 100%.”

In response to a question raised during the evaluation, Romania provided revised estimates for the non-mandatory years 2006-2013 using interpolation for the proportion of livestock stocked in sludge-based system between the two studies undertaken in 2005 and 2014 for the categories mentioned above (Annex A Table 4).

The values for ARfeedstock obtained directly from the farmers by questionnaires at national level, were used in the Excel spreadsheet "Manure Management N-flow tool" tool to extract the values for digestate created by the anaerobic digestion of manure, that is returned from chapter 5B2, from the categories whose manure was used: dairy cows (for period 2014-2022), finishing pigs (for period 2016-2022) and laying hens (for period 2013-2022) (Annex A, Table 5).

Emission factor values for Tier 1 methodology are based on Table 3.2 and Table 3.3 (3B – Manure Management, 2019 EMEP/EEA Guidebook) and were used for the rest of the livestock categories.

To calculate the **NMVOC emissions**, Romania used the AgrEE Tool to implement the Tier2 methodology for dairy cattle (NFR 3.B.1a), non-dairy cattle (NFR 3.B.1b), laying hens (NFR 3B4gi) and broilers (NFR 3B4gii), with the equations described in the EMEP/EEA Guide 2019 and the default emission factors from Table 3.11, Table 3.12, less the "N_{ex} head" parameter taken from the Excel spreadsheet "N- flow Manure Management Tool". The values for feed intake (GE), included in calculation for subcategory diary-cattle and non-dairy cattle were provided by Romania’s Greenhouse Gas reporting, as the volatile excretion (VS), for laying hens and broilers subcategories (Annex A Table 6 and below notes). The percent of silage feeding for dairy cattle, non-dairy cattle (10%), sheep, goats and buffalos (3%) according to the study “Romanian Projections for Pollutants Emissions to 2030” was used in calculation.

For the calculation of NMVOC emissions, the AgrEE tool provided the possibility to obtain values for NFR 3Da2a and NFR 3Da3, only for the emission categories calculated with the Tier2 approach. The Tier1 calculation method was used for the rest of the subcategories with values from table 3.4 (EMEP/EEA Guide 2019).

The **PM emissions** were calculated with AgrEE Tool, by using the default Tier 1 $PM_{2.5}$ EFs provided in the 2019 Guidebook (Table 3.5) based on the default housing period (Table 3.7), for all livestock categories and entire time series.

The **NOx emissions** is based on the Tier 1 methodology (Table 3.3 – stored manure NO) of the EMEP/EEA Guidebook 2019, which used the proportion of animals housed in the slurry-based system for certain livestock categories (mentioned in the emission description of ammonia) from the study "Romanian projections for pollutant emissions until 2030" and were calculated with AgrEE Tool.

Every category of livestock is described below by the trend of the activity data and the main pollutants over the period 1990-2022.

Table 5.5.a - Activity data trends (*Population Size (1000 head)*) for the livestock categories in Romania

Year/Pollutant	Dairy cattle	Non-dairy cattle	Sheep	Fatting pigs	Sows	Buffalos	Goats	Horses
1990	3002	2314	14062	11052	951	65	1005	670
1991	2430	1873	13879	10183	771	52	954	749
1992	2055	1584	12079	9060	792	44	805	721
1993	2007	1547	11499	8584	678	43	776	751
1994	1942	1497	10897	7182	576	42	745	784
1995	1950	1504	10381	7370	590	42	705	806
1996	1916	1477	9663	7651	584	41	654	816
1997	1805	1391	8938	6591	506	39	610	822
1998	1753	1352	8409	6679	515	38	585	839
1999	1702	1312	8121	5443	405	37	558	858
2000	1601	1234	7657	4474	323	34	538	864
2001	1562	1204	7251	4113	334	34	525	860
2002	1606	1238	7312	4696	362	35	633	879
2003	1616	1246	7447	4810	335	35	678	897
2004	1566	1208	7425	6069	426	34	661	840
2005	1626	1191	7611	6128	494	45	687	834
2006	1639	1254	7678	6294	520	41	727	805
2007	1573	1214	8469	6122	442	32	865	862
2008	1483	1170	8882	5797	376	30	898	820
2009	1419	1063	9141	5434	359	30	917	764
2010	1179	797	8417	5073	356	25	1241	611
2011	1154	814	8533	4983	381	21	1236	596
2012	1147	842	8834	4836	399	20	1266	575
2013	1155	849	9136	4797	384	18	1313	548
2014	1173	825	9518	4663	378	20	1417	525
2015	1176	898	9810	4552	375	18	1440	503
2016	1177	853	9875	4347	361	20	1483	520
2017	1160	832	9982	4056	350	19	1503	481
2018	1143	815	10176	3616	309	19	1539	448
2019	1125	779	10359	3526	309	19	1595	407

2020	1107	749	10281	3469	316	20	1612	408
2021	1068	741	10087	3321	299	18	1493	374
2022	1062	753	10247	3044	285	18	1483	323

Table 5.5.b - Activity data trends (*Population Size (1000 head)*) for the poultry and rabbits categories in Romania

Year/Pollutant	Laying hens	Broilers	Turkeys	Other poultry	Rabbits
1990	51475	69879	5	20	1330
1991	50213	55797	5	17	1000
1992	42406	45301	4	14	640
1993	37981	38532	4	15	771
1994	36233	33905	4	14	8000
1995	38574	41931	4	15	1000
1996	38883	39579	4	13	1000
1997	35089	31516	3	12	1000
1998	37272	32190	4	13	1200
1999	38497	30632	3	11	1300
2000	40760	29302	3	11	1300
2001	42156	29245	3	10	540
2002	44667	32698	3	11	552
2003	44122	32481	3	11	564
2004	51889	35105	5	16	576
2005	49725	36807	5	16	570
2006	50278	34691	5	16	479
2007	45208	36811	4	13	495
2008	45529	38821	3	20	458
2009	45046	38765	3	29	456
2010	44504	36309	3	29	268
2011	45464	34329	18	30	276
2012	45402	34616	85	33	297
2013	42541	36786	68	45	290
2014	42739	32534	126	48	288
2015	43663	34156	784	45	292
2016	40833	34015	778	64	297
2017	38312	34154	751	72	278
2018	38134	34878	916	65	259
2019	40728	33518	1040	78	275
2020	36648	33535	937	63	254
2021	42038	34108	946	57	237
2022	41883	35258	1024	55	201

5.1 NFR 3.B.1.a Manure management - Dairy cattle

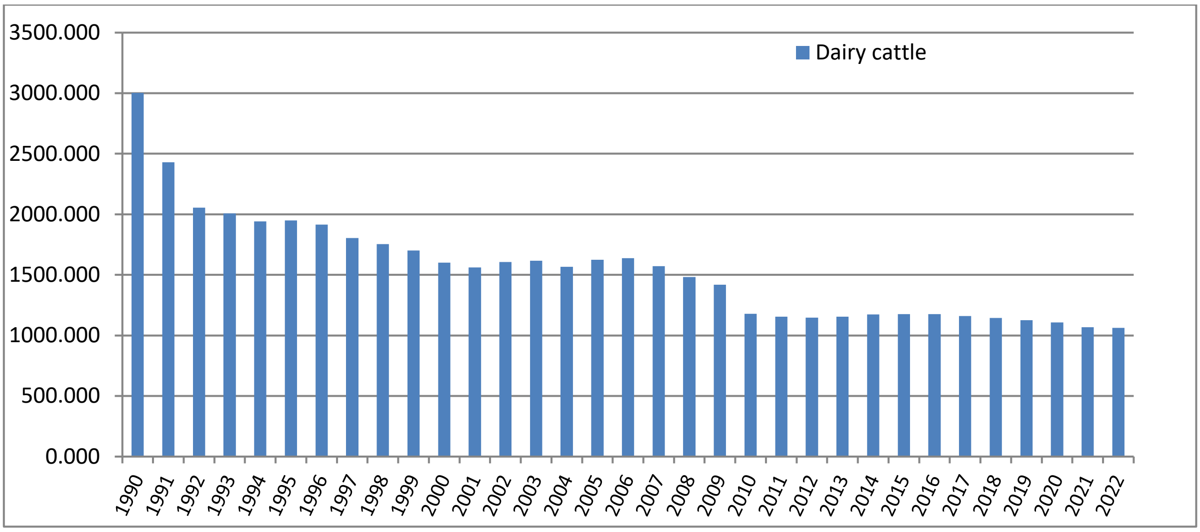


Figure 5.1.1. Activity data trends (*Population Size (1000 head)*) for NFR 3.B.1.a Manure management - Dairy cattle

Activity data for dairy cattle with which the graph was obtained are presented in table 5.5.a above.

Table 5.1.1. Emission trends (kt) for NFR 3.B.1.a Manure management - Dairy cattle

Year/Pollutant	NMVOC(kt)	NH_3(kt)
1990	30.163	32.471
1991	25.461	26.280
1992	22.183	22.225
1993	22.051	21.706
1994	22.199	21.006
1995	22.634	21.096
1996	22.418	20.728
1997	21.366	19.521
1998	20.737	18.966
1999	20.111	18.411
2000	19.168	17.319
2001	19.009	16.896
2002	19.581	17.367
2003	19.944	17.482
2004	19.660	16.943
2005	20.151	17.584
2006	20.611	17.732
2007	19.649	17.013
2008	18.683	16.044
2009	17.618	15.349
2010	14.920	12.748

2011	14.841	12.482
2012	14.563	12.406
2013	14.694	12.491
2014	14.729	14.521
2015	14.607	14.557
2016	14.448	14.563
2017	14.247	14.359
2018	14.116	14.150
2019	13.865	13.922
2020	13.726	13.701
2021	13.529	13.216
2022	13.403	13.150

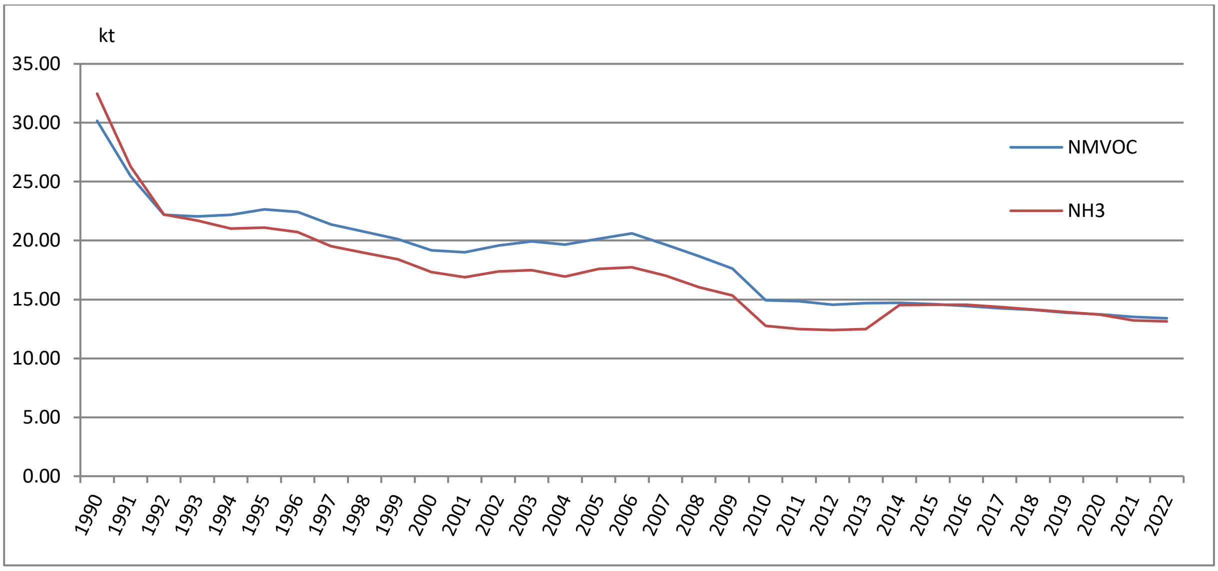


Figure 5.1.2. Emission trends (kt) for NFR 3.B.1.a Manure management - Dairy cattle

The estimates of NH3 and NMVOC emissions obtained at the recommendation of the EMEP/EEA Guide 2019 follow the evolution of the activity data, respectively the change of the manure management system.

5.2 NFR 3.B.1.b Manure management - Non-dairy cattle

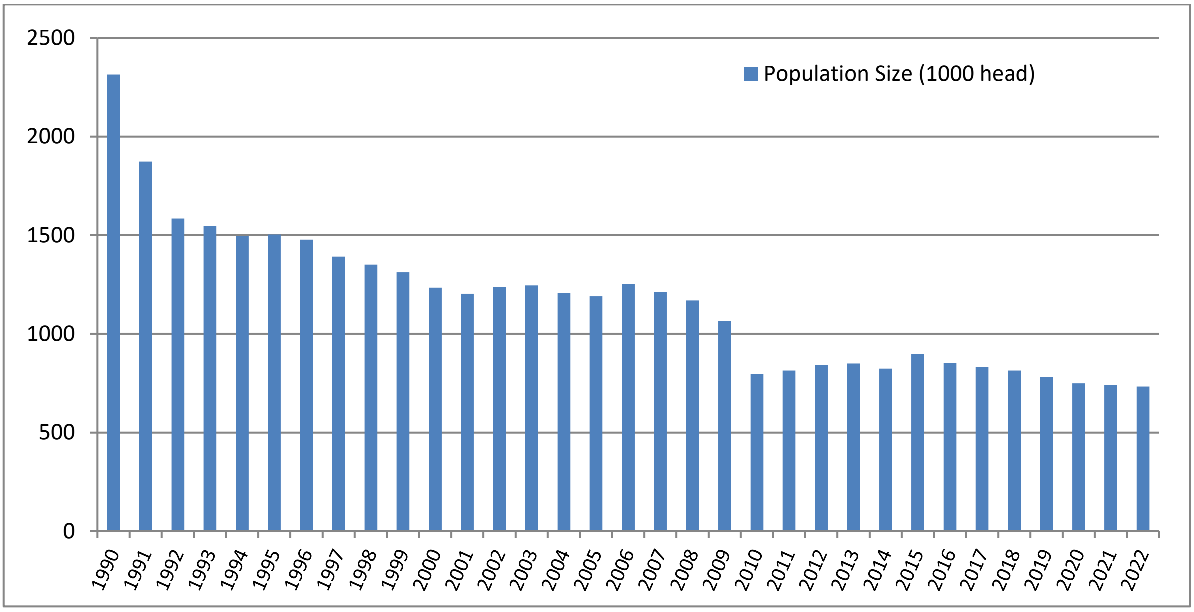


Figure 5.2.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.1.b Manure management - Non-dairy cattle

Activity data for non-dairy cattle with which the graph was obtained are presented in table 5.5.a above.

Table 5.2.1 Emission trends (kt) for NFR 3.B.1.b Manure management - Non-dairy cattle

Year/Pollutant	NMVOC	NH_3
1990	17.906	16.171
1991	14.492	13.088
1992	12.256	11.068
1993	11.970	10.810
1994	11.583	10.461
1995	11.633	10.506
1996	11.430	10.323
1997	10.765	9.722
1998	10.459	9.446
1999	10.153	9.169
2000	9.550	8.625
2001	9.317	8.415
2002	9.577	8.649
2003	9.640	8.706
2004	9.345	8.440
2005	9.216	8.323
2006	9.603	8.948
2007	9.215	8.847
2008	8.811	8.705
2009	7.946	8.070
2010	5.915	6.169
2011	6.000	6.420

2012	6.172	6.769
2013	6.193	6.956
2014	5.981	6.877
2015	6.513	7.489
2016	6.186	7.113
2017	6.036	6.941
2018	5.911	6.797
2019	5.654	6.501
2020	5.431	6.245
2021	5.373	6.178
2022	5.465	6.284

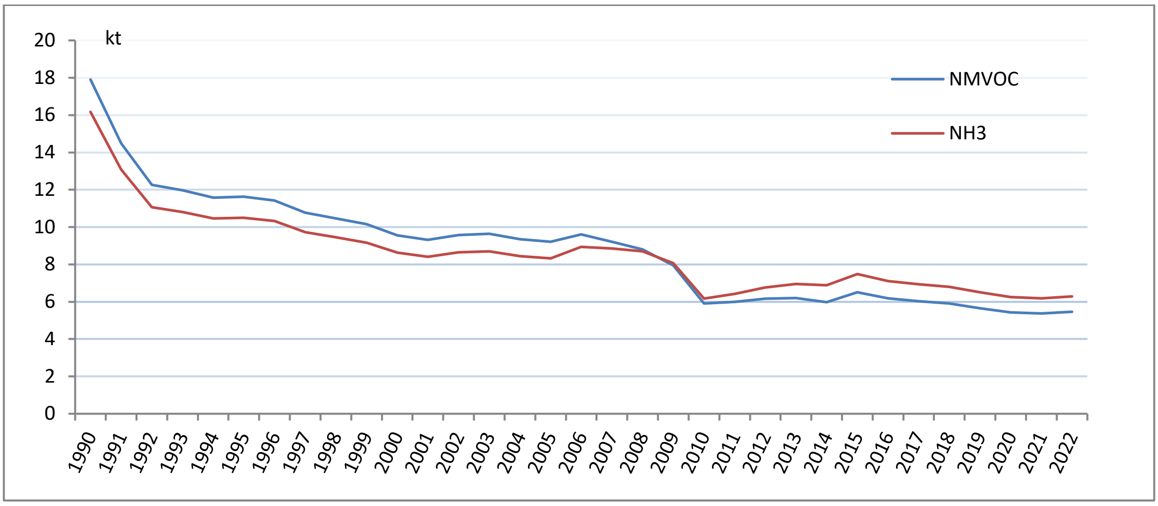


Figure 5.2.2 Emission trends (kt) for NFR 3.B.1.b Manure management - Non-dairy cattle for NMVOC and NH_3

The estimates of NH_3 and NMVOC emissions obtained with the 2019 EMEP/EEA Guidebook recommendation are observed on trends from 2014, the year of a change in the manure management system for this.

5.3 NFR 3.B.2 Manure management – Sheep

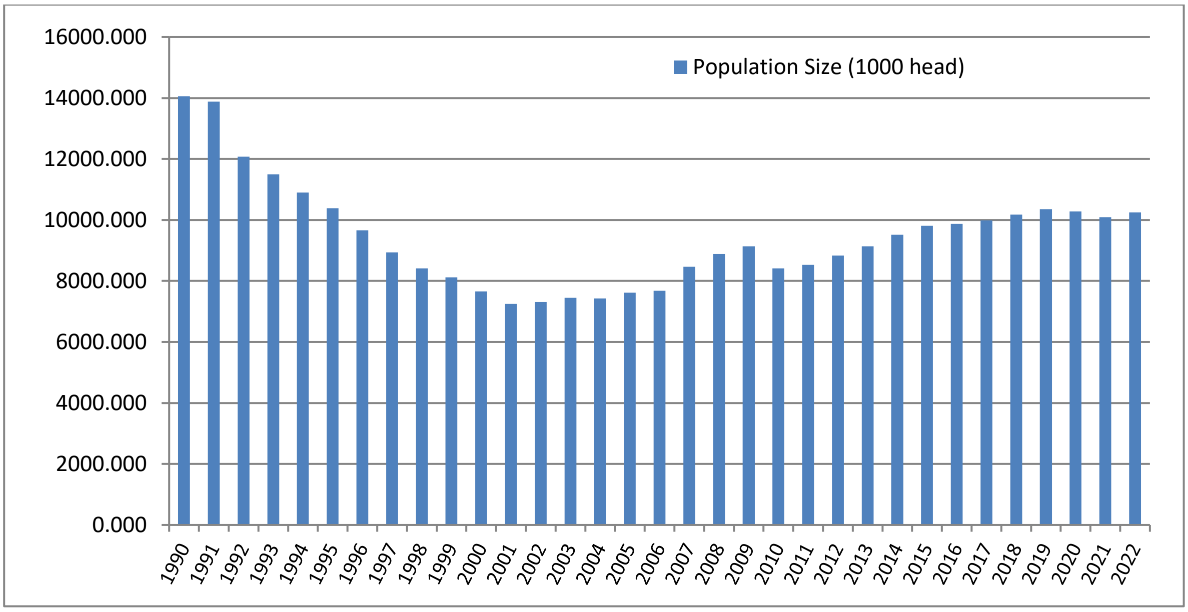


Figure 5.3.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.2 Manure management – Sheep

Activity data for sheep with which the graph was obtained are presented in table 5.5.a above.

Table 5.3.1 Emission trends (kt) for 3.B.2 Manure management – Sheep

Year/Pollutant	NMVOC	NH_3
1990	2.423	6.832
1991	2.392	6.743
1992	2.081	5.868
1993	1.981	5.587
1994	1.878	5.294
1995	1.789	5.043
1996	1.665	4.694
1997	1.540	4.342
1998	1.449	4.085
1999	1.399	3.945
2000	1.319	3.720
2001	1.249	3.523
2002	1.260	3.552
2003	1.283	3.618
2004	1.279	3.607
2005	1.311	3.698
2006	1.323	3.730
2007	1.459	4.115
2008	1.530	4.315
2009	1.575	4.441
2010	1.450	4.089

Year/Pollutant	NMVOC	NH_3
2011	1.470	4.146
2012	1.522	4.292
2013	1.574	4.438
2014	1.640	4.624
2015	1.690	4.766
2016	1.702	4.798
2017	1.720	4.849
2018	1.754	4.944
2019	1.785	5.032
2020	1.747	4.995
2021	1.738	4.901
2022	1.766	4.978

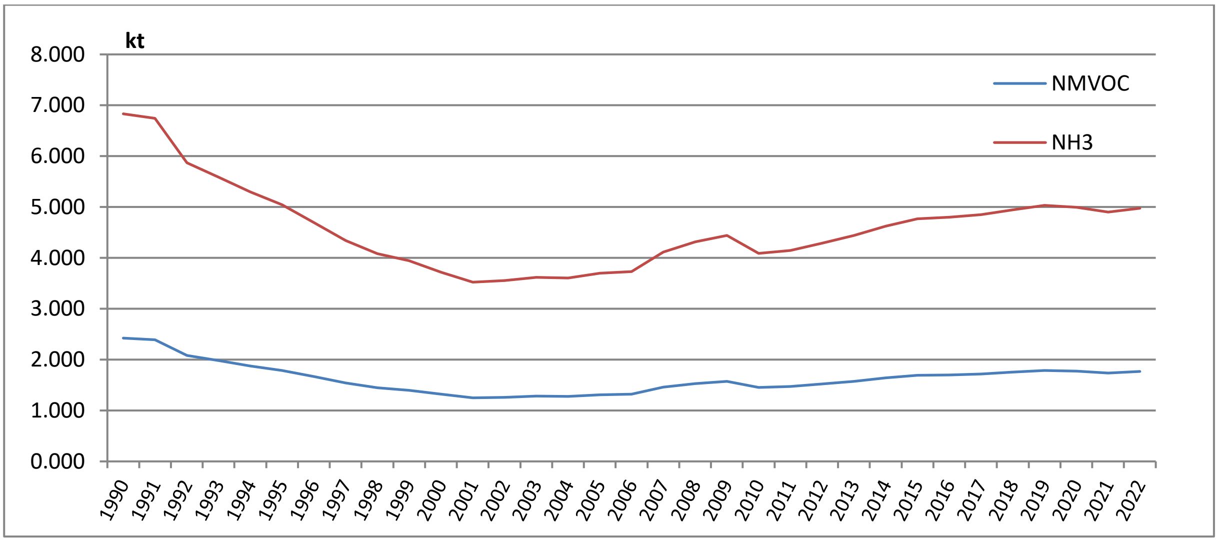


Figure 5.3.2 Emission trends (kt) for NMVOC, NH_3 for 3.B.2 Manure management – Sheep

The emissions of NMVOC and NH_3 from the manure management-sheep follow the activity data trends which varied from year to year due variations in livestock.

5.3 NFR 3.B.3 Manure management – Swine

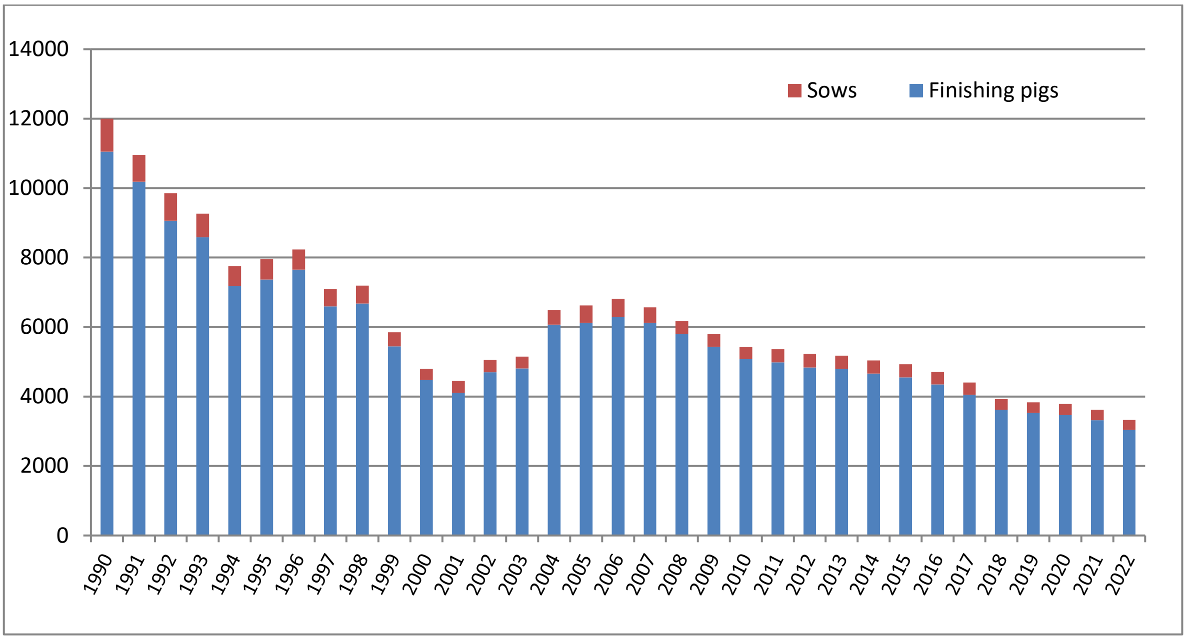


Figure 5.4.1 Activity data trends (Population Size (1000 head)) for NFR 3.B.3 Manure management – Swine

Activity data for swine (finishing pigs and sows) with which the graph was obtained are presented in table 5.5.a above.

Table 5.4.1 Emission trends (kt) for NFR 3.B.3 Manure management – Swine

Year/Pollutant	NMVOC finishing	NH3 finishing	NMVOC sows	NH3 sows
1990	6.09	45.981	1.621	5.857
1991	5.611	42.366	1.314	4.748
1992	4.992	37.694	1.35	4.878
1993	4.73	35.713	1.155	4.176
1994	3.957	29.88	0.982	3.547
1995	4.061	30.662	1.005	3.634
1996	4.216	31.832	0.995	3.597
1997	3.632	27.421	0.862	3.116
1998	3.68	27.788	0.878	3.172
1999	2.999	22.645	0.69	2.494
2000	2.465	18.614	0.55	1.989
2001	2.266	17.112	0.569	2.057
2002	2.588	19.537	0.617	2.229
2003	2.65	20.012	0.571	2.063
2004	3.344	26.001	0.726	2.624
2005	3.376	27.433	0.842	3.045
2006	3.469	27.751	0.886	3.241
2007	3.373	26.541	0.754	2.786
2008	3.194	25.459	0.641	2.396
2009	2.994	23.785	0.612	2.312
2010	2.795	22.490	0.606	2.312

Year/Pollutant	NMVOC finishing	NH3 finishing	NMVOC sows	NH3 sows
2011	2.746	20.982	0.649	2.501
2012	2.664	19.741	0.679	2.648
2013	2.643	19.424	0.654	2.574
2014	2.570	18.569	0.645	2.564
2015	2.508	17.931	0.638	2.539
2016	2.395	17.186	0.615	2.448
2017	2.235	15.986	0.596	2.371
2018	1.993	14.447	0.526	2.093
2019	1.943	14.332	0.526	2.092
2020	1.911	14.074	0.538	2.140
2021	1.830	13.948	0.509	2.023
2022	1.677	12.726	0.485	1.929

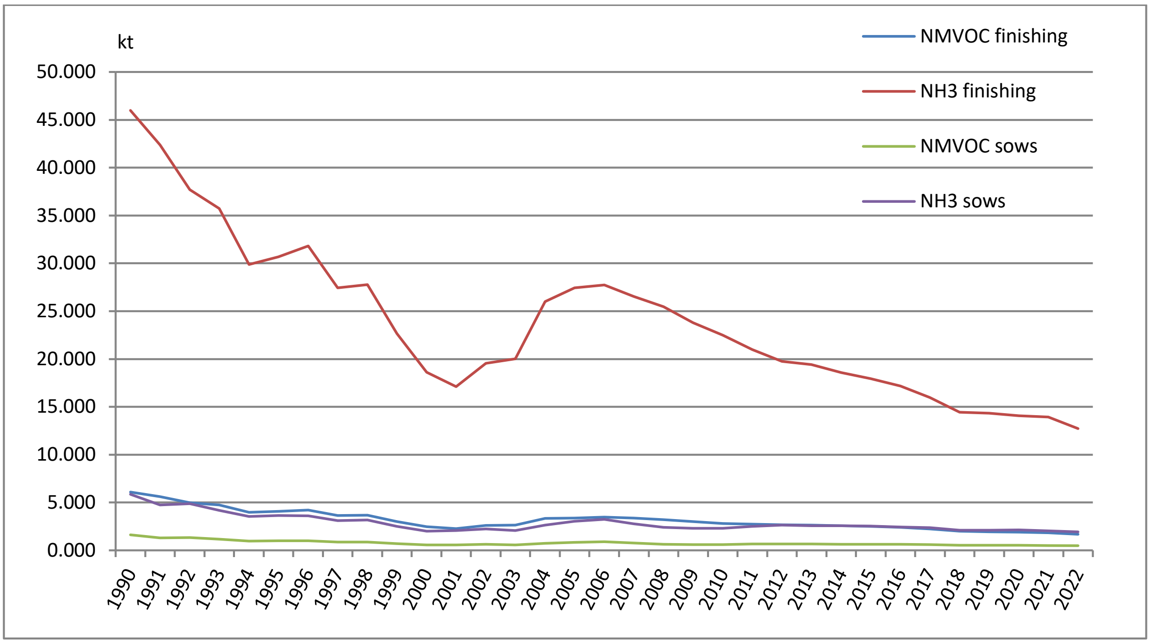


Figure 5.4.2 Emission trends (kt) for 3.B.3 Manure management – Swine

The estimates of NH3 and NMVOC emissions obtained with the EMEP / EEA Guide of 2019 and the TERT revision recommendation for the use of average weights for fattening pigs can be seen in the graph above.

After 1989, the number of swine halved (figure 12.3.), drastically decreasing in the large breeding complexes, and this decrease was not compensated by a significant increase in the number of pigs of small farms in the private sector. Small producers sized their livestock at the level of their own needs, being restricted by the high prices of inputs (feed, fuel, energy, etc). Thus, on the trend of activity data and emissions, a maximum decrease can be observed in 2001, after which an increase in the number of animals began, as a result of the economic balancing of the farms.

5.4 NFR 3.B.4.a Manure management - Buffalo

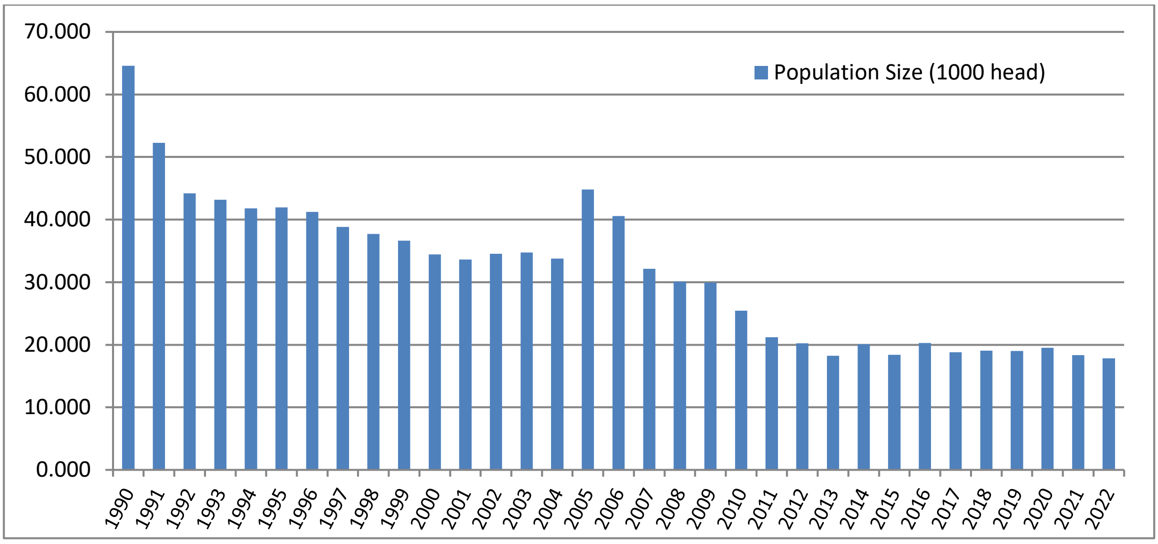


Figure 5.5.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.a Manure management – Buffalo

Activity data for buffalos with which the graph was obtained are presented in table 5.5.a above.

Table 5.5.1 Emission trends (kt) for NFR 3.B.4.a Manure management – Buffalo

Year/Pollutant	NMVOC	NH_3
1990	0.284	0.278
1991	0.230	0.225
1992	0.195	0.190
1993	0.190	0.186
1994	0.184	0.180
1995	0.185	0.180
1996	0.182	0.177
1997	0.171	0.167
1998	0.166	0.162
1999	0.161	0.157
2000	0.152	0.148
2001	0.148	0.145
2002	0.152	0.149
2003	0.153	0.150
2004	0.149	0.145
2005	0.197	0.193
2006	0.179	0.175
2007	0.142	0.138
2008	0.133	0.129
2009	0.132	0.129
2010	0.112	0.109
2011	0.093	0.091
2012	0.089	0.087
2013	0.080	0.078

Year/Pollutant	NMVOC	NH_3
2014	0.088	0.086
2015	0.081	0.079
2016	0.089	0.087
2017	0.083	0.081
2018	0.084	0.082
2019	0.084	0.082
2020	0.086	0.084
2021	0.081	0.079
2022	0.078	0.077

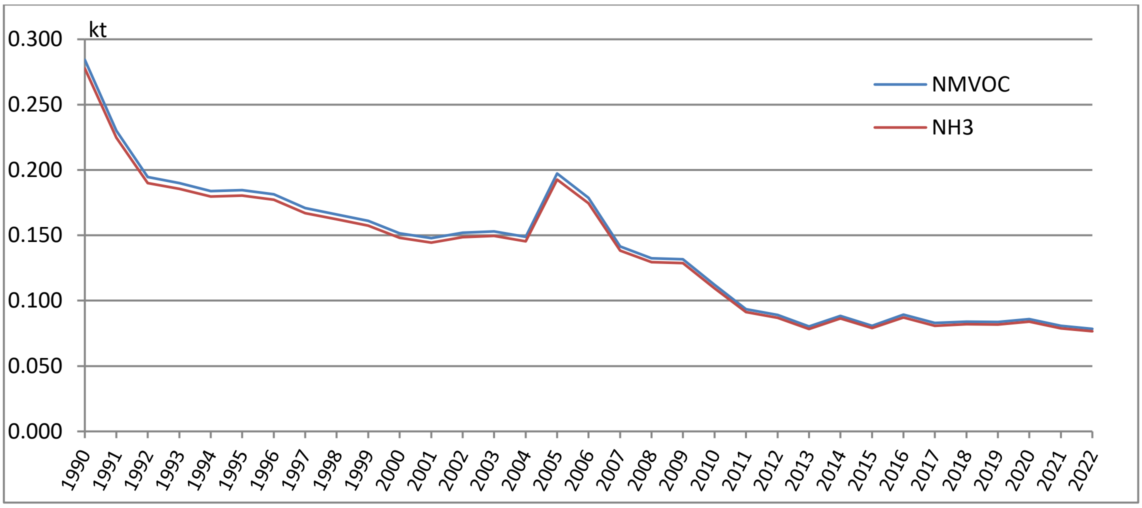


Figure 5.5.2 Emission trends (kt) for NFR 3.B.4.a Manure management - Buffalo

The emissions of NMVOC and NH_3 from manure management-buffalo follow the activity data trends which varied from year to year due variations in livestock.

5.5 NFR 3.B.4.d Manure management - Goats

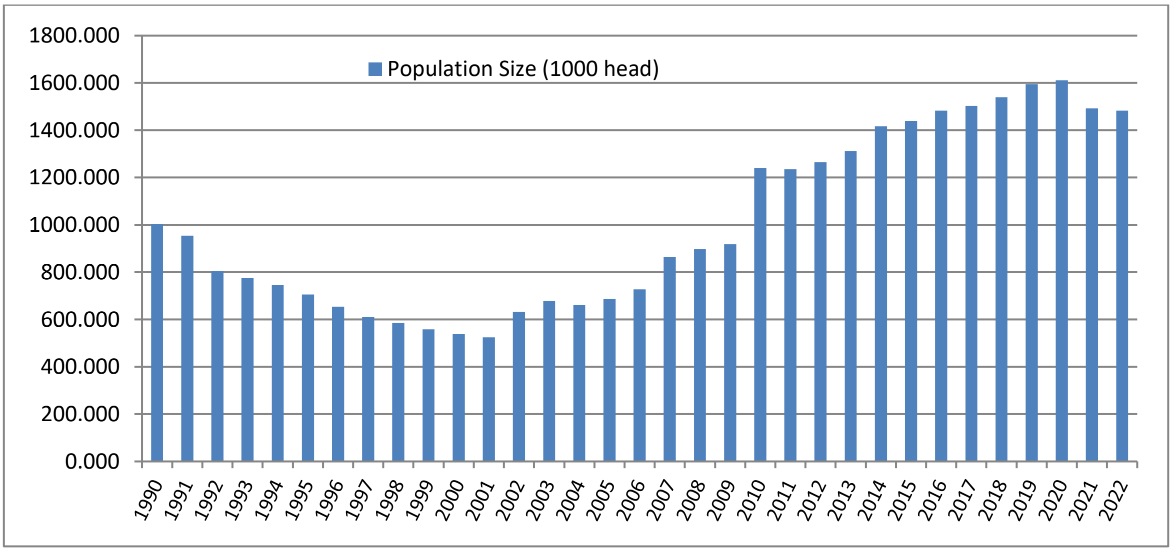


Figure 5.6.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.d Manure management – Goats

Activity data for goats with which the graph was obtained are presented in table 5.5.a above.

Table 5.6.1 Emission trends (kt) for NFR 3.B.4.d Manure management - Goats

Year/Pollutant	NMVOC	NH_3
1990	0.547	0.402
1991	0.519	0.382
1992	0.438	0.322
1993	0.423	0.311
1994	0.406	0.298
1995	0.384	0.282
1996	0.356	0.262
1997	0.332	0.244
1998	0.318	0.234
1999	0.304	0.223
2000	0.293	0.215
2001	0.286	0.210
2002	0.345	0.253
2003	0.369	0.271
2004	0.360	0.264
2005	0.374	0.275
2006	0.396	0.291
2007	0.471	0.346
2008	0.489	0.359
2009	0.499	0.367
2010	0.676	0.496
2011	0.673	0.495
2012	0.689	0.506
2013	0.715	0.525
2014	0.772	0.567
2015	0.784	0.576
2016	0.808	0.593
2017	0.819	0.601
2018	0.838	0.616
2019	0.868	0.638
2020	0.878	0.645
2021	0.813	0.597
2022	0.808	0.593

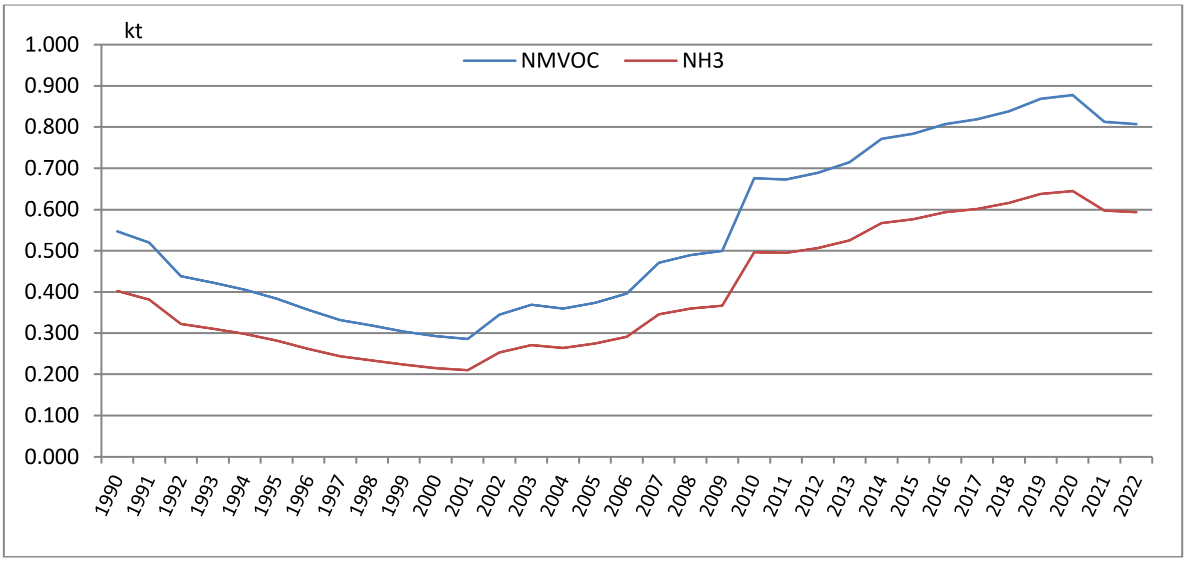


Figure 5.6.2 Emission trends (kt) for NFR 3.B.4.d Manure management – Goats

The emissions of NMVOC and NH_3 from manure management - goats follow the activity data trends which varied from year to year due variations in livestock.

5.6 NFR 3.B.4.e Manure management – Horses

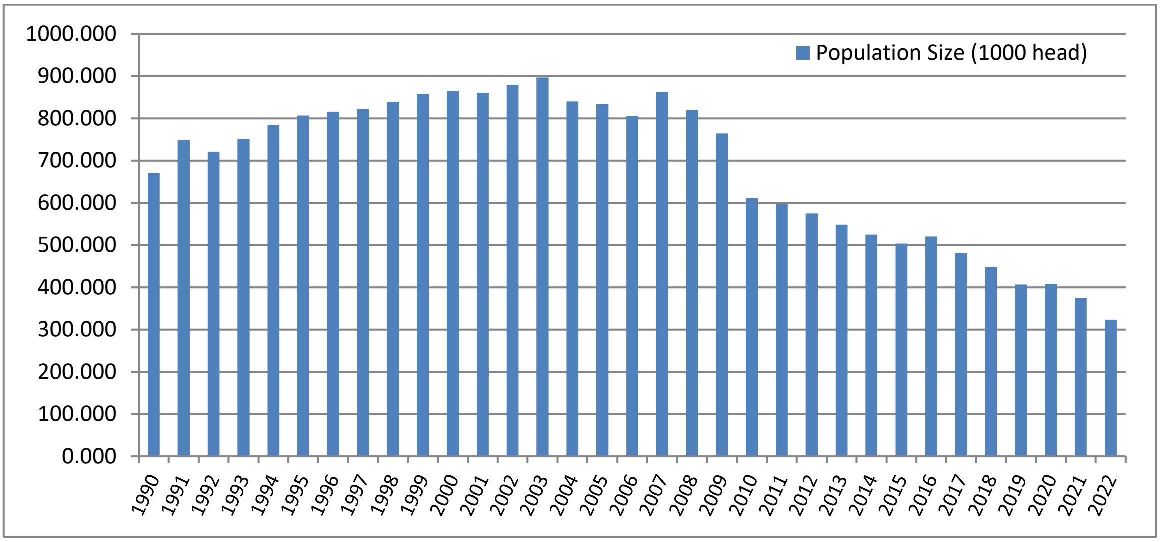


Figure 5.7.1 Activity data trends (*Population Size (1000 head)*)
for NFR 3.B.4.e Manure management – Horses

Activity data for horses with which the graph was obtained are presented in table 5.5.a above. The mules and donkeys are included in this category.

Table 5.7.1 Emission trends (kt) for NFR 3.B.4.e Manure management - Horses

Year/Pollutant	NMVOC	NH_3
1990	2.864	4.690
1991	3.202	5.243
1992	3.082	5.047
1993	3.211	5.258

Year/Pollutant	NMVOC	NH_3
1994	3.351	5.487
1995	3.447	5.645
1996	3.487	5.710
1997	3.513	5.752
1998	3.588	5.875
1999	3.668	6.007
2000	3.696	6.051
2001	3.678	6.022
2002	3.759	6.156
2003	3.834	6.278
2004	3.589	5.877
2005	3.565	5.838
2006	3.441	5.635
2007	3.685	6.034
2008	3.503	5.737
2009	3.266	5.348
2010	2.611	4.276
2011	2.550	4.175
2012	2.457	4.022
2013	2.344	3.838
2014	2.243	3.673
2015	2.152	3.524
2016	2.223	3.639
2017	2.055	3.365
2018	1.914	3.135
2019	1.739	2.847
2020	1.745	2.857
2021	1.601	2.621
2022	1.382	2.264

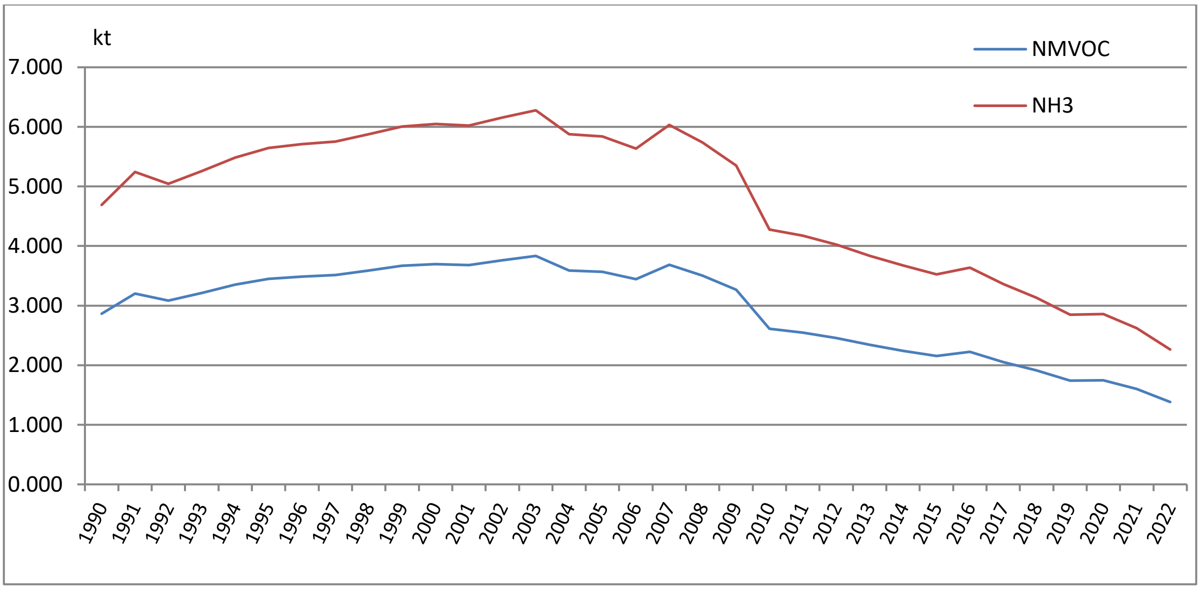


Figure 5.7.2 Emission trends (kt) for NFR 3.B.4.e Manure management - Horses

The emissions of NMVOC and NH_3 from manure management - horses follow the activity data trends which varied from year to year due variations in livestock.

5.7 NFR 3.B.4.g.i Manure management - Laying hens

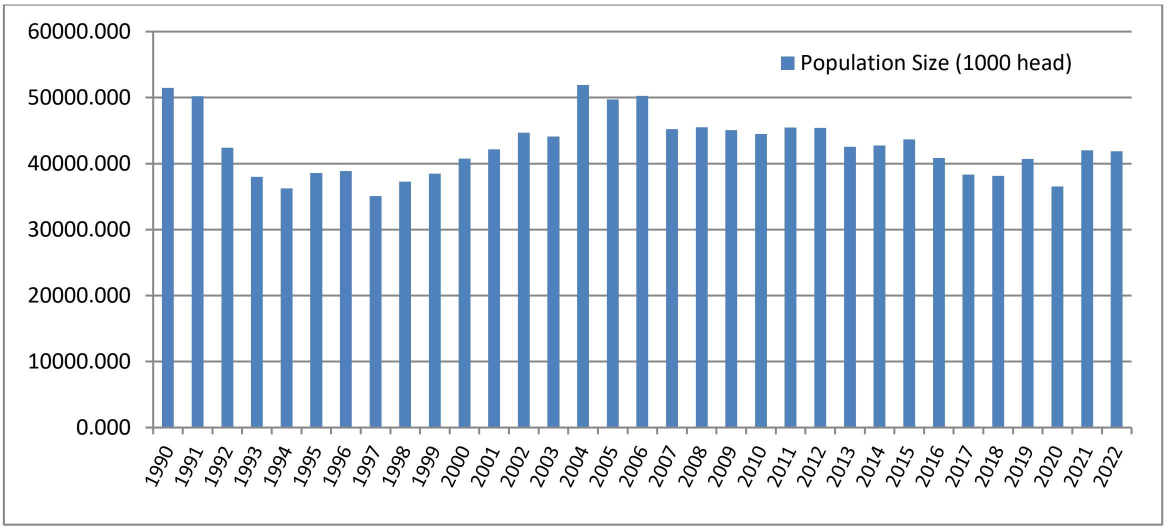


Figure 5.8.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.g.i Manure management - Laying hens

Activity data for laying hens with which the graph was obtained are presented in table 5.5.b above.

Table 5.8.1 Emission trends (kt) for NFR 3.B. 4.g.i Manure management - Laying hens

Year/Pollutant	NMVOC	NH_3	TSP
1990	2.230	5.772	9.780
1991	2.175	5.631	9.540
1992	1.837	4.755	8.057
1993	1.645	4.259	7.216
1994	1.570	4.063	6.884
1995	1.671	4.326	7.329
1996	1.684	4.360	7.388
1997	1.520	3.935	6.667
1998	1.615	4.180	7.082
1999	1.668	4.317	7.314
2000	1.766	4.571	7.744
2001	1.826	4.727	8.010
2002	1.935	5.009	8.487
2003	1.911	4.948	8.383
2004	2.248	5.819	9.859
2005	2.154	5.576	9.448
2006	2.178	5.638	9.553
2007	1.958	5.070	8.590
2008	1.972	5.106	8.651
2009	1.951	5.052	8.559
2010	1.928	4.991	8.456
2011	1.969	5.098	8.638
2012	1.967	5.091	8.626
2013	1.843	4.771	8.083
2014	1.851	4.793	8.120

2015	1.891	4.896	8.296
2016	1.769	4.579	7.758
2017	1.660	4.296	7.279
2018	1.652	4.276	7.245
2019	1.764	4.567	7.738
2020	1.588	4.110	6.940
2021	1.821	4.714	7.987
2022	1.814	4.697	7.958

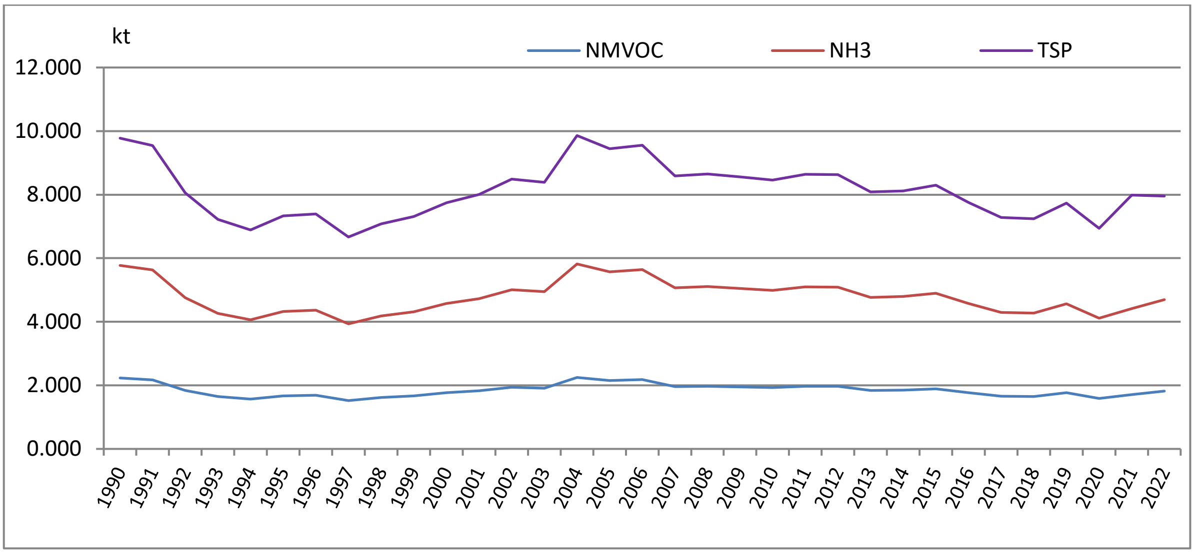


Figure 5.8.2 Emission trends (kt) for NFR 3.B.4.g.i Manure management - Laying hens

The emissions of NMVOC, NH_3 and TSP from manure management – laying hens follow the activity data trends which varied from year to year due variations in livestock.

5.8 NFR 3.B.4.g.ii Manure management – Broilers

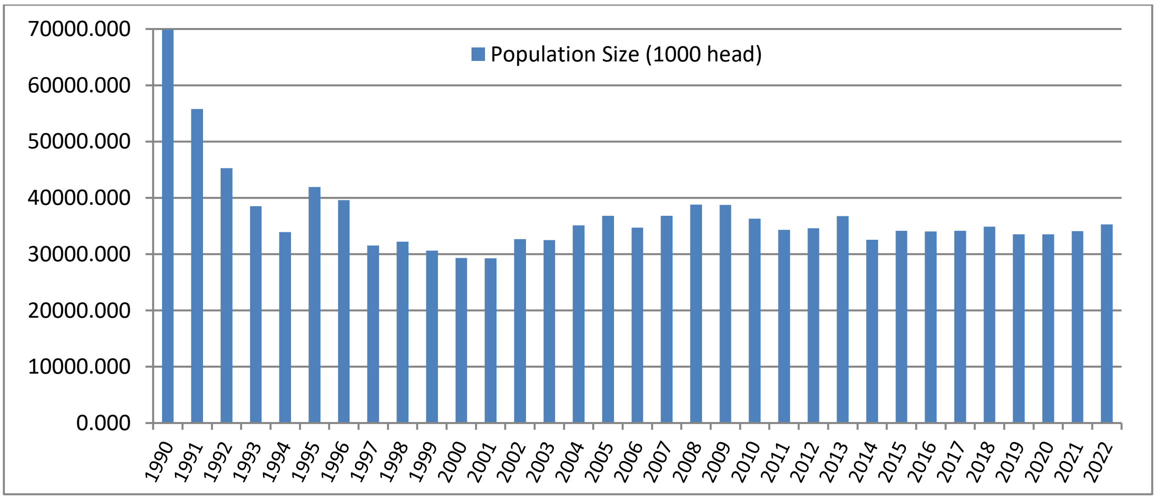


Figure 5.9.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.g.ii Manure management – Broilers

Activity data for broilers with which the graph was obtained are presented in table 5.5.b above.
The broilers heads counts for the entire time series were corrected by subtracting new values from turkeys (NFR 3B4giii) and other poultry (NFR 3B4giv) from the NIS values for poultry.

Table 5.9.1 Emission trends (kt) for NFR 3.B.4.g.ii Manure management - Broilers

Year/Pollutant	NMVOC	NH_3
1990	6.569	9.084
1991	5.245	7.254
1992	4.259	5.889
1993	3.622	5.009
1994	3.187	4.408
1995	3.942	5.451
1996	3.721	5.145
1997	2.963	4.097
1998	3.026	4.185
1999	2.880	3.982
2000	2.755	3.809
2001	2.749	3.802
2002	3.074	4.251
2003	3.053	4.223
2004	3.300	4.564
2005	3.460	4.785
2006	3.261	4.51
2007	3.461	4.785
2008	3.649	5.048
2009	3.644	5.041
2010	3.413	4.721
2011	3.227	4.464
2012	3.254	4.511
2013	3.458	4.781
2014	3.058	4.239
2015	3.211	4.495
2016	3.198	4.422
2017	3.211	4.437
2018	3.279	4.539
2019	3.151	4.359
2020	3.153	4.36
2021	3.206	4.434
2022	3.314	4.584

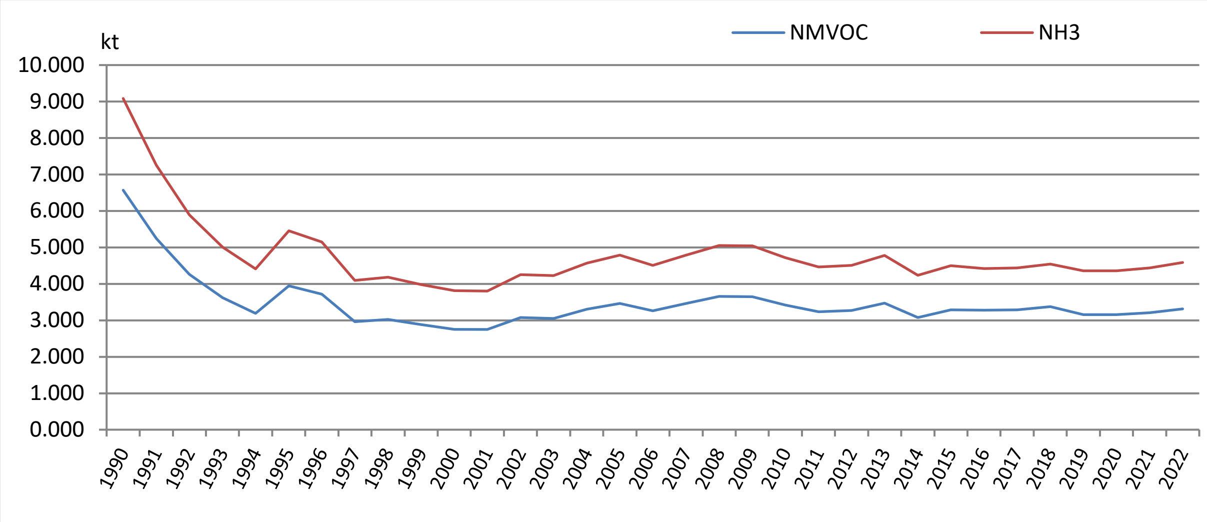


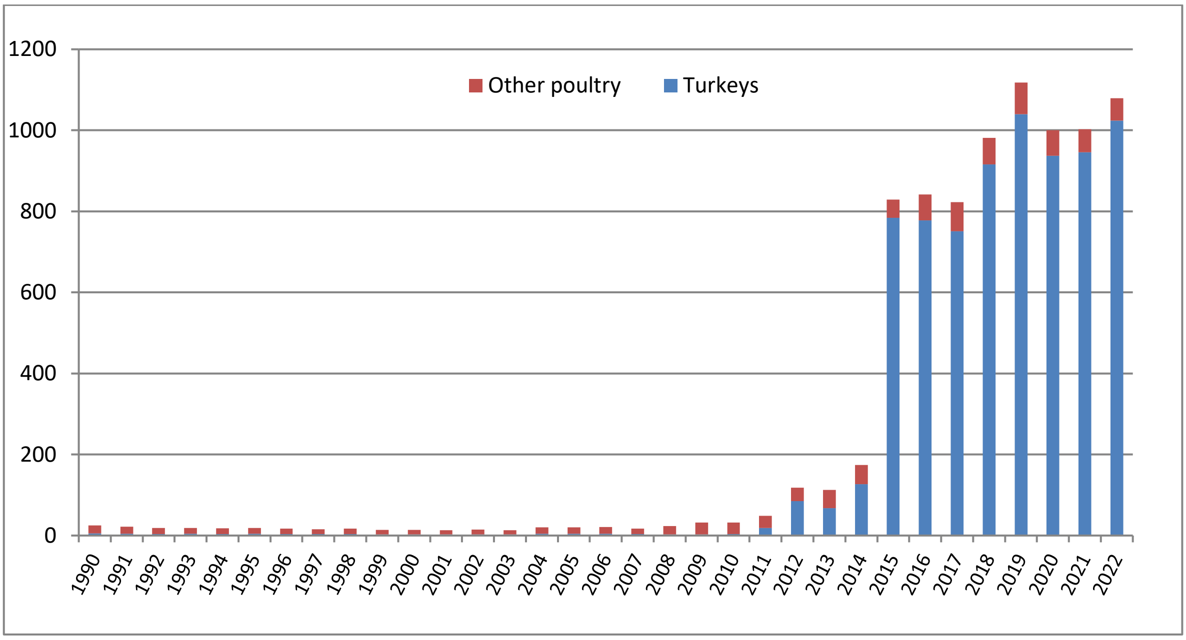
Figure 5.9.2 Emission trends (kt) for NFR 3.B.4.g.ii Manure management – Broilers

The emissions of NMVOC, NH_3 and PM_{10} from manure management - broilers follow the activity data trends which varied from year to year due variations in livestock.

5.9 NFR 3.B.4.g.iii Manure management – Turkeys and 3.B.4.giv Manure management – Other poultry

This subcategory, "Other Poultry" includes reported farms of ducks, partridges, pheasants and guinea fowl.

Table 5.10.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.g.iii Manure management – Turkeys and NFR 3.B.4.g.iv Manure management – Other poultry



Activity data for broilers with which the graph was obtained are presented in table 5.5.b above.

Table 5.10.2 Emission trends (kt) for NFR 3.B.4.g.iii Manure management - Turkeys and NFR 3.B.4.g.iv Manure management – Other poultry

Year/Pollutant	NMVOC Turkeys	NH3 Turkeys	NMVOC Other poultry	NH3 Other poultry
1990	0.0027	0.0031	0.0097	0.0089
1991	0.0024	0.0027	0.0085	0.0078
1992	0.0020	0.0022	0.0071	0.0065
1993	0.0020	0.0023	0.0073	0.0067
1994	0.0019	0.0022	0.0070	0.0064
1995	0.0020	0.0023	0.0073	0.0067
1996	0.0018	0.0020	0.0064	0.0059
1997	0.0017	0.0019	0.0060	0.0056
1998	0.0018	0.0021	0.0065	0.0060
1999	0.0014	0.0017	0.0052	0.0048
2000	0.0015	0.0017	0.0053	0.0049
2001	0.0014	0.0016	0.0049	0.0045
2002	0.0015	0.0018	0.0056	0.0051
2003	0.0014	0.0016	0.0052	0.0048
2004	0.0024	0.0027	0.0077	0.0071
2005	0.0022	0.0026	0.0076	0.0070
2006	0.0023	0.0027	0.0080	0.0074
2007	0.0019	0.0022	0.0063	0.0058
2008	0.0016	0.0018	0.0097	0.0056
2009	0.0014	0.0016	0.0144	0.0082
2010	0.0017	0.0019	0.0142	0.0088
2011	0.0090	0.0103	0.0149	0.0086
2012	0.0414	0.0094	0.0162	0.0092
2013	0.0332	0.0476	0.0220	0.0170
2014	0.0618	0.0373	0.0233	0.0169
2015	0.3834	0.2063	0.0222	0.0169
2016	0.3804	0.4392	0.0313	0.0257
2017	0.3672	0.4387	0.0352	0.0284
2018	0.4478	0.4971	0.0319	0.0246
2019	0.5085	0.5560	0.0380	0.0505
2020	0.4584	0.5249	0.0307	0.0282
2021	0.4625	0.5296	0.0278	0.0256
2022	0.5009	0.5736	0.0270	0.0249

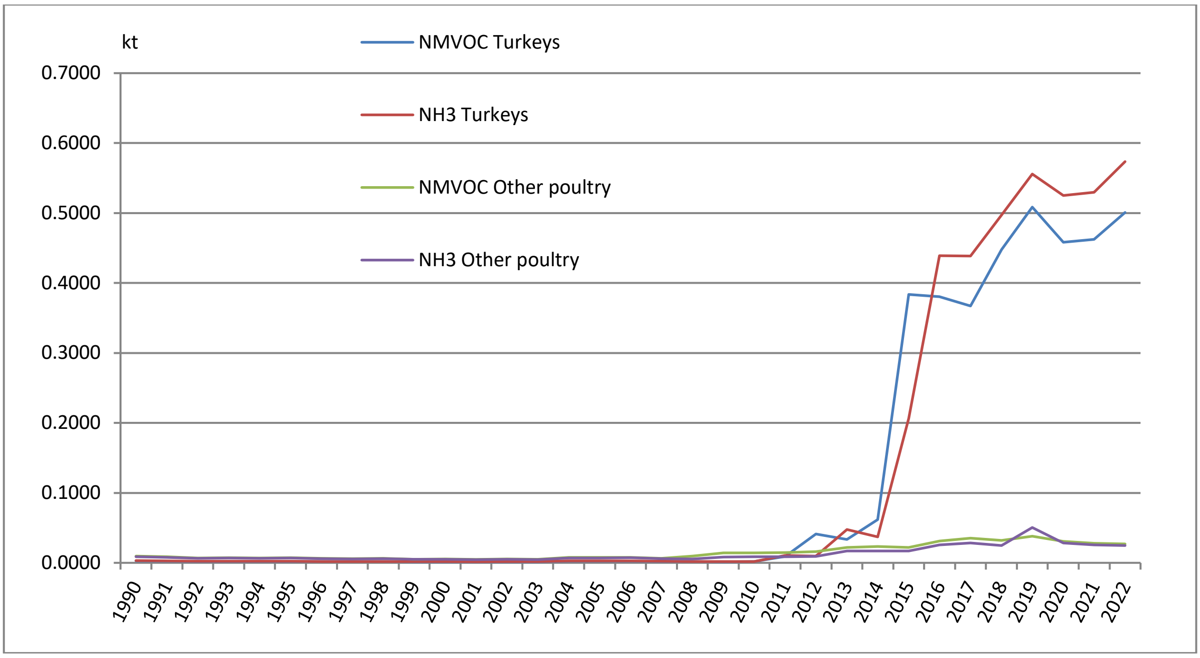


Figure 5.10.1 Emission trends (kt) for NFR 3.B.4.g.iii Manure management – Turkeys and NFR 3.B.4.g.iv Manure management – Other poultry

The NMVOC and NH3 emissions from manure management in these categories follow activity data trends that have varied from year to year due to variations in livestock numbers, which show an increasing interest in raising turkeys and other poultry.

5.10 NFR 3.B.4.h Manure management – Rabbits

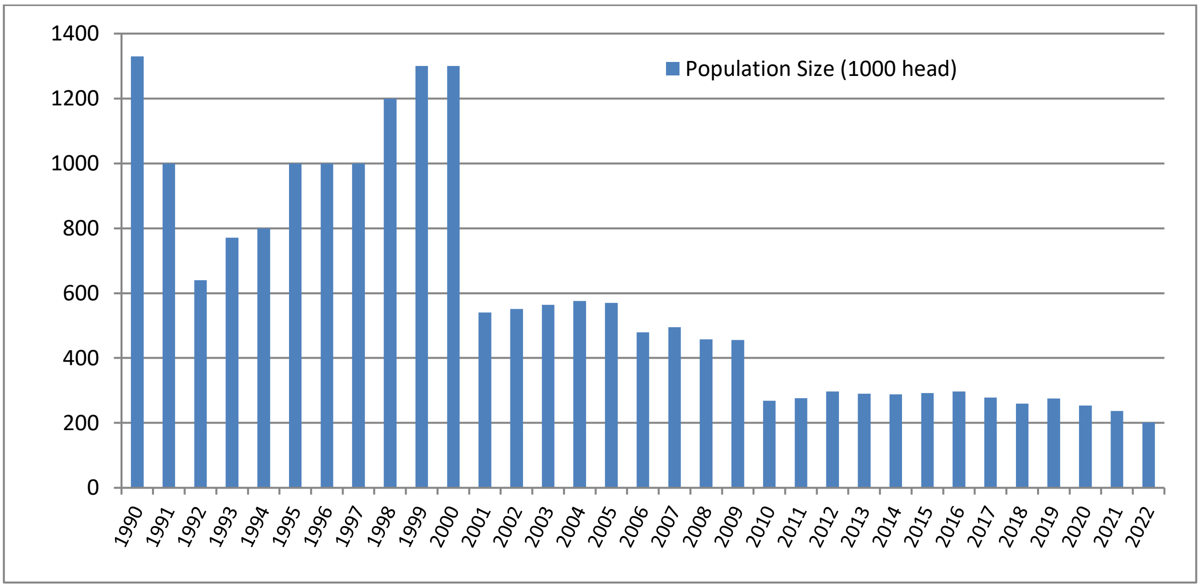


Figure 5.11.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.g.ii Manure management – Rabbits

Activity data for rabbits with which the graph was obtained are presented in table 5.5.b above.

Table 5.11.1 Emission trends (kt) for NFR 3.B.4.h Manure management – Rabbits

Year/Pollutant	NMVOC	NH_3
1990	0.078	0.027
1991	0.059	0.020
1992	0.038	0.013
1993	0.045	0.015
1994	0.047	0.016
1995	0.059	0.020
1996	0.059	0.020
1997	0.059	0.020
1998	0.071	0.024
1999	0.077	0.026
2000	0.077	0.026
2001	0.032	0.011
2002	0.033	0.011
2003	0.033	0.011
2004	0.034	0.012
2005	0.034	0.011
2006	0.028	0.010
2007	0.029	0.010
2008	0.027	0.009
2009	0.027	0.009
2010	0.016	0.005
2011	0.016	0.006
2012	0.018	0.006
2013	0.017	0.006
2014	0.017	0.006
2015	0.017	0.006
2016	0.018	0.006
2017	0.016	0.006
2018	0.015	0.005
2019	0.016	0.006
2020	0.015	0.005
2021	0.014	0.005
2022	0.012	0.004

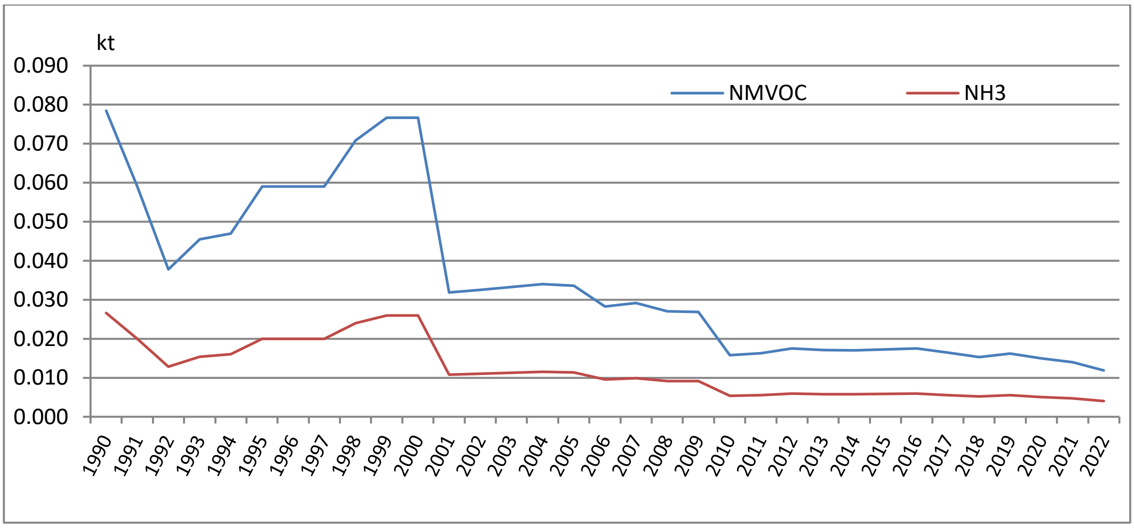


Figure 5.11.1 Emission trends (kt) for NFR 3.B.4.g.ii Manure management – Rabbits

The emissions of NMVOC and NH_3 for this category from manure management follow the activity data trends which varied from year to year due variations in livestock.

Recalculations and improvements for NFR 3B:
- Error filling in values for those pollutants: NOx, PM2.5, PM10, TSP for 3B1b category, year 2021.
- Interpolation of AWMS percentage values at the recommendation of TERT for the categories of dairy cattle (3B1a), non-dairy cattle (3B1b) and swine (3B3) categories, with changes in NH3, NMVOC and NOx emissions for the 2006-2013 time series.
- Recalculation of all pollutants due to the error of number of heads, for 3B4gi category for the year 2021.
- The change in the number of turkeys and other poultry from nationwide questionnaires, led to the change of the all pollutants emissions, for 3B4gii - Broilers, 3B4giii - Turkeys and 3B4giv - Other poultry categories, for the time series 2008-2021.

Planned improvements:
- Studying for introducing and applying country-specific data for all pollutants as much as possible for a real estimation of emissions for this sector.

5.11 NFR 3.D.a.1 Inorganic N-fertilizers (also includes urea application)

The inorganic N-fertilizers sector represents a key category for agricultural sector for which the emission of NH_3 (16.8% from national total) and NOx (9.1% from national total) were estimated.

The emission of NH_3 from inorganic fertilizers contributes in 2022 with 18.72% of the emission for the agricultural sector and emission of NOx contributes in 2022 with 63.3% of the emission for the agricultural sector, representing the first source of NOx emissions of the Agriculture sector.

The emission factors for ammonia used in the calculation were provided by Table 3-2 which corresponds to the Tier 2 methodology (EMEP/EEA Guidebook - 2019), assuming soils with the normal acidity of the soil (pH) and cool climate for Romania.

Table 5.12.1 EFs for NH_3 emissions from fertilizers (in g NH_3 (kg N applied)$^{-1}$)

N-ammonia fertilizers categories	Climate-Cool, Normal pH
Ammonium nitrate (AN)	15
Ammonium phosphates (AP)	50
Ammonium sulphate (AS)	90
Calcium ammonium nitrate (CAN)	8
Mixtures	15
NPK Mixtures	50
NP Mixtures	50
N solutions	98
Other straight N compounds	10

The total inorganic N fertilizer applied to soil activity data is provided by N.I.S., but without information about the amount of N used in different fertilizer types, in accordance with the requirements of the Tier 2 approach. At the recommendation of TERT, Romania studied the possibility of splitting data, according to the IFA source (https://www.fastat.org/databases/plant-nutrition). The calculation consisted in obtaining the proportions for each type of fertilizers provided by source IFA and applying then on the national data from N.I.S. The categories for N-fertilizers applied to soils vary over time; the ammonia applied direct to the fields is not used in our country.

The activity data for these categories were correlate with the CRF (UNFCCC) report.

The emissions factor for NOx used is 0.04 kg NO kg^{-1} fertilizer N applied, based on the value given in 2019 EMEP/EEA Guidebook, Table 3.1, for the entire time series, 1990-2021.

Table 5.12.2 The activity data of the N-fertilizer categories obtained by applying IFA source percentages to national data, Tier 2 calculation

Year	AN (kt)	AS (kt)	CAN (kt)	N sol. (kt)	N K (N) (kt)	Urea (kt)	AP (kt)	Other N straight (kt)	NPK (kt)	Other NP (kt)	TOTAL N-fert (kt)
1990	257.16	21.43	0.00	42.86	0.00	141.44	0.00	0.00	0.00	193.21	**656.09**
1991	109.97	15.00	0.00	10.00	0.00	39.99	0.00	0.00	0.00	99.98	**274.94**
1992	96.84	0.00	10.68	0.00	0.00	37.03	0.00	0.00	0.00	113.21	**257.76**
1993	131.19	0.00	12.61	0.00	0.00	58.87	0.00	0.00	0.00	142.97	**345.65**
1994	109.75	4.81	12.52	0.00	0.00	70.42	0.00	0.00	0.00	115.53	**313.04**
1995	105.02	3.94	0.00	0.00	0.00	65.64	0.00	0.00	0.00	131.28	**305.88**
1996	85.59	6.04	0.00	0.00	0.00	50.34	0.00	0.00	0.00	125.86	**267.84**
1997	108.43	4.77	0.00	0.00	0.00	56.00	0.00	0.00	0.00	92.94	**262.14**
1998	137.28	0.00	0.00	0.00	0.00	41.66	0.00	0.00	0.00	74.79	**253.73**
1999	106.41	0.00	0.00	0.00	0.00	61.86	0.00	0.00	0.00	56.92	**225.19**
2000	106.68	0.00	0.00	0.00	0.00	81.75	0.00	0.00	0.00	50.85	**239.28**
2001	109.99	0.00	0.00	0.00	0.00	70.49	0.00	0.00	0.00	87.99	**268.47**
2002	94.99	0.00	0.00	0.00	0.00	64.99	0.00	0.00	0.00	79.09	**239.07**
2003	94.70	0.00	0.00	0.00	0.00	65.11	0.00	0.00	0.00	92.33	**252.14**
2004	145.11	0.00	0.00	0.00	0.00	43.53	0.00	0.00	81.49	0.00	**270.13**
2005	148.85	0.00	8.68	0.25	0.00	48.38	0.00	0.00	93.03	0.00	**299.20**
2006	143.22	0.00	0.00	0.22	0.00	59.23	0.00	0.00	49.54	0.00	**252.20**
2007	106.46	0.00	0.00	0.16	0.00	75.34	0.00	0.00	83.53	0.00	**265.49**
2008	113.58	0.00	4.06	0.00	0.00	81.13	0.00	0.00	81.13	0.00	**279.89**
2009	120.14	0.00	4.29	0.00	0.00	85.81	0.00	0.00	85.81	0.00	**296.06**
2010	156.15	2.45	6.54	6.54	0.82	87.48	11.45	0.82	12.26	21.26	**305.76**
2011	127.52	2.43	12.75	4.86	1.21	107.48	8.50	1.21	20.04	27.33	**313.33**
2012	130.22	4.05	14.47	2.32	3.47	85.66	13.89	1.74	12.73	21.41	**289.96**
2013	153.71	8.92	9.61	15.78	2.74	86.46	21.27	1.37	17.15	27.45	**344.47**
2014	113.98	6.50	27.76	13.58	2.36	76.78	17.72	1.18	14.76	28.94	**303.56**
2015	141.95	7.07	27.33	9.27	3.62	99.17	16.93	0.48	20.56	30.96	**357.35**

Year	AN (kt)	AS (kt)	CAN (kt)	N sol. (kt)	N K (N) (kt)	Urea (kt)	AP (kt)	Other N straight (kt)	NPK (kt)	Other NP (kt)	TOTAL N-fert (kt)
2016	119.28	10.13	31.80	6.85	4.10	88.50	28.51	1.02	23.77	30.35	**344.31**
2017	121.61	12.50	35.46	14.25	1.19	91.80	34.39	4.47	33.48	32.18	**381.34**
2018	168.20	7.12	51.18	13.53	0.99	97.28	40.32	3.38	43.35	43.28	**468.64**
2019	143.19	8.48	59.60	14.26	1.17	88.27	48.70	3.36	42.78	46.14	**455.96**
2020	151.06	8.50	75.78	16.23	1.47	93.36	26.33	3.64	48.31	44.22	**468.89**
2021	164.57	9.26	82.55	17.70	1.58	101.68	28.70	3.99	52.65	48.13	**510.80**
2022	147.89	8.33	74.17	15.92	1.40	91.35	25.80	3.61	47.33	43.20	**459.02**

Figure 5.12.1 Trends of proportions of the categories of N-fertilizers (kt) for NFR 3Da1 Inorganic N-fertilizers

Table 5.12.3 The proportions obtained for each of the N-fertilizer categories used in the Tier2 calculation

N-Fertilizers	1990	1995	2000	2005	2010	2015	2020	2021	2022
Ammonium nitrate (N)	39.195%	34.335%	44.583%	49.751%	51.070%	39.724%	32.216%	32.218%	32.220%
Ammonium phosphate (N)	0%	0%	0%	0%	3.743%	4.739%	5.615%	5.618%	5.622%
Ammonium sulphate (N)	3.266%	1.288%	0%	0%	0.802%	1.979%	1.812%	1.814%	1.815%
Calc. amm. nitrate (N)	0%	0%	0%	2.902%	2.139%	7.649%	16.162%	16.160%	16.158%
N K compound (N)	0%	0%	0%	0%	0.267%	0.133%	0.313%	0.310%	0.305%
N P K compound (N)	0%	0%	0%	31.095%	4.011%	5.753%	10.303%	10.307%	10.312%
Nitrogen solutions (N)	6.533%	0%	0%	0.083%	2.139%	2.594%	3.461%	3.465%	3.469%
Other N straight (N)	0%	0%	0%	0%	0.267%	1.014%	0.777%	0.781%	0.787%
Other NP (N)	29.449%	42.918%	21.250%	0%	6.952%	8.663%	9.430%	9.422%	9.412%
Urea (N)	21.557%	21.459%	34.167%	16.169%	28.610%	27.752%	19.910%	19.906%	19.900%

The total amount of N-fertilizers used in agriculture were correlate with the CRF (UNFCCC) report database.

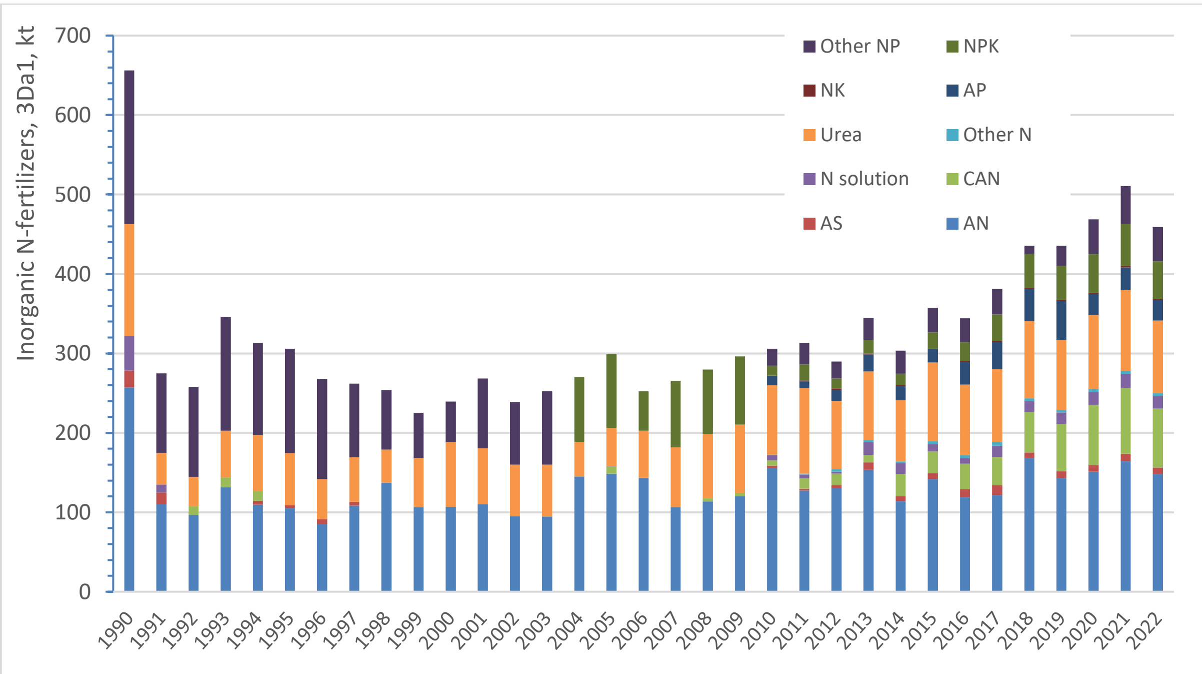


Table 5.12.4 Emission trends (kt) for NFR 3Da1 Inorganic N-fertilizers

Year/Pollutant	NOx, kt	NH_3,kt
1990	26.244	41.569
1991	10.997	15.176
1992	10.310	12.938
1993	13.826	18.342
1994	12.521	18.871
1995	12.235	18.668
1996	10.713	15.924
1997	10.486	15.383
1998	10.149	12.256
1999	9.007	14.031
2000	9.571	16.814
2001	10.739	16.976
2002	9.563	15.453
2003	10.086	16.129
2004	10.805	12.999
2005	11.968	14.477
2006	10.088	13.826
2007	10.619	17.467
2008	11.195	18.367
2009	11.842	19.428
2010	12.230	19.084
2011	12.533	22.193
2012	11.599	18.400
2013	13.779	21.507
2014	12.142	18.860
2015	14.294	22.730
2016	13.772	21.532
2017	15.254	23.923
2018	18.746	26.375
2019	18.239	25.400
2020	18.756	25.699
2021	20.432	27.995
2022	18.361	25.155

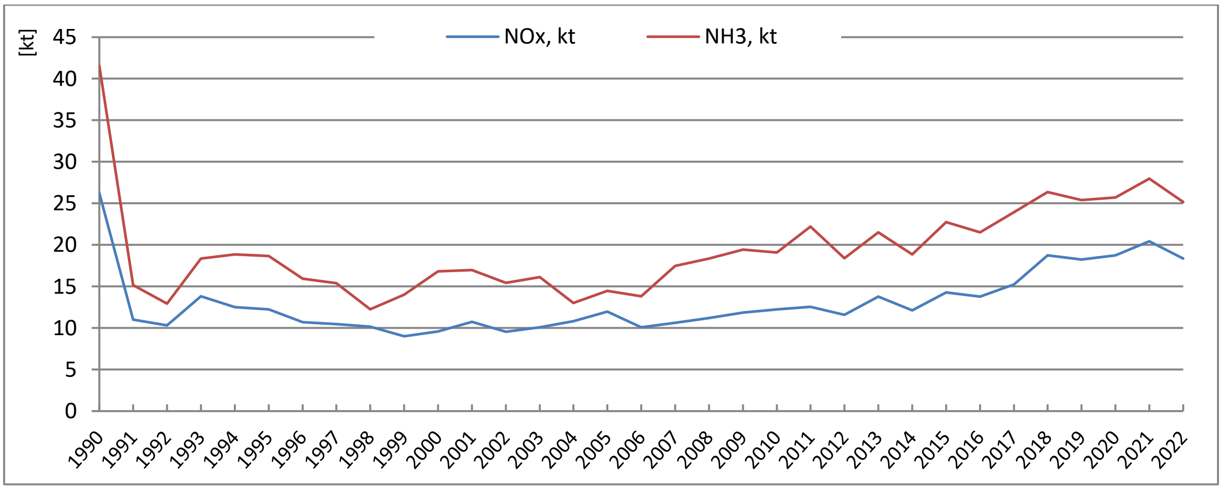


Figure 5.12.2 Emission trends (kt) for NFR 3Da1 Inorganic N-fertilizers

Recalculations and improvements:

- There were not recalculations since the previous submission.

5.12 NFR 3.D.a.2.a Animal manure applied to soils

For the sector animal manure applied to soils, the emission of NOx, NH3 and NMVOC were estimated. The emissions of NH3 from animal manure applied to soils contributes in 2022 with 28.66% from the ammonia emission of the agricultural sector and represent a key source, with 25.70% from total national emissions.

The methodology used to calculate the NH3 and NMVOC emissions is described in chapter 3B Manure Management, considering these emissions as part of a chain of sources, enabling the estimation of the impact of NH_3 and other N emissions in different stages.

Activity data from the application of animal manure to soils represents a percentage of the total manure from all animal species in source category 3B, as is specified in 2019 EMEP/EEA Guidebook.

The Excel spreadsheet "Manure Management N-flow tool" was used to calculate ammonia emissions with the Tier 2 method for dairy cattle, non-dairy cattle, swine, sheep and laying hens. The rest of the categories are calculated with Tier 1 methodology. The emissions of NH_3 for NFR 3Da2a have been calculated by splitting the NH_3 emissions from manure in NFR 3B, NFR 3Da2a and NFR 3Da3 according the 2019 EMEP/EEA Guidebook as mentioned above.

The use of the AgrEE Tool led to NMVOC emissions values for manure applied to the soil, from the categories calculated with Tier2 approach: dairy cattle, non-dairy cattle, laying hens and broilers, which in previous years was included in emissions from 3B, Manure Management.

The activity data for NOx estimation was the amount of animal manure applied to soils, provided by the N.I.S. and in correlation with GHG (UNFCCC) - CRF database; the Tier 1 approach from 2019 Guidebook EMEP/EEA, table 3.1, was used to calculate the emissions for this pollutant.

Table 5.13.1 Activity data trends for NFR 3Da2a for pollutant NOx

Year	Animal manure applied to soils, Kg N
1990	400167680.9
1991	374825010.8
1992	327910142.9
1993	307782003.2
1994	286662537.8
1995	287898713.2
1996	285355601.1

Year	Animal manure applied to soils, Kg N
1997	259701486.6
1998	259410369.1
1999	245751899.6
2000	232304682.2
2001	221792597
2002	231303731.5
2003	236214210.3
2004	252532552.1
2005	250936095.2
2006	247462372.3
2007	248808344.3
2008	246747122.1
2009	242289934.4
2010	222017072.3
2011	219796123.8
2012	220307452.8
2013	221244632.6
2014	220325297
2015	223012137
2016	219837918.3
2017	213857784.1
2018	209916830.7
2019	209419669.3
2020	205614307.3
2021	204093929.2
2022	201803038.4

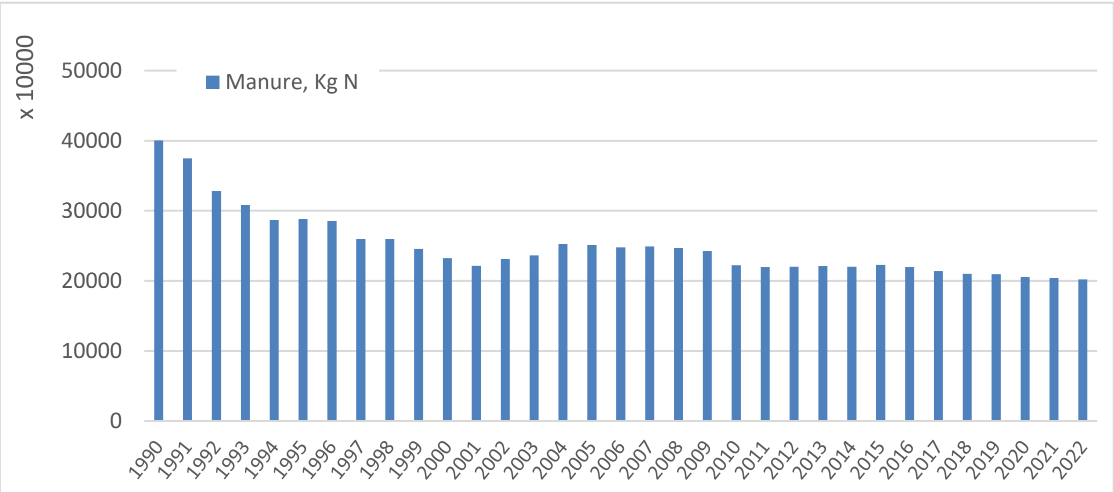


Figure 5.13.1 Activity data trends for NFR 3Da2a – pollutant NOx

Table 5.13.2 Emission trends (kt) for NFR 3Da2a Animal manure applied to soils

Year	NOx	NH_3
1990	16.007	94.606
1991	14.993	82.742
1992	13.116	71.922

1993	12.311	68.528
1994	11.467	62.821
1995	11.516	63.964
1996	11.414	63.961
1997	10.388	58.004
1998	10.376	57.727
1999	9.830	53.205
2000	9.292	48.865
2001	8.872	47.331
2002	9.252	50.284
2003	9.449	50.703
2004	10.101	55.406
2005	10.037	56.857
2006	9.898	57.974
2007	9.952	56.144
2008	9.870	54.539
2009	9.692	52.084
2010	8.881	46.418
2011	8.792	45.571
2012	8.812	45.155
2013	8.850	44.986
2014	8.813	44.517
2015	8.920	44.988
2016	8.794	43.889
2017	8.554	42.268
2018	8.397	40.789
2019	8.377	40.586
2020	8.225	39.407
2021	8.164	39.521
2022	8.072	38.514

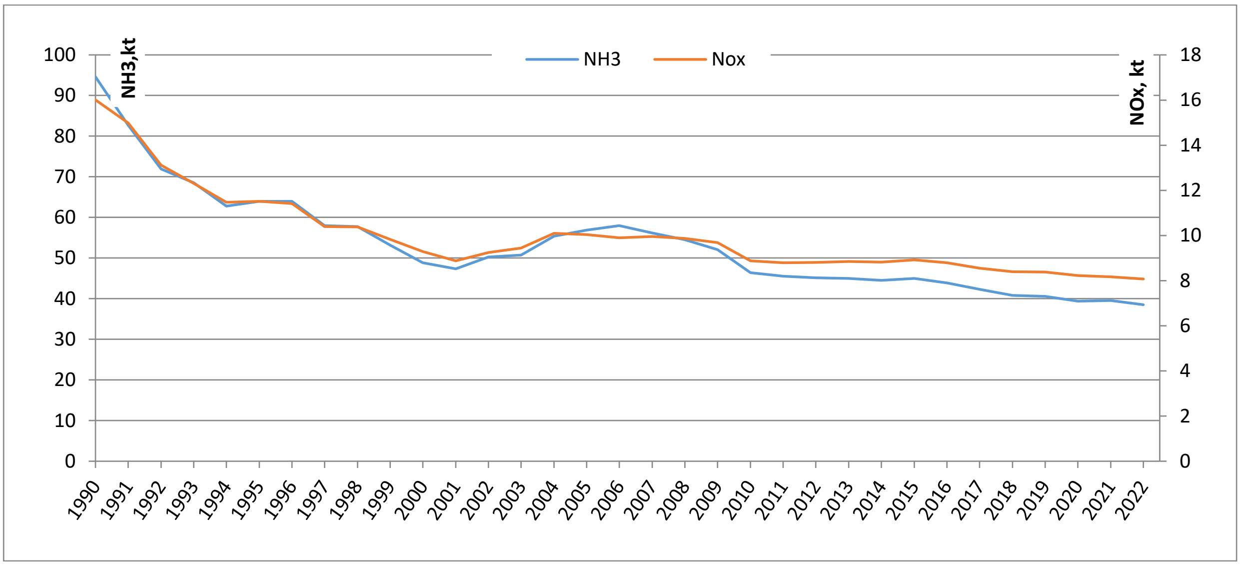


Figure 5.13.2 Emission trends (kt) for NFR 3Da2a Animal manure applied to soils

The emissions of NH_3 and NOx from animal manure applied to soils follow the activity data trend.

Recalculations and improvements:

- Recalculation of NMVOC emissions for the entire time series as an effect of changes in activity data from the poultry sector (time series 2008-2021) and interpolation of AWMS percentage values for the categories of dairy cattle (3B1a), non-dairy cattle (3B1b) (time series 2006 -2013).
- Recalculation of NOx emissions for the entire time series 1990-2021 with the updated activity data.

5.13 NFR 3. D.a.2.b Sewage sludge applied to soils

The emissions for this NFR is generated in sewage treatment works consisting in removing biologically degradable organic matter from wastewater, preventing pollution of freshwater and coastal marine ecosystems [1].

The NH_3 and NOx emissions were estimated here, with a minor share in the total national values.

The methodology used to calculate the emissions is Tier 1 describes in the 2019 EMEP/EEA Guidebook, table 3.1, for NH_3 and NOx pollutants.

The calculation used population related to wastewater treatment plants as activity data from National Institute of Statistics, for 2006 - 2022 period, completed with values for 1990 - 2005 period from a Romania's Greenhouse Gas study[2].

Table 5.14.1. Activity data (population size) for NFR 3Da2b - Sewage sludge applied to soils

Year	**Population** on wastewater treatment plants (1000 head)
1990	2836.99
1991	2824.29
1992	2782.66
1993	2791.40
1994	2796.21
1995	1744.01
1996	1737.56
1997	1736.66
1998	1728.70
1999	1722.38
2000	2460.77
2001	3254.53
2002	3935.02
2003	4788.86
2004	5203.79
2005	5738.36
2006	6068.66

[1] EMEP/EEA air pollutant emission inventory guidebook 2019, Annex 1, pg. 26.

[2] "Elaboration/documentation of national emission factors/other parameters relevant to NGHGI Sectors Energy, Industrial Processes, Agriculture and Waste, values to allow for the higher Tier calculation methods implementation".

Year	Population on wastewater treatment plants (1000 head)
2007	6130.40
2008	6215.16
2009	6236.53
2010	6541.22
2011	8568.77
2012	8641.24
2013	8883.58
2014	8998.26
2015	9089.71
2016	9415.52
2017	9710.08
2018	10035.29
2019	10264.30
2020	10540.39
2021	10792.65
2022	11062.43

Table 5.14.2 Emission trends (kt) for 3Da2b - Sewage sludge applied to soils

Year	NOx	NH_3
1990	0.0056	0.0192
1991	0.0056	0.0192
1992	0.0055	0.0189
1993	0.0055	0.0189
1994	0.0055	0.0190
1995	0.0034	0.0118
1996	0.0034	0.0118
1997	0.0034	0.0118
1998	0.0034	0.0117
1999	0.0034	0.0117
2000	0.0049	0.0167
2001	0.0065	0.0221
2002	0.0078	0.0267
2003	0.0095	0.0325
2004	0.0104	0.0353
2005	0.0114	0.0390
2006	0.0121	0.0412
2007	0.0122	0.0416
2008	0.0124	0.0422
2009	0.0124	0.0424
2010	0.0130	0.0444
2011	0.0171	0.0582
2012	0.0172	0.0587
2013	0.0177	0.0604
2014	0.0180	0.0611
2015	0.0181	0.0618
2016	0.0188	0.0640

Year	NOx	NH_3
2017	0.0194	0.0660
2018	0.0200	0.0682
2019	0.0205	0.0698
2020	0.0210	0.0716
2021	0.0215	0.0733
2022	0.0221	0.0752

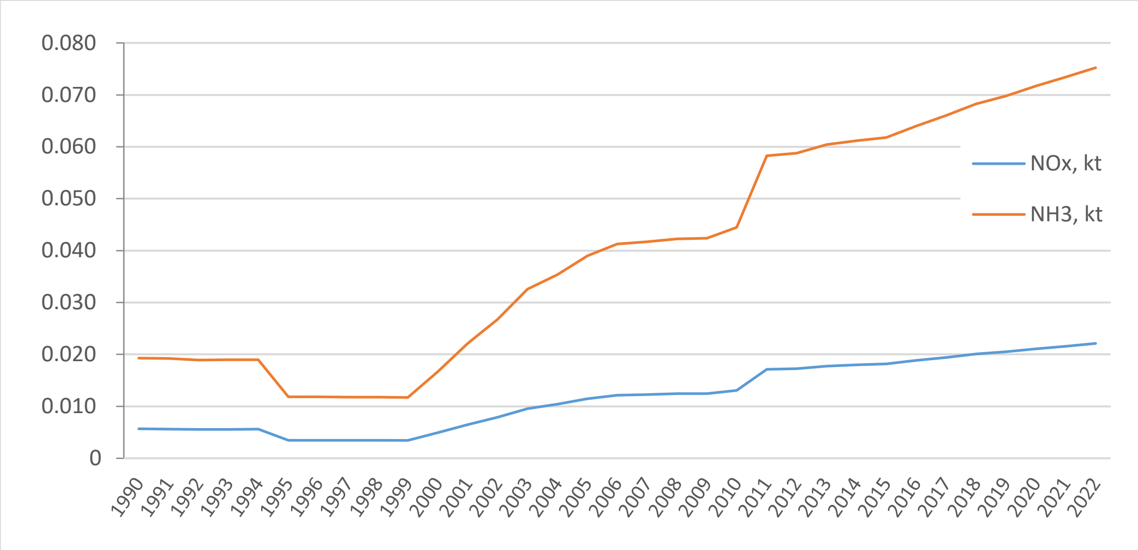


Figure 5.14.1 Emission trends (kt) for 3Da2b - Sewage sludge applied to soils

Recalculations and improvements:

- There were not recalculations since the previous submission.

5.14 NFR 3.D.a.3 Urine and dung deposited by grazing animals

For this sector, the emission of NH3 and NMVOC were estimated. The emission of ammonia from animal manure - urine and dung deposited by grazing animals contributed in 2022 with 12.50%, as a key source, of the national total ammonia emissions.

The methodology used to calculate the emissions is described in chapter 3B Manure Management, considering these emissions as part of a chain of sources, enabling the estimation of the impact of NH3 and other N emissions in different stages.

Activity data from the urine and dung deposited by grazing animals represent a percentage of the total manure from all animal species in source category 3B, as is specified in 2019 EMEP/EEA Guidebook.

The Excel spreadsheet "Manure Management N-flow tool" was used to calculate ammonia emissions with the Tier 2 method for dairy cattle, non-dairy cattle, swine, sheep and laying hens. The rest of the categories were calculated with Tier 1 methodology. The emissions of NH3 for NFR 3Da3 have been calculated by splitting the NH3 emissions from manure in NFR 3B, NFR 3Da2a and NFR 3Da3 according the 2019 EMEP/EEA Guidebook as mentioned above.

The use of the AgrEE Tool led to NMVOC emissions values for grazing, which in previous years was included in emissions from 3B, Manure Management, from the categories calculated with Tier2 approach: dairy cattle, non-dairy cattle, laying hens and broilers.

Table 5.15.1 Emission trends (kt) for NFR 3Da3 - Urine and dung deposited during grazing animals

Year/Pollutant	NH_3, kt
1990	35.054
1991	32.164
1992	28.065
1993	27.399
1994	26.633
1995	26.286
1996	25.419
1997	24.102
1998	23.395
1999	22.926
2000	21.943
2001	21.299
2002	21.800
2003	22.132
2004	21.475
2005	21.828
2006	21.955
2007	22.818
2008	22.563
2009	21.978
2010	19.049
2011	19.021
2012	19.256
2013	19.463
2014	19.770
2015	20.153
2016	20.232
2017	19.995
2018	19.908
2019	19.717
2020	19.521
2021	18.878
2022	18.733

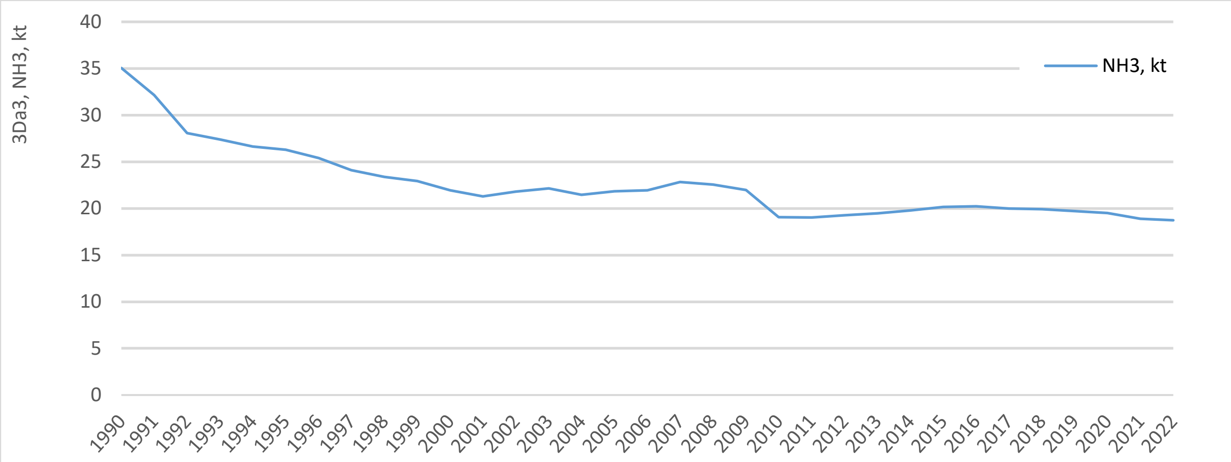


Figure 5.15.1 Emission trends (kt) for
NFR 3Da3 - Urine and dung deposited during grazing animals

Table 5.15.2 Comparison between the split of NH_3 for NFR 3B, 3Da2a, 3Da3

Year	3B-NH_3, kt	3Da2a-NH_3, kt	3Da3-NH_3, kt
1990	127.577	94.607	35.054
1991	111.989	82.742	32.164
1992	97.958	71.922	28.065
1993	93.038	68.528	27.400
1994	84.648	62.821	26.633
1995	86.855	63.964	26.286
1996	86.856	63.962	25.420
1997	78.345	58.005	24.102
1998	78.124	57.728	23.395
1999	71.384	53.206	22.926
2000	65.094	48.866	21.943
2001	62.926	47.331	21.299
2002	67.171	50.284	21.800
2003	67.767	50.704	22.132
2004	74.305	55.406	21.475
2005	76.770	56.858	21.828
2006	77.955	57.975	21.956
2007	76.239	56.145	22.818
2008	74.085	54.540	22.563
2009	70.895	52.084	21.979
2010	63.440	46.418	19.049
2011	62.079	45.571	19.021
2012	61.490	45.155	19.257
2013	61.549	44.987	19.463
2014	60.569	44.517	19.770
2015	61.083	44.989	20.154
2016	59.913	43.889	20.232

Year	3B-NH_3, kt	3Da2a-NH_3, kt	3Da3-NH_3, kt
2017	57.752	42.269	19.995
2018	55.598	40.790	19.908
2019	54.981	40.587	19.718
2020	53.772	39.407	19.522
2021	53.277	39.521	18.879
2022	51.884	38.515	18.733

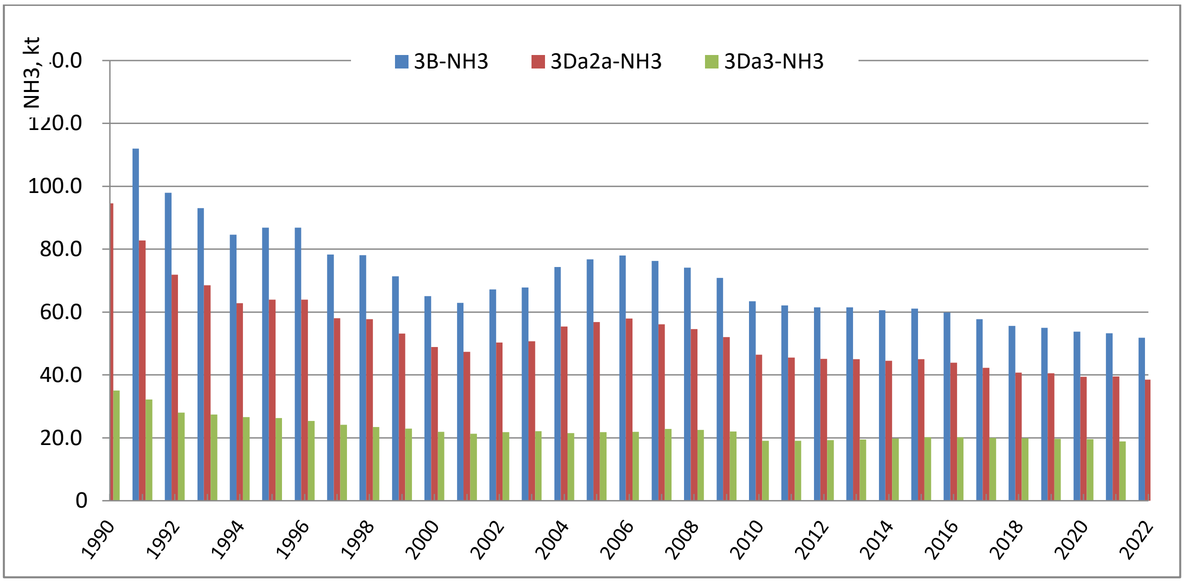


Figure 5.15.2 Comparison between the split of NH_3 [kt] for category 3B, 3Da2a, 3D3

Recalculations and improvements:

- Recalculation of NMVOC emissions for the entire time series as an effect of changes in activity data from the poultry sector (time series 2008-2021) and interpolation of AWMS percentage values for the categories of dairy cattle (3B1a), non-dairy cattle (3B1b) (time series 2006 -2013).

5.15 NFR 3.D.c Farm-level agricultural operations including storage, handling and transport of agricultural products

Particulate emissions occur during agricultural operations, such as soil cultivation, harvesting, cleaning, drying and transportation. The emissions of PM_{10} and TSP from field operations contribute as key sources, with 12.27% of the total national emissions of PM_{10}, respectively with 8.91% of the total national emissions of TSP in 2022.

The emissions of particulate matters from field operations are calculated by area of cultivated crops multiplied with emission factor, using the Tier 1 methodology, according to the 2019 EMEP/EEA Guidebook.

As activity data, the area of cultivated crops is used, as provided by the N.I.S. and in correlation with GHG (UNFCCC) - CRF database.

Table 5.16.1. Activity data (area of cultivated crops, ha) for NFR 3Dc Farm-level agricultural operations

Year/Activity data	Crops areas, ha
1990	12111900
1991	8818293
1992	5524686
1993	7145286
1994	7389015
1995	7447588
1996	7156908
1997	6669130
1998	6512917
1999	5418761
2000	5502443
2001	5874452
2002	5292608
2003	6370573
2004	6267177
2005	6711748
2006	6015346
2007	6422910
2008	6766070
2009	6317769
2010	7357786
2011	7466912
2012	7821665
2013	7800421
2014	8359262
2015	8328061
2016	8702268
2017	9262254
2018	10039777
2019	11746435
2020	11714546
2021	12952657
2022	11255420

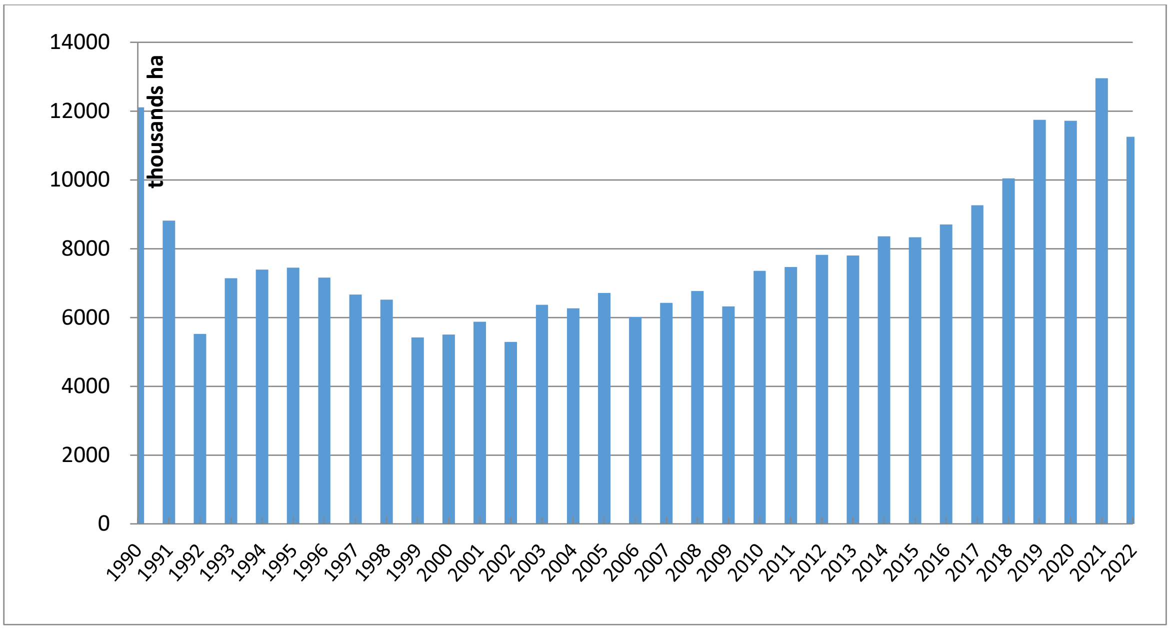


Figure 5.16.1 Activity data trends (ha) for NFR 3Dc Farm-level agricultural operations

The emissions represented here are from PM2,5 and PM10, the TSP having the same values (i.e. emission factor) as PM10.

Table 5.16.2 Emission trends (kt) for NFR 3Dc Farm-level agricultural operations

Year/Pollutant	$PM_{2.5}$	PM_{10}
1990	0.727	18.895
1991	0.529	13.757
1992	0.331	8.619
1993	0.429	11.147
1994	0.443	11.527
1995	0.447	11.618
1996	0.429	11.165
1997	0.400	10.404
1998	0.391	10.160
1999	0.325	8.453
2000	0.330	8.584
2001	0.352	9.164
2002	0.318	8.256
2003	0.382	9.938
2004	0.376	9.777
2005	0.403	10.470
2006	0.361	9.384
2007	0.385	10.020
2008	0.406	10.555
2009	0.379	9.856
2010	0.441	11.478
2011	0.448	11.648
2012	0.469	12.202
2013	0.468	12.169

Year/Pollutant	$PM_{2.5}$	PM_{10}
2014	0.502	13.040
2015	0.500	12.992
2016	0.522	13.576
2017	0.556	14.449
2018	0.602	15.662
2019	0.704	18.324
2020	0.703	18.275
2021	0.777	20.206
2022	0.675	17.558

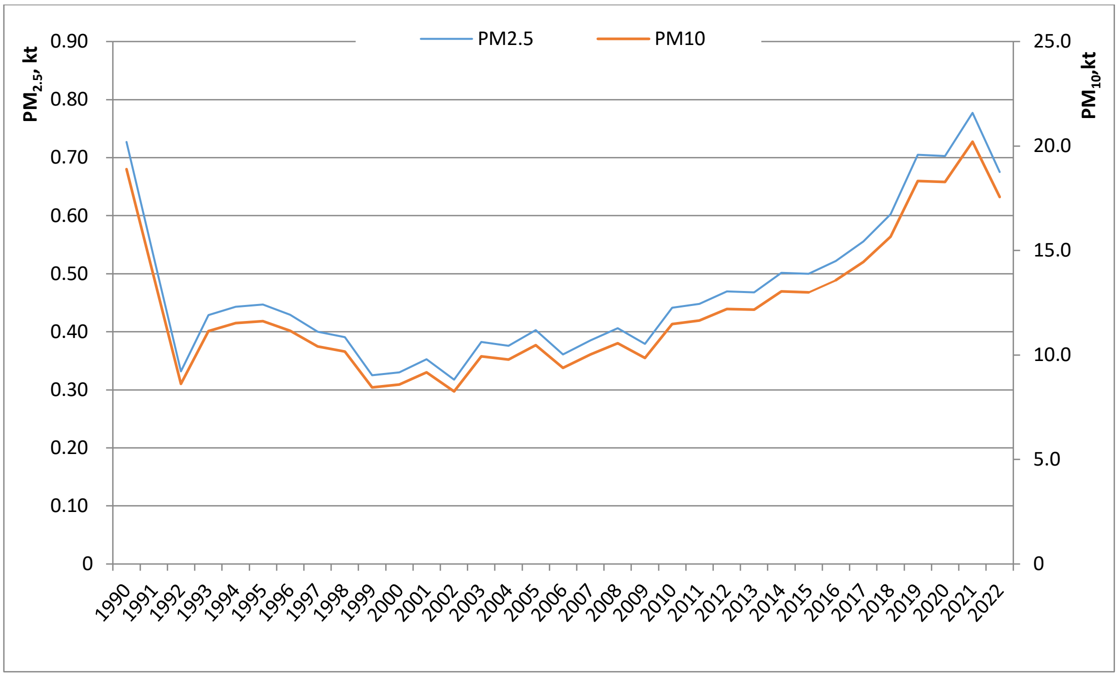


Figure 5.16.2 Emission trends (kt) for NFR 3Dc Farm-level agricultural operations

The emissions of particulate matter from farm-level agricultural operations follow the activity data trend.

Recalculations and improvements:

- recalculation of particulate matter emissions for 2021 year due to updated activity data from NIS.

5.16 NFR 3.D.e Cultivated crops

For the cultivated crops sector the emission of NMVOC were estimated, with a percent of 3.3%, as a key source, from the total national of NMVOC emissions.

Following the reviewing of 2023, for NFR 3.D.e the estimation method was changed and it was switched to the Tier 2 methodology with the emission factors from Table 3.3 of 2019 EMEP/EEA Guidebook and calculated with the AgrEE Tool for wheat, rape, rye and grass crops; for the remaining undifferentiated cultures, it was calculated with the Tier 1 emission factors from table 3.1 of the same Guidebook.

The activity data represented by cultivated crop areas were provided by N.I.S.

Table 5.17.1 Emission trends (kt) for NFR 3De - Cultivated crops

Year/Pollutant	NMVOC
1990	7.500
1991	4.946
1992	2.646
1993	3.587
1994	3.780
1995	3.929
1996	3.995
1997	3.432
1998	3.414
1999	2.694
2000	2.541
2001	2.630
2002	1.920
2003	3.203
2004	3.576
2005	3.570
2006	3.220
2007	3.281
2008	3.752
2009	3.153
2010	4.058
2011	4.472
2012	4.770
2013	4.807
2014	5.266
2015	5.258
2016	5.547
2017	6.107
2018	6.665
2019	8.181
2020	7.985
2021	9.553
2022	7.702

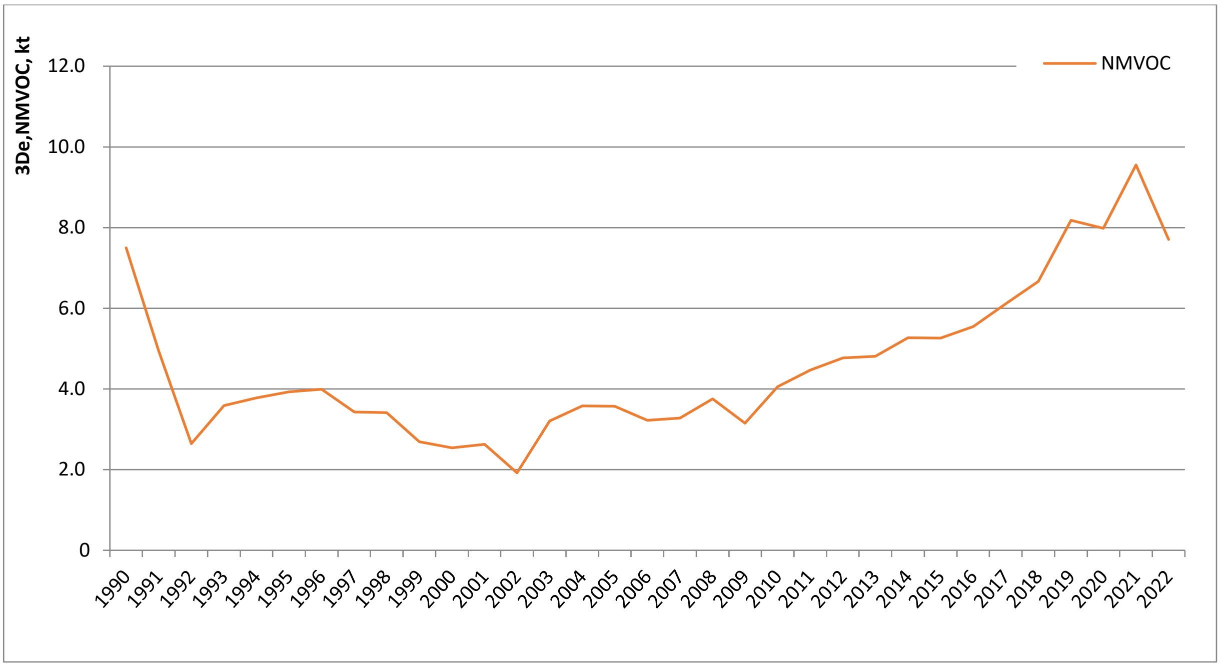


Figure 5.17.1 Emission trends (kt) for NFR 3De - Cultivated crops, NMVOC, kt

The emissions of NMVOC from cultivated crops follow the activity data trend.

Recalculations and improvements:

- recalculation of NMVOC emissions for the entire time series, 1990-2021, at TERT recommendation.

5.17 NFR 3.F Field Burning of Agricultural Residues

This category includes emissions for the open burning of crops residues on arable lands after harvest. This activity does not include the burning of crops residues after they have been used on the farm, which is reported under NFR code 5.C.2 Open burning of waste. Emissions of NOx, NMVOCs, SOx, NH3, particulate matter, BC, CO, heavy metals and PAHs were reported for NFR 3F. These emissions contribute less than 1% of total national emissions.

The methodology for estimating emissions from field burning of agricultural residues is based on the 2019 EMEP/EEA Guidebook, Tier 2 approach, applying the general equation:

$E_{pollutant} = AR_{residue\_burnt} \cdot EF_{pollutant}$, where:

- $AR_{residue\_burnt}$ = activity rate, mass of residue burnt (kg dry matter)
- $EF_{pollutant}$ = emission factor for pollutant (kg kg-1 dry matter).

This equation is applied at the national level, using the total amount of residue burnt for each crop type (wheat, maize, barley, rye and other cereals).

The mass of crop residue burned is calculated with the following equation:

$AR_{residue\_burnt} = A \cdot Y \cdot s \cdot d \cdot p_b \cdot Cf$, where:

- A (ha) is the area of land on which crops are grown whose residues are burned

- Y (kg ha^{-1} fresh weight) is the average yield of those crops
- s is the ratio between the mass of crop residues and the crop yield
- d is the dry matter content of that yield
- p_b is proportion of those residues that are burned
- Cf is the combustion factor (proportion of the fuel present at the time of the fire that is actually burned).

According to EMEP/EEA 2019, Chapter 3.F, the following values are used:

- for wheat: Y = 3.6, Cf = 0.9; for maize: Y = 11.8, Cf = 0.8; rice: Y = 4.6, Cf = 0.8
- default values of s is from Table 3–2
- d = 0.85, for consistency with IPCC (2006, chapter 2.4)
- the value of 1 is used for p_b.

For crops other than wheat, maize and rice, the values for wheat are used (table 3-3).

The emission factors used are from 2019 EMEP/EEA Guidebook, chapter 3.F Field Burning of Agricultural Residues, Table 3-3, Table 3-4 and Table 3-5.

The areas of land on which are the burned crop residues are provided by from the Romania's Greenhouse Gas Inventory – N.I.R., following the consistency between data for NFR and CRF.

Table 5.18.1 Area of land on which crops are grown whose residues are burned - A (ha)

Year	Wheat	Maize	Barley	Rye	Other cereals
1990	445001	487170	147927	8778	1272
1991	385000	460181	181881	11223	1367
1992	467392	1067349	201050	4668	4490
1993	587071	788814	163918	6645	2138
1994	524336	648517	170646	6248	2081
1995	512448	642253	120163	4255	1528
1996	501509	922413	145061	4513	2890
1997	431905	544794	112351	2890	1442
1998	508848	788268	130301	3426	2837
1999	361188	649644	89579	2482	1124
2000	672751	1057345	142810	4879	2066
2001	531398	620670	110356	2569	2719
2002	579681	730303	146030	3096	3807
2003	493372	909730	93706	3641	6334
2004	385496	549731	71280	3678	2038
2005	459772	488089	89984	3835	625
2006	423390	530162	69769	3627	525
2007	765031	977953	140921	4684	1357
2008	411260	475805	76791	2536	1917
2009	462287	503150	111335	3339	1544
2010	383464	372115	91472	2581	2603
2011	315239	419291	67922	2000	2658
2012	549509	751012	116701	2386	7059
2013	338652	405334	79784	1729	4098

Year	Wheat	Maize	Barley	Rye	Other cereals
2014	321386	382221	78488	1547	3389
2015	376689	465720	83774	1717	2878
2016	338001	408083	76148	1654	2184
2017	244489	286072	54242	1142	2060
2018	221223	255062	44273	1073	1954
2019	253631	313300	52505	1094	1941
2020	425222	498829	83068	2097	2083
2021	278536	326456	57548	1551	1113
2022	409196	458707	80360	2396	1328

Table 5.18.2 Mass of residue burnt - ARresidue_burnt (kg dry matter)

Year	Wheat	Maize	Barley	Rye	Other cereals
1990	1593191	3909055	488868	38678	4553
1991	1378378	3692490	601079	49452	4893
1992	1673356	8564410	664430	20567	16075
1993	2101833	6329442	541717	29279	7656
1994	1877228	5203697	563951	27530	7452
1995	1834666	5153437	397113	18747	5472
1996	1795504	7401442	479398	19887	10349
1997	1546307	4371426	371298	12736	5162
1998	1821778	6325059	430620	15099	10156
1999	1293126	5212744	296040	10935	4024
2000	2408584	8484133	471959	21499	7395
2001	1902511	4980260	364703	11321	9735
2002	2075373	5859952	482600	13642	13631
2003	1766371	7299671	309679	16043	22677
2004	1380155	4411044	235565	16208	7295
2005	1646075	3916429	297378	16899	2237
2006	1515822	4254020	230574	15984	1878
2007	2738964	7847092	465717	20639	4858
2008	1472393	3817861	253777	11177	6861
2009	1655081	4037272	367940	14712	5529
2010	1372877	2985854	302297	11375	9320
2011	1128617	3364390	224469	8814	9516
2012	1967352	6026119	385674	10513	25273
2013	1212441	3252397	263671	7617	14672
2014	1150625	3066937	259386	6815	12133
2015	1348621	3736937	276857	7564	10303
2016	1210112	3274461	251652	7288	7819
2017	875319	2295441	179259	5032	7374
2018	792024	2046616	146313	4728	6995
2019	908049	2513923	173520	4822	6948
2020	1522379	4002603	274525	9240	7456
2021	997216	2619484	190186	6832	3984
2022	1465004	3680661	265574	10559	4753

PAHs emissions trends show below in the following table and figure.

Table 5.18.3 Emission trends (t) for NFR 3.F Field Burning of Agricultural Residues

Year/Pollutant	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd) pyrene
1990	0.029	0.017	0.009	0.010
1991	0.028	0.017	0.009	0.010
1992	0.063	0.034	0.020	0.022
1993	0.047	0.026	0.015	0.016
1994	0.039	0.022	0.013	0.014
1995	0.038	0.021	0.012	0.013
1996	0.054	0.030	0.017	0.019
1997	0.032	0.018	0.010	0.011
1998	0.047	0.026	0.015	0.016
1999	0.038	0.021	0.012	0.013
2000	0.062	0.034	0.020	0.022
2001	0.037	0.021	0.012	0.013
2002	0.043	0.024	0.014	0.015
2003	0.053	0.029	0.017	0.018
2004	0.032	0.018	0.010	0.011
2005	0.029	0.017	0.009	0.010
2006	0.031	0.017	0.010	0.011
2007	0.058	0.032	0.019	0.020
2008	0.028	0.016	0.009	0.010
2009	0.030	0.017	0.010	0.011
2010	0.022	0.013	0.007	0.008
2011	0.025	0.014	0.008	0.009
2012	0.044	0.025	0.014	0.015
2013	0.024	0.014	0.008	0.008
2014	0.023	0.013	0.007	0.008
2015	0.028	0.016	0.009	0.010
2016	0.024	0.014	0.008	0.008
2017	0.017	0.009	0.005	0.006
2018	0.015	0.008	0.005	0.005
2019	0.018	0.010	0.006	0.006
2020	0.029	0.016	0.009	0.010
2021	0.019	0.011	0.006	0.007
2022	0.027	0.015	0.009	0.009

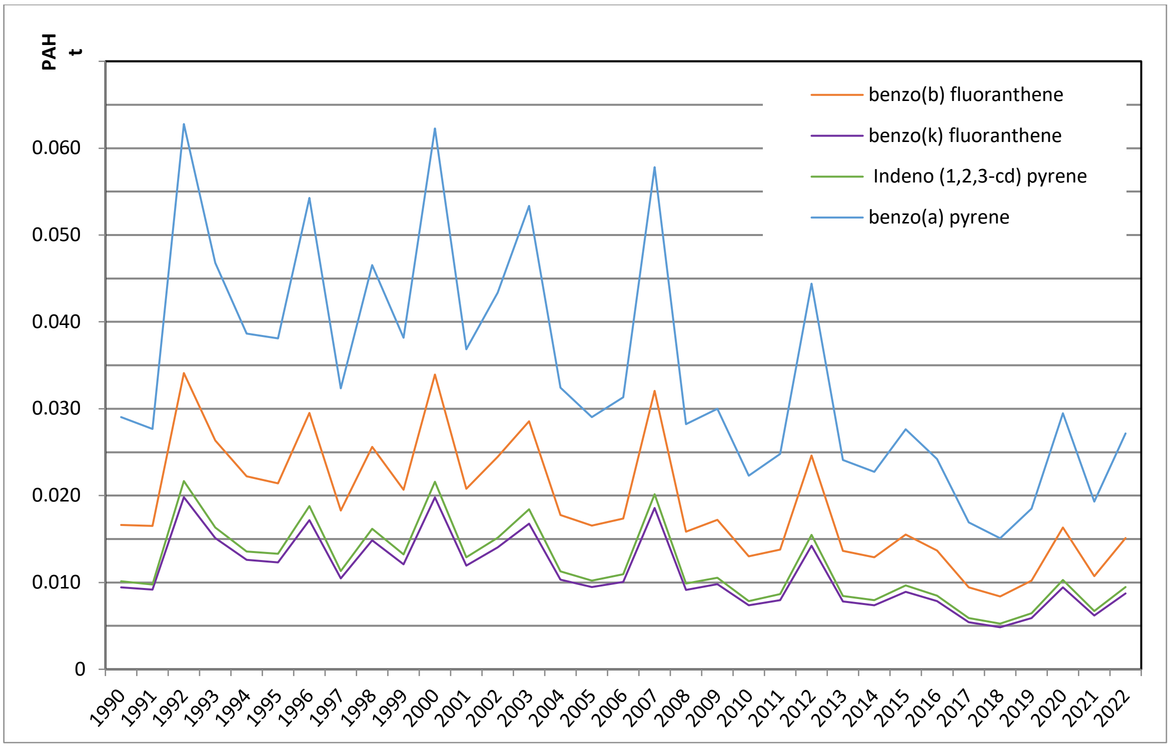


Figure 5.18.1 Emission trends (t) for NFR 3.F Field Burning of Agricultural Residues

The emissions of PAHs follow the activity data trend.

Recalculations and improvements:
- The activity data (the burned areas) were updated after the latest data on the amounts of biomass burned from FAO statistics.

6. WASTE (NFR sector 5)

This sector covers emissions from the solid wastes disposal on land, biological treatment of waste (composting, anaerobic digestion and biogas facilities), clinical and industrial wastes incineration, cremation, small scale waste burning and compost manufacturing, wastewater handling and other waste (car fires and house fires).

Table 6 Pollutants and Emission factors for Sector 5

NFR	Pollutants Reported	Emission Factor tier and source
5A Biological treatment of waste - Solid waste disposal on land	NMVOC, PM2.5, PM10, TSP	T1 - EMEP EEA guidebook (2019) factors
5B1 Biological treatment of waste - Composting	NH3	T2 - EMEP EEA guidebook (2019) factors
5B2 Biological treatment of waste - Anaerobic digestion at biogas facilities	NH3	T2 - EMEP EEA guidebook (2019) factors
5C1bi Industrial waste incineration	All pollutants (except NH3, Cr, Cu, Se, Zn, PAHs, PCBs)	T1 - EMEP EEA guidebook (2019) factors from 1992- 2006

		T2 - EMEP EEA guidebook (2019) factors from 2007- present
5C1bii Hazardous waste incineration	-	
5C1biii Clinical waste incineration	All pollutants (except NH3, PM2.5, PM10, Se, Zn, PAHs)	T2 - EMEP EEA guidebook (2019) factors
5C1biv Sewage sludge incineration	-	
5C1bv Cremation	All P pollutants (except NH3, BC)	T1 - EMEP EEA guidebook (2019) factors
5C1bvi Other waste incineration (please specify in the IIR)	-	
5C2 Open burning of waste	All pollutants (except NH3, Hg, Ni, PAHs, HCB, PCBs)	T1 - EMEP EEA guidebook (2019) factors
5D1 Domestic wastewater handling	-	
5D2 Industrial wastewater handling	-	
5D3 Other wastewater handling	NMVOC, NH3	T1 - EMEP EEA guidebook (2019) factors for SNAP 0910 water handling T2 - EMEP EEA guidebook (2019) factors for SNAP 091007 latrines
5E Other waste (please specify in the IIR)	PM2.5, PM10, TSP, Pb, Cd, Hg, As, Cr, Cu, PCDD/ PCDF	T2 - EMEP EEA guidebook (2019) factors

6.1 NFR 5.A. Biological treatment of waste - Solid waste disposal on land

Activity data for NMVOC represent the total CH_4 emissions from the IPCC inventory. Using the expert judgment it has been considered that 98.7% of the total CH_4 emissions are landfill gas. For the TSP, $PM_{2.5}$, PM_{10}, activity data is the amount of waste disposed on land (SWDS total solid waste disposal sites).

The NMVOC emissions were calculated using emission factors from the 2019 EMEP/EEA Guidebook. Also, for the TSP, $PM_{2.5}$ and PM_{10} emissions were estimated and calculated for this NFR category using the emission factors in the 2019 EMEP/EEA Guidebook and following the Tier 1 methodology (Table 3-1).

The emissions were calculated based on the Tier 1 methodology by applying the general equation:

$$Epollutant = ARproduction \times EFpollutant$$

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate (CH_4 in Gg; total solid waste disposal on land);
- EFpollutant is the emission factor for each pollutant.

The emission factors used to calculate the emissions are from the 2019 EMEP/EEA Guidebook (Tier 1, Table 3.1).

Table 6.1.1 Activity data trends (*Solid waste disposal on land and CH_4 from annual deposition of MSW at the SWDS [Gg]*) for NFR 5.A Biological treatment of waste - Solid waste disposal on land

Year	Solid waste disposal on land (Gg)	CH4 (Gg)
1990	4295.03	49.38
1991	4290.07	50.86
1992	4221.99	52.28
1993	4223.52	53.53
1994	4223.56	54.69
1995	5913.26	55.80
1996	5297.58	59.10
1997	3504.37	62.25
1998	4750.41	63.02
1999	5834.11	65.15
2000	6828.85	76.87
2001	6199.33	82.24
2002	7143.52	87.01
2003	6594.52	92.81
2004	7019.40	98.01
2005	7399.43	102.60
2006	7295.42	104.65
2007	7432.07	111.38
2008	8486.13	114.53
2009	7068.24	118.82
2010	5998.66	124.09
2011	5782.52	105.33
2012	4658.19	128.83
2013	4714.25	140.91
2014	5014.41	141.39
2015	5075.91	141.52
2016	5300.56	143.78
2017	4953.20	146.19
2018	5298.32	147.39
2019	5507.42	152.72
2020	5150.13	154.70
2021	5468.12	155.47
2022	5553.94	156.38

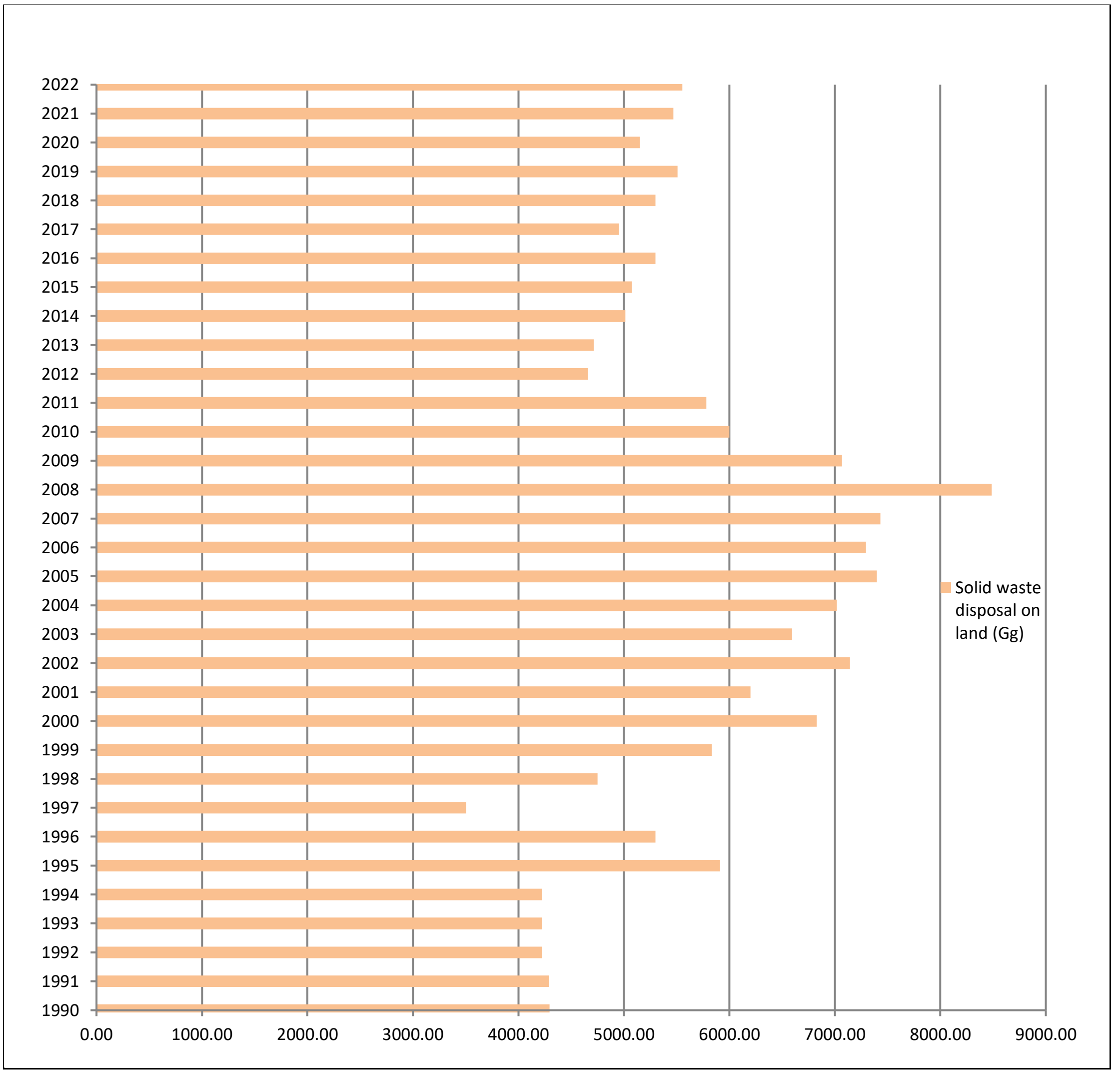


Figure 6.1.1.a Activity data trends *(Solid waste disposal on land [Gg])* for NFR 5.A

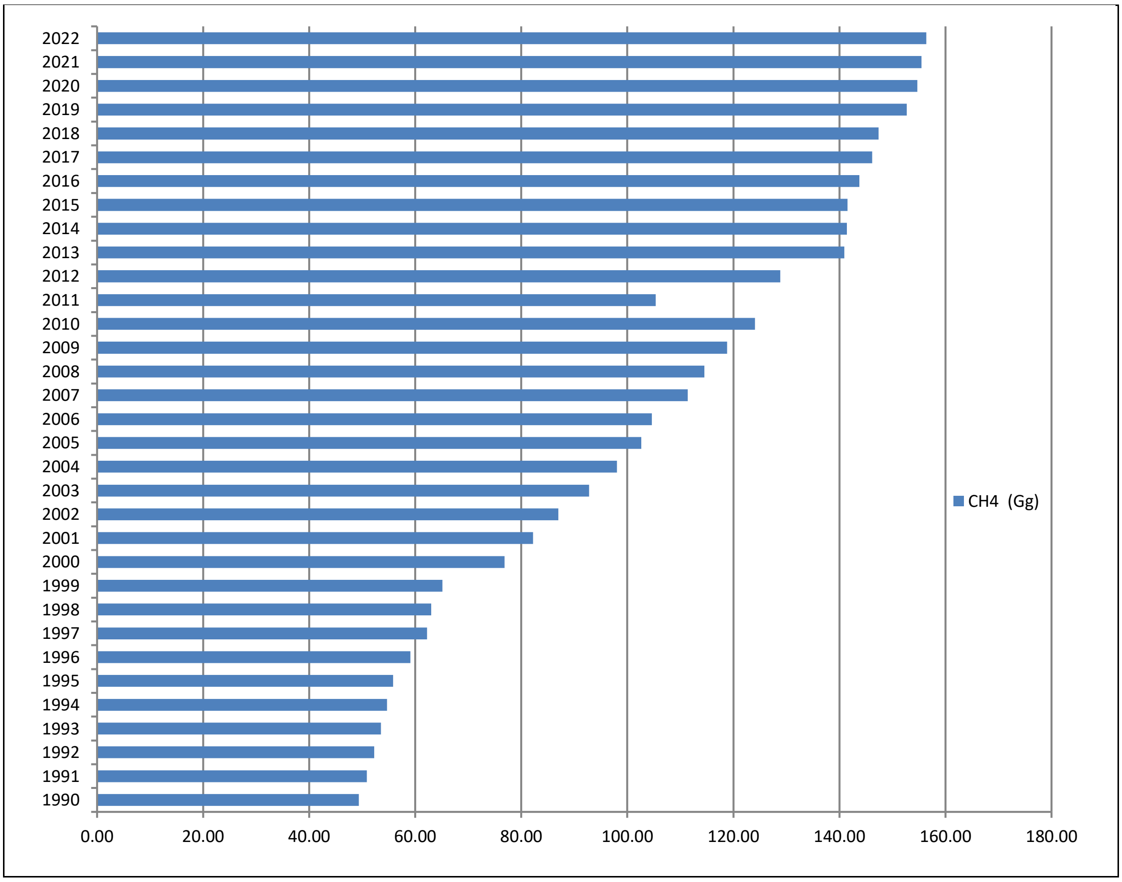


Figure 6.1.1.b. Activity data trends (CH_4 *from annual deposition of MSW at the SWDS [Gg]*) for NFR 5.A

Table 6.1.2 Emission trends (kt for NMVOC) for NFR 5.A Biological treatment of waste –Solid waste disposal on land

Year	NMVOC (kt)
1990	0.650
1991	0.670
1992	0.689
1993	0.705
1994	0.720
1995	0.735
1996	0.778
1997	0.820
1998	0.830
1999	0.858
2000	1.012
2001	1.083
2002	1.146
2003	1.222
2004	1.291
2005	1.351
2006	1.378
2007	1.467
2008	1.509
2009	1.565
2010	1.634
2011	1.387
2012	1.697
2013	1.856
2014	1.862
2015	1.864

Year	NMVOC (kt)
2016	1.894
2017	1.925
2018	1.941
2019	2.011
2020	2.038
2021	2.048
2022	2.063

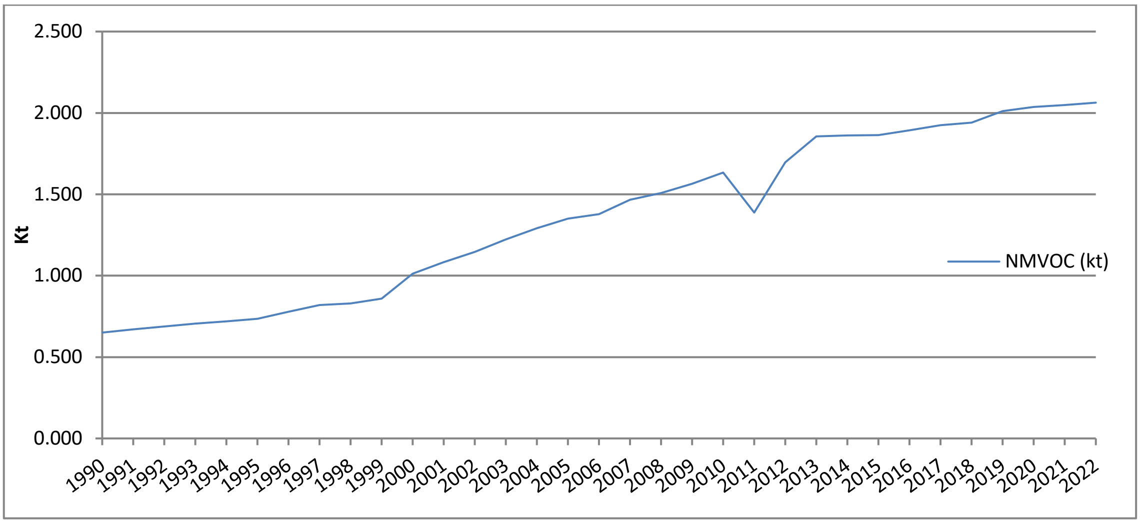


Figure 6.1.2 Emission trends (*kt for NMVOC*) for NFR 5.A Biological treatment of waste – Solid waste disposal on land

NMVOC emissions trend follows the activity data trend - total CH_4 emissions from the IPCC inventory.

Table 6.1.3 Emission trends (*kt for $PM_{2.5}$, PM_{10}. TSP*) for NFR 5.A Biological treatment of waste – solid waste disposal on land

Year	$PM_{2.5}$ (kt)	PM_{10} (kt)	TSP (kt)
1990	0.00014	0.00094	0.00199
1991	0.00014	0.00094	0.00199
1992	0.00014	0.00092	0.00195
1993	0.00014	0.00092	0.00196
1994	0.00014	0.00092	0.00196
1995	0.00020	0.00130	0.00274
1996	0.00017	0.00116	0.00245
1997	0.00012	0.00077	0.00162
1998	0.00016	0.00104	0.00220
1999	0.00019	0.00128	0.00270
2000	0.00023	0.00150	0.00316
2001	0.00020	0.00136	0.00287
2002	0.00024	0.00156	0.00331

Year	$PM_{2.5}$ (kt)	PM_{10} (kt)	TSP (kt)
2003	0.00022	0.00144	0.00305
2004	0.00023	0.00154	0.00325
2005	0.00024	0.00162	0.00343
2006	0.00024	0.00160	0.00338
2007	0.00025	0.00163	0.00344
2008	0.00028	0.00186	0.00393
2009	0.00023	0.00155	0.00327
2010	0.00020	0.00131	0.00278
2011	0.00019	0.00127	0.00268
2012	0.00015	0.00102	0.00216
2013	0.00016	0.00103	0.00218
2014	0.00017	0.00110	0.00232
2015	0.00017	0.00111	0.00235
2016	0.00017	0.00116	0.00245
2017	0.00016	0.00108	0.00229
2018	0.00017	0.00116	0.00245
2019	0.00018	0.00121	0.00255
2020	0.00017	0.00113	0.00238
2021	0.00018	0.00120	0.00253
2022	0.00018	0.00122	0.00257

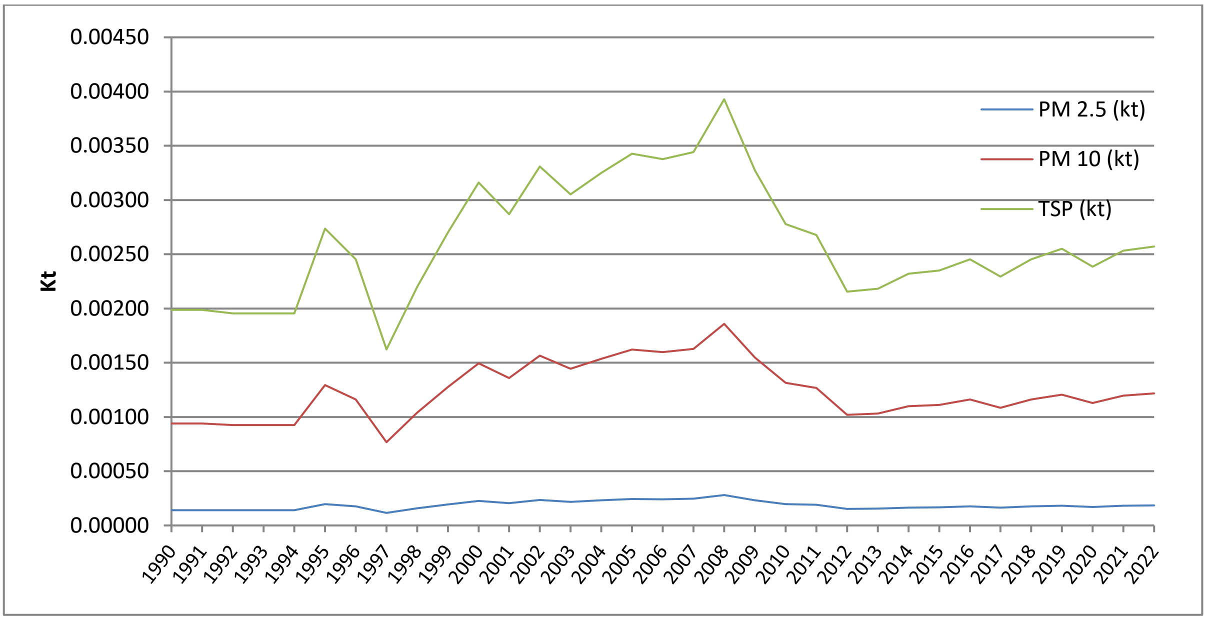


Figure 6.1.3 Emission trends (*kt for $PM_{2.5}$, PM_{10}. TSP*) for NFR 5.A Biological treatment of waste –solid waste disposal on land

The $PM_{2.5}$, PM_{10} and TSP emissions trend follows the activity data trend - total Solid waste disposal on land (Mg).

Recalculations and improvements:

- For the year 2021 recalculation the emission of $PM_{2.5}$, PM_{10} and TSP (total solid waste disposal on land update).

6.2 NFR 5.B.1 Biological treatment of waste – Composting

This category includes emissions from the compost production.

The emissions for NFR 5.B.1 are NH_3 and were calculated using the 2019 EMEP/EEA Guidebook Tier 2 Table 3-1. There are no activity data for the 1990-2004 period (N.E.P.A. does not any information).

Emissions are calculated based on Tier 2 methodology and applies the general equation:

Epollutant = ARproduction× EFpollutant

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate (total quantity of compost produced);
- EFpollutant is the emission factor for this pollutant.

The emission factors used to calculate the emissions are from the 2019 EMEP/EEA Guidebook, Tier 2, Table 3-1.

The activity data is represented by the total quantity of compost produced and is taken from waste related data collected by N.E.P.A.

Table 6.2.1 Activity data trends (kt compost) for NFR 5.B.1 Biological treatment of waste – Composting

Year	Kt composting
2005	0.22
2006	0.33
2007	2.34
2008	2.36
2009	2.92
2010	1.21
2011	15.10
2012	20.55
2013	30.33
2014	17.15
2015	36.83
2016	50.84

Year	Kt composting
2017	86.12
2018	64.99
2019	122.40
2020	139.78
2021	97.94
2022	100.75

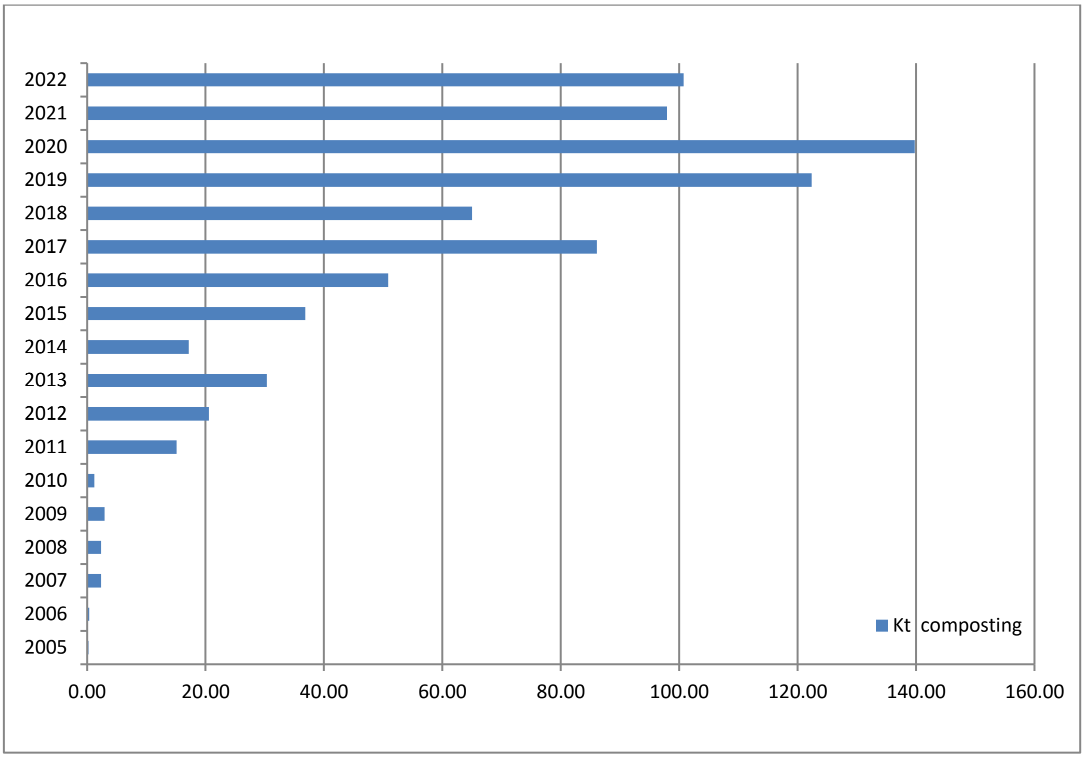


Figure 6.2.1 Activity data trends *(kt compost)* for NFR 5.B.1
Biological treatment of waste – Composting

Table 6.2.2 Emission trends *(kt for NH_3)* for NFR 5.B.1
Biological treatment of waste – Composting.

Year	NH_3 (kt)
2005	0.00005
2006	0.00008
2007	0.00056
2008	0.00057
2009	0.00070
2010	0.00029
2011	0.00362
2012	0.00493
2013	0.00728
2014	0.00412
2015	0.00884

Year	NH_3 (kt)
2016	0.01220
2017	0.02067
2018	0.01560
2019	0.02937
2020	0.03355
2021	0.02351
2022	0.02418

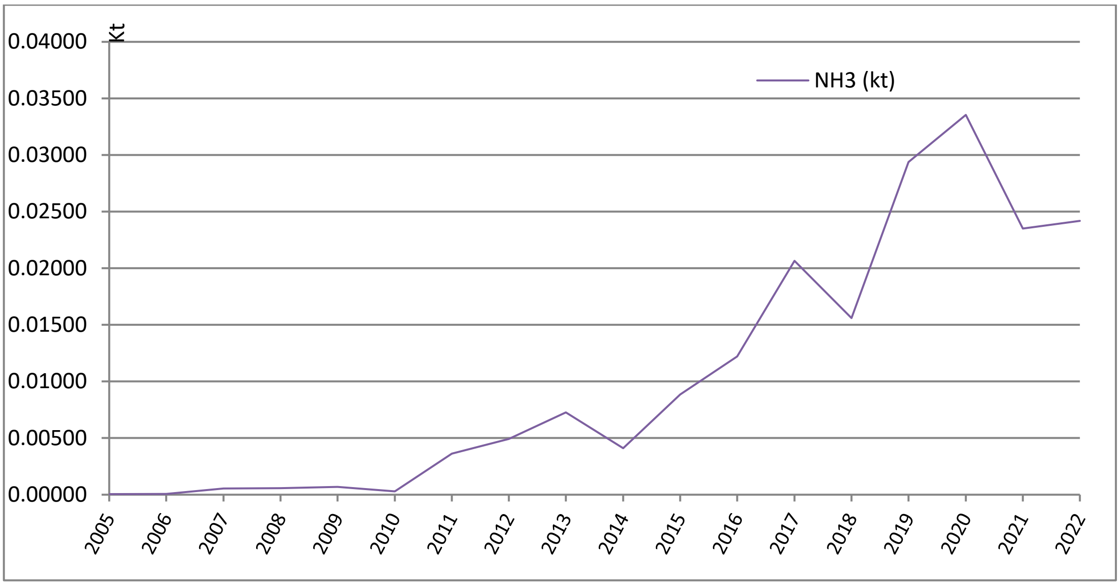


Figure 6.2.2 Emission trends (*kt for NH_3*) NFR 5.B.1
Biological treatment of waste – Composting

The NH_3 emissions from compost production follow the activity data trend.
- For the year 2021 recalculation the emission of NH3 (total quantity of compost produced update).

6.3 NFR 5.B.2 Biological treatment of waste – anaerobic digestion at biogas facilities

This chapter covers the emissions from the biological treatment of waste by anaerobic digestion at biogas facilities. The feedstock's for anaerobic digestion can be any biodegradable organic material such as livestock manure and crops from agriculture, food waste from food processing industries, households and restaurants, and organic waste from municipalities

Anaerobic digestion is a natural process by which biomass is broken down by naturally occurring microorganisms in the absence of oxygen. These microorganisms digest the biomass and release a methane-rich gas (biogas) that, if collected in a biogas plant, can be used to generate renewable heat and power. The remaining material (the solid residue called digestate) is rich in nutrients, so it can be used as a fertiliser.

In Romania, biogas plants are relatively few and use as raw material, manure, food and additional energy crops. The large cogeneration biogas plants operating since 2002 are fully automated (the digester is completely closed and NH3 emissions are insignificant) and the emissions generated by biogas combustion are addressed separately in the "Energy" chapter. For NFR 5B2, NH_3 emissions were calculated in the open storage phase of digestate remaining for fertilization, from small biogas plants operating since 2012 and using manure, food and additional energy crops as feedstock.

Activity data were obtained from economic operator.

NH3 emissions have been reported since 2013 from small biogas plants that have open digestate storage.

In Romania, the main sources of biogas are agricultural waste (vegetable waste, manure) and energy crops (corn, grass, etc.), industrial organic waste, especially in the food processing sector.

For NFR 5B2 Biological treatment of waste – anaerobic digestion at biogas facilities the activity data represent the total annual amount of nitrogen in the raw material entering the biogas plants

These are derived from the amount of fresh matter (they cover all biodegradable organic materials, including manure, crops that are grown for energy production and other organic agricultural waste, such as crop residues, which are used for anaerobic digestion at biogas plants)

The emissions from NFR 5B2 Biological treatment of waste – anaerobic digestion at biogas facilities were calculated using the 2019 EMEP/EEA Guidebook (Tier 2, Table 3-2) by applying the algorithm:

$$E_{NH_3} = AR_{feedstock} \times \sum EF_{NH_3\text{-}N,\ stage\ i} \times 17/14$$

where :

ARfeedstock is the total annual amount of N in feedstock, in kg a-1;

and EFNH3-N, stage i is the NH3- N EF for stage i (i is the pre-storage, digester, and storage of digestate) related to the total N in feedstock (kg NH3-N per kg total N).

AR feedstock is calculated by multiplying the total fresh weight of feedstock (tonnes a-1) by the dry matter content of the feedstock (kg kg-1) and the concentration of N in the feedstock dry matter (kg N kg-1) using the 2019 EMEP/EEA Guidebook (Table 3.4 N content for various feedstock categories).

Table 6.3.1 Calculation Total feedstock in during storage of the digestate for NFR 5B2Biological treatment of waste – anaerobic digestion at biogas facilities

Feedstock type	UM	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Municipal organic waste	kg									21000	471000
Green waste (grass, etc.)(a)	kg					314287	39310	673505	1043360	616680	831870
Food waste (food processing)1)	kg		6415390	3999190	10760270	17208530	21962717.8	27090337	29842905	65428831	86972145
Cattle slurry (a)	kg		1762450	7184940	15975400	33612040	39897360	56623080	61039960	53407550	40319509
Pig slurry (a)	kg				1950000	9592369	3376000	642000	672000	1147000	1277400
Cattle solid manure(b)	kg			1093000	4616000	17917000	16129200	18640015	18767182	20354990	19698469
Pig solid manure(b)	kg					6658836	3951179	941000	182000	0	0
Poultry manure(b)	kg	9700000	7430000	1070000	5690000	4517000	3524000	3110000	1390500	1926000	3337450
Maize silage (a)	kg	11569056	43159570	58657710	58543000	80547094	79495412	61423769	45623576	40717800	32521500
Grass silage (a)	kg							2054000	90000	103738	950000
Straw (a)	kg					144686	198404	84043	39608	25550	286000
TOTAL feedstock	**kg**	**21269056**	**58767410**	**72004840**	**97534670**	**170511842**	**168573582.8**	**171281749**	**158691091**	**183749139**	**186665343**

Table 6.3.2 Calculation AR feedstock total in during storage of the digestate for NFR 5.B.2. Biological treatment of waste – anaerobic digestion at biogas facilities

AR.feedstock	(1) Dry matter content of fresh matter	(2) N content of fresh matter		AR.feedstock type = (1)x(2)xFeedstock type (kg a-1)									
	(kg kg – 1)	(kg kg – 1)	UM	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Municipal organic waste (a)	0.4	0.0068	(kg a – 1)	0	0	0	0	0	0	0	0	57.12	1281.12
Green waste (grass, etc.) (a)	Not available	0.0046	(kg a – 1)	0	0	0	0	1445.72	180.83	3098.12	4799.46	2836.73	3826.60
Food waste (food processing)1)	Not available	0.0051	(kg a – 1)	0	32718.49	20395.87	54877.38	87763.50	112009.86	138160.72	152198.82	333687.04	443557.94
Cattle slurry (a)	0.1	0.0052	(kg a – 1)	0	916.47	3736.17	8307.21	17478.26	20746.63	29444.00	31740.78	27771.93	20966.14
Pig slurry (a)	0.06	0.0048	(kg a – 1)	0	0	0.00	561.60	2762.60	972.29	184.90	193.54	330.34	367.89
Cattle solid manure	0.25	0.0052	(kg a – 1)	0	0	1420.90	6000.80	23292.10	20967.96	24232.02	24397.34	26461.49	25608.01
Pig solid manure (b)	0.25	0.006	(kg a – 1)	0	0	0	0	9988.25	5926.77	1411.50	273.00	0	0
Poultry manure (b)	0.5	0.0175	(kg a – 1)	84875.00	65012.50	9362.50	49787.50	39523.75	30835.00	27212.50	12166.88	16852.50	29202.69
Maize silage (a)	0.35	0.0046	(kg a – 1)	18626.18	69486.91	94438.91	94254.23	129680.82	127987.61	98892.27	73453.96	65555.66	52359.62
Grass silage (a)	0.35	0.0094	(kg a – 1)	0	0	0	0	0	0	6757.66	296.10	341.30	3125.50
Straw (a)	0.86	0.0051	(kg a – 1)	0	0	0	0	634.59	870.20	368.61	173.72	112.06	1254.40
AR.feedstock total			**(kg a – 1)**	**103501.18**	**168134.37**	**129354.35**	**213788.72**	**312569.60**	**320497.14**	**329762.30**	**299693.58**	**474006.15**	**581549.91**

Table 6.3.3 Activity data trends (AR.feedstock [kg a-1]) for NFR 5.B.2. Biological treatment of waste – anaerobic digestion at biogas facilities

Year	AR.feedstock total [kg a-1]
2013	103501.18
2014	168134.37
2015	129354.35
2016	213788.72
2017	312569.60
2018	320497.14

2019	329762.30
2020	299693.58
2021	474006.15
2022	581549.91

Figure 6.3.3 Activity data trends (AR feedstock) for NFR 5.B.2. Biological treatment of waste – anaerobic digestion at biogas facilities

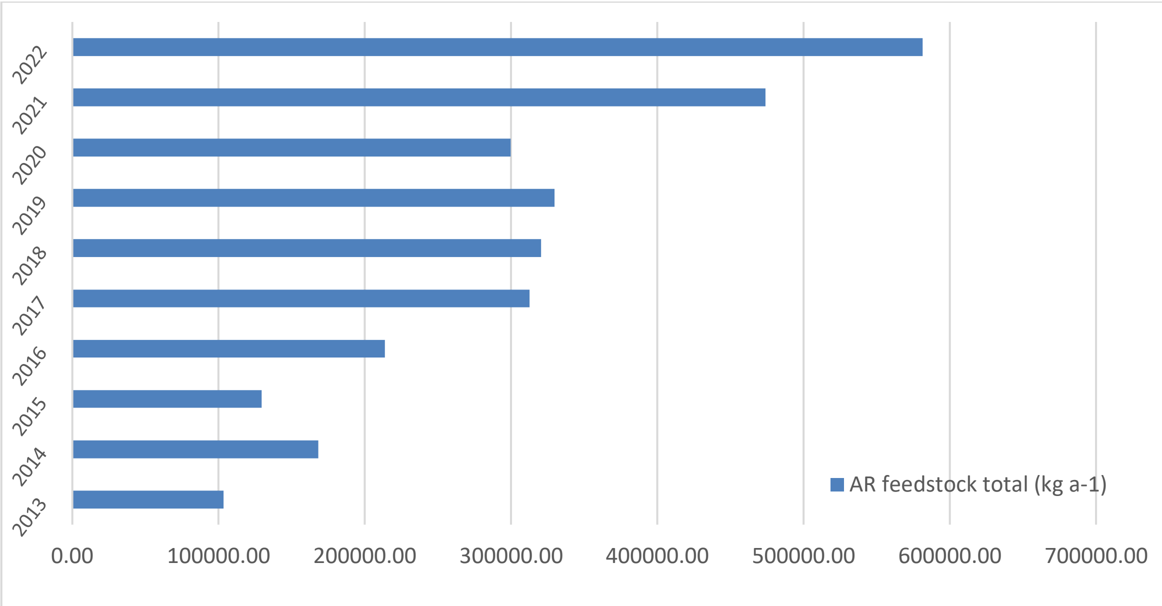


Table 6.3.4 Calculation NH3 emissions for NFR 5.B.2. Biological treatment of waste – anaerobic digestion at biogas facilities

Pol.	Value EFNH3-N, stage i	UM EFNH3-N, stage i	UM ENH3	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
NH3	0.0266	kg NH3-N per kg N in feedstock	kg	3343.088	5430.740	4178.146	6905.375	10095.998	10352.058	10651.322	9680.103	15310.399	18784.062

Table 6.3.5 Emission trends (kt for NH3) for NFR 5.B.2. Biological treatment of waste – anaerobic digestion at biogas facilities

Year	NH3 [kt]
2013	0.003
2014	0.005
2015	0.004
2016	0.007
2017	0.010
2018	0.010
2019	0.011
2020	0.010
2021	0.015
2022	0.019

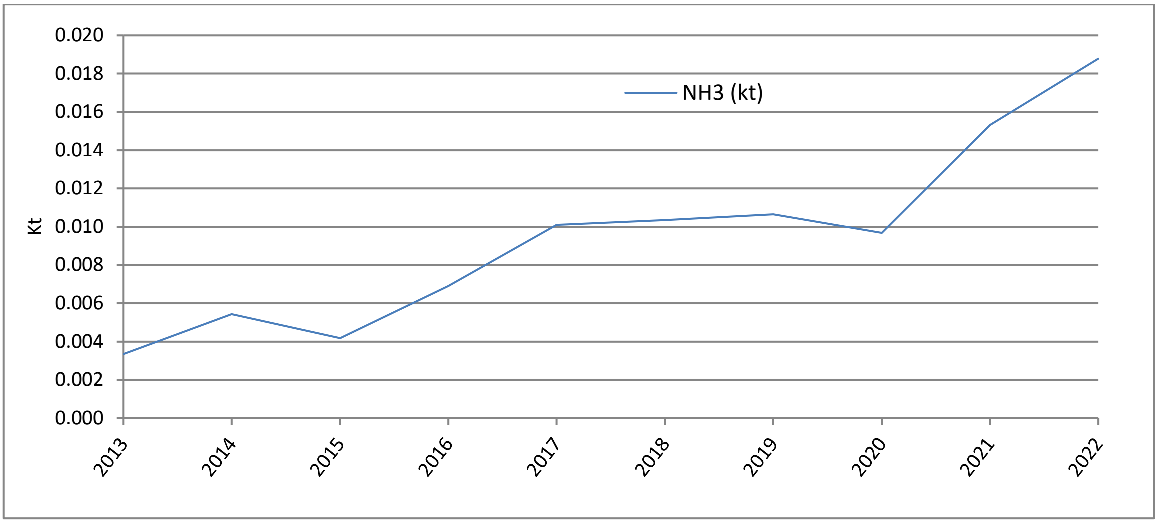


Figure 6.3.5 Emission trends (kt NH3) for NFR 5.B.2. Biological treatment of waste – anaerobic digestion at biogas facilities

Recalculations and improvements:

During the review, *RO-5B2-2022-0001*, for the year 2019 the error (typing) was corrected.

- There were no recalculations and improvements for this category.

6.4 NFR 5.C.1.b.i Industrial waste incineration

This chapter covers the atmospheric emissions from the incineration of industrial waste.

For NFR 5C1bi Industrial waste incineration, the activity data were estimated by study ("Determining the quantities of industrial waste with biodegradable contents and the quantities of sludge resulting from the treatment of wastewaters, disposed in compliant landfills (for 1989-2012) and in non-compliant landfills (for 1950-2012), performed by ISPE in 2013), according with Romanian Greenhouse Gas Inventory.

The amount of industrial waste has been increased from 2003 until 2005 because operators must comply with European regulations and they incinerated a large amount of industrial waste.

According to the Implementation Plan for the Directive 2000/76/EC on waste incineration (document issued within negotiations for accession of Romania to EU) all plants for industrial waste incineration which, in 2004, did not fully comply to the directive regarding the emissions reduction equipment, had to be brought into compliance by 31December 2006. Starting with 1 January 2007, all industrial waste incineration plants comply with the European Directive.

The emissions were calculated based on Tier1 (The Tier 2 approach is similar to the Tier 1 approach) methodology by applying the general equation:

Epollutant = ARproduction× EFpollutant

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate (industrial waste incinerated);
- EFpollutant is the emission factor for each pollutant.

The activity data is represented by the total industrial waste incinerated (in kt) and for this category, the activity data were correlated with the Romanian Greenhouse Gas Inventory - N.I.R.

The NFR 5.C.1.b.iv Sewage sludge incineration was included under NFR 5.C.1.b.i Industrial waste incineration.
The NFR 5.C.1.bii Hazardous waste incineration was included under NFR 5.C.1.b.i Industrial waste incineration.

Table 6.4.1 Activity data trends (*Waste incinerated [kt]*) for NFR 5.C.1.b.i Industrial waste incineration

Year	Industrial Waste incinerated [kt]
1990	0.26
1991	3.45
1992	6.64
1993	9.88
1994	13.11
1995	16.35
1996	19.58
1997	0.53
1998	26.06
1999	29.29
2000	32.53
2001	35.63
2002	38.06
2003	41.70
2004	55.33
2005	99.54
2006	20.06
2007	0.45
2008	0.75
2009	0.53

Year	Industrial Waste incinerated [kt]
2010	0.56
2011	1.50
2012	2.35
2013	2.34
2014	1.63
2015	1.19
2016	3.20
2017	1.41
2018	4.18
2019	3.96
2020	2.63
2021	2.64
2022	1.87

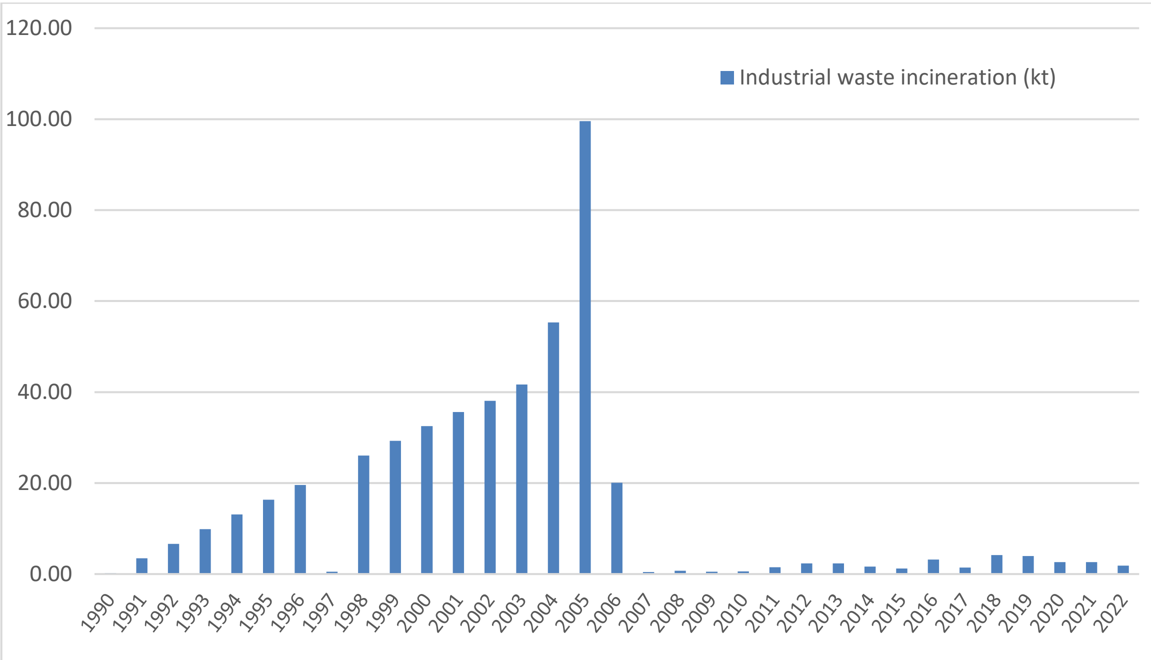


Figure 6.4.1 Activity data trends (*kt waste*) for NFR 5.C.1.b.i Industrial waste incineration

Table 6.4.2 Emission trends (*kt for NOx and NMVOC, t for Pb and g I-TEQ for dioxins*) for NFR 5.C.1.b.i Industrial waste incineration

Year	NOx (kt)	NMVOC (kt)	Pb (t)	PCDD/F (g I-TEQ)
1990	0.0002	0.0020	0.0003	0.0923
1991	0.0030	0.0255	0.0045	1.2080
1992	0.0058	0.0491	0.0086	2.3237
1993	0.0086	0.0731	0.0128	3.4565
1994	0.0114	0.0970	0.0170	4.5892
1995	0.0142	0.1210	0.0213	5.7220
1996	0.0170	0.1449	0.0255	6.8547

Year	NOx (kt)	NMVOC (kt)	Pb (t)	PCDD/F (g I-TEQ)
1997	0.0199	0.1689	0.0297	7.9875
1998	0.0227	0.1928	0.0339	9.1203
1999	0.0255	0.2168	0.0381	10.2530
2000	0.0283	0.2407	0.0423	11.3858
2001	0.0310	0.2636	0.0463	12.4696
2002	0.0331	0.2816	0.0495	13.3204
2003	0.0363	0.3086	0.0542	14.5963
2004	0.0481	0.4094	0.0719	19.3648
2005	0.0866	0.7366	0.1294	34.8374
2006	0.0175	0.1484	0.0261	7.0203
2007	0.0004	0.0034	0.0006	0.1591
2008	0.0006	0.0055	0.0010	0.2608
2009	0.0005	0.0039	0.0007	0.1855
2010	0.0005	0.0042	0.0007	0.1976
2011	0.0013	0.0111	0.0019	0.5248
2012	0.0020	0.0174	0.0031	0.8236
2013	0.0020	0.0173	0.0030	0.8180
2014	0.0014	0.0121	0.0021	0.5716
2015	0.0010	0.0088	0.0015	0.4162
2016	0.0028	0.0236	0.0042	1.1183
2017	0.0012	0.0104	0.0018	0.4918
2018	0.0036	0.0309	0.0054	1.4620
2019	0.0034	0.0293	0.0052	1.3874
2020	0.0023	0.0194	0.0034	0.9198
2021	0.0023	0.0196	0.0034	0.9247
2022	0.0016	0.0138	0.0024	0.6545

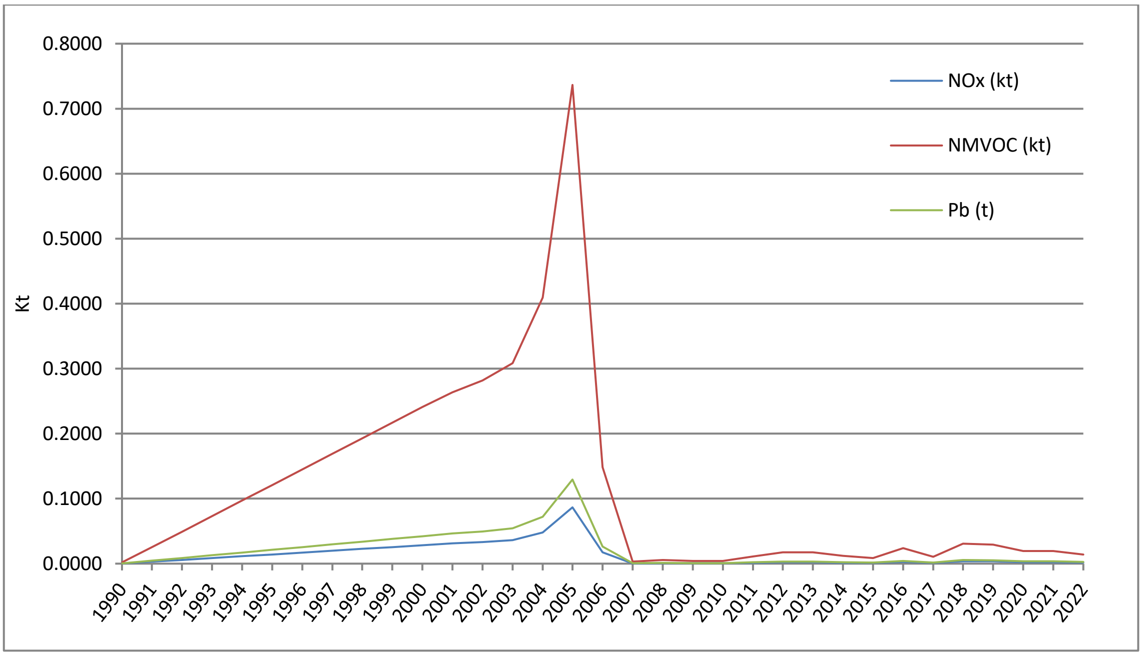


Figure 6.4.2.a. Emission trends (*Kt for NOx and NMVOC, t for Pb*)
for NFR 5.C.1.b.i Industrial waste incineration

Emission trends for NOx, NMVOC and Pb follow the waste incineration activity data trend.

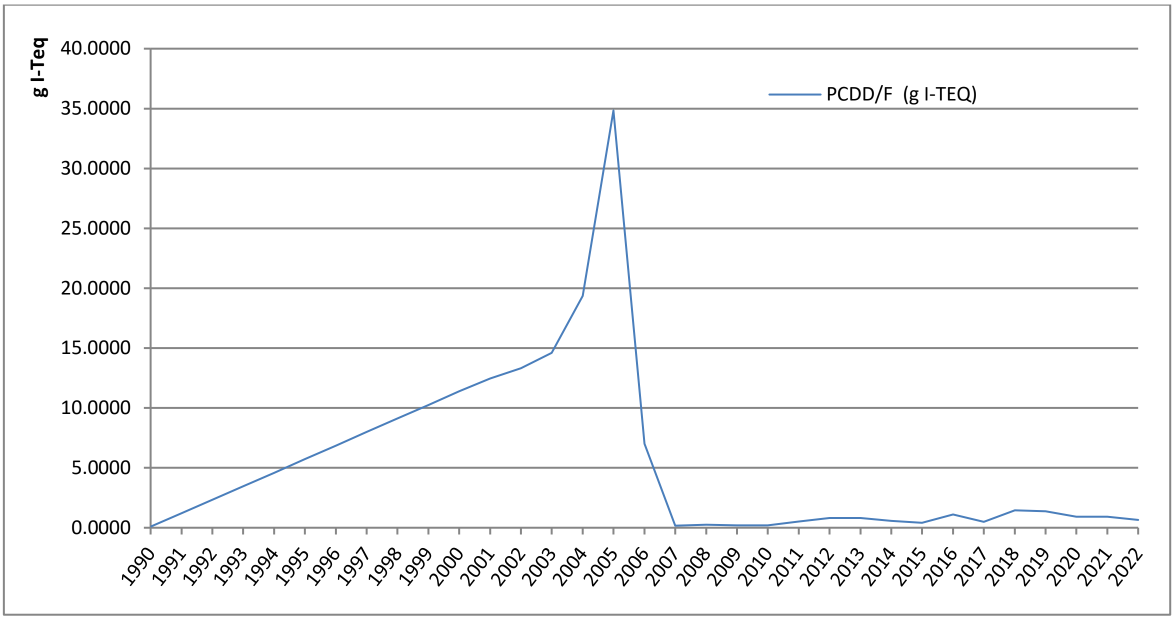


Figure 6.4.2.b. Emission trends (*g I-TEQ for PCDD/F)* for NFR 5.C.1.b.i Industrial waste incineration

Emission trends for PCDD/F follow the waste incineration activity data trend.

Recalculations and improvements:

- There were no recalculations and improvements for this category.

6.5 NFR 5.C.1.b.iii Clinical waste incineration

This category includes emissions from the incineration of hospital wastes.

For NFR 5C1biii clinical waste incineration, Public Health Institute of Bucharest was provided the data on amounts of clinical waste generated and of clinical waste incinerated.

The activity data for NFR 5C1biii clinical waste incineration were correlated with the Romanian Greenhouse Gas Inventory – N.I.R., according with TERT recommendations (data consistency with the I.N.E.G.E.S. Inventory is ensured).

The emissions from Clinical waste incineration was calculated using the 2019 EMEP/EEA Guidebook (Tier 2, Table 3-2). The emissions of SO_2, TSP, As, Cd, Hg, Ni, Pb, Cr, Cu, were calculated by replacing the technology-specific emission factor with an abated emission factor (2019 EMEP/EEA Guidebook Tier 2, Table 3-2) as given in the formula:

$$EF_{tehnologyabated} = (1-\dot{\eta}_{abatement}) \times EF_{tehnology\ abated}$$

The emissions were calculated based on Tier2 methodology by applying the general equation:

$E_{pollutant} = AR_{production} \times EF_{pollutant}$

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate (industrial waste incinerated);
- EFpollutant is the emission factor for each pollutant.

The activity data is represented by the total clinical waste incinerated (in kt).

Table 6.5.1 Activity data trends (Clinical Waste incinerated [kt]) for NFR 5.C.1.b.iii Clinical waste incineration

Year	Clinical Waste incinerated [kt]
1990	2.20
1991	2.22
1992	2.24
1993	2.27
1994	2.31
1995	2.32
1996	2.35
1997	2.63
1998	3.63
1999	10.15
2000	15.03
2001	19.06
2002	17.03
2003	18.79
2004	17.03
2005	13.55
2006	12.61
2007	10.00
2008	6.44
2009	4.79
2010	5.46
2011	5.13
2012	5.81
2013	5.94
2014	6.53
2015	7.35
2016	8.02
2017	9.33
2018	9.87
2019	10.73
2020	13.38
2021	17.78
2022	14.49

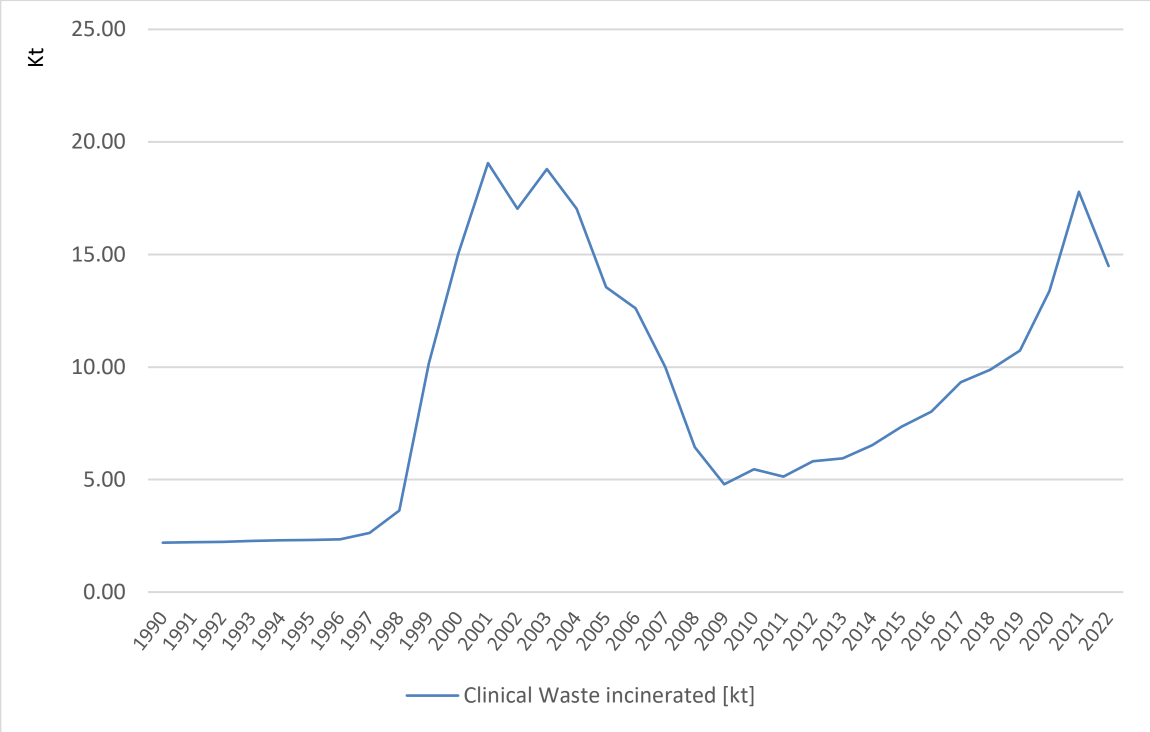


Figure 6.5.1 Trend data activity for 5.C.1.b.iii Clinical waste incineration (kt)

Table 6.5.2 Emission trends (*kt for NOx, NMVOC, SOx, TSP, BC, CO*)
for NFR 5.C.1.b.iii Clinical waste incineration

Year	NOx (kt)	NMVOC (kt)	SOx (kt)	TSP (kt)	BC (kt)	CO (kt)
1990	0.00395	0.00154	0.00019	0.00051	1.16E-05	0.00329
1991	0.00400	0.00156	0.00020	0.00051	1.18E-05	0.00333
1992	0.00403	0.00157	0.00020	0.00051	1.18E-05	0.00336
1993	0.00408	0.00159	0.00020	0.00052	1.20E-05	0.00340
1994	0.00415	0.00162	0.00020	0.00053	1.22E-05	0.00346
1995	0.00418	0.00163	0.00020	0.00053	1.23E-05	0.00348
1996	0.00423	0.00165	0.00021	0.00054	1.24E-05	0.00353
1997	0.00474	0.00184	0.00023	0.00061	1.39E-05	0.00395
1998	0.00653	0.00254	0.00032	0.00083	1.92E-05	0.00545
1999	0.01827	0.00710	0.00089	0.00233	5.37E-05	0.01522
2000	0.02706	0.01052	0.00132	0.00346	7.95E-05	0.02255
2001	0.03431	0.01334	0.00168	0.00438	1.01E-04	0.02859
2002	0.03065	0.01192	0.00150	0.00392	9.01E-05	0.02554
2003	0.03383	0.01315	0.00165	0.00432	9.94E-05	0.02819
2004	0.03065	0.01192	0.00150	0.00392	9.01E-05	0.02554
2005	0.02439	0.00949	0.00119	0.00312	7.17E-05	0.02033
2006	0.02270	0.00883	0.00111	0.00290	6.67E-05	0.01892

Year	NOx (kt)	NMVOC (kt)	SOx (kt)	TSP (kt)	BC (kt)	CO (kt)
2007	0.01799	0.00700	0.00088	0.00230	5.29E-05	0.01500
2008	0.01160	0.00451	0.00057	0.00148	3.41E-05	0.00966
2009	0.00862	0.00335	0.00042	0.00110	2.53E-05	0.00719
2010	0.00983	0.00382	0.00048	0.00126	2.89E-05	0.00819
2011	0.00924	0.00359	0.00045	0.00118	2.71E-05	0.00770
2012	0.01046	0.00407	0.00051	0.00134	3.07E-05	0.00872
2013	0.01069	0.00416	0.00052	0.00137	3.14E-05	0.00891
2014	0.01175	0.00457	0.00057	0.00150	3.45E-05	0.00979
2015	0.01323	0.00515	0.00065	0.00169	3.89E-05	0.01103
016	0.01444	0.00561	0.00071	0.00184	4.24E-05	0.01203
2017	0.01679	0.00653	0.00082	0.00215	4.94E-05	0.01400
2018	0.01777	0.00691	0.00087	0.00227	5.22E-05	0.01481
2019	0.01931	0.00751	0.00094	0.00247	5.68E-05	0.01609
2020	0.02408	0.00936	0.00118	0.00308	7.08E-05	0.02006
2021	0.03200	0.01244	0.00156	0.00408	9.40E-05	0.02666
2022	0.02608	0.01014	0.00127	0.00333	7.66E-05	0.02173

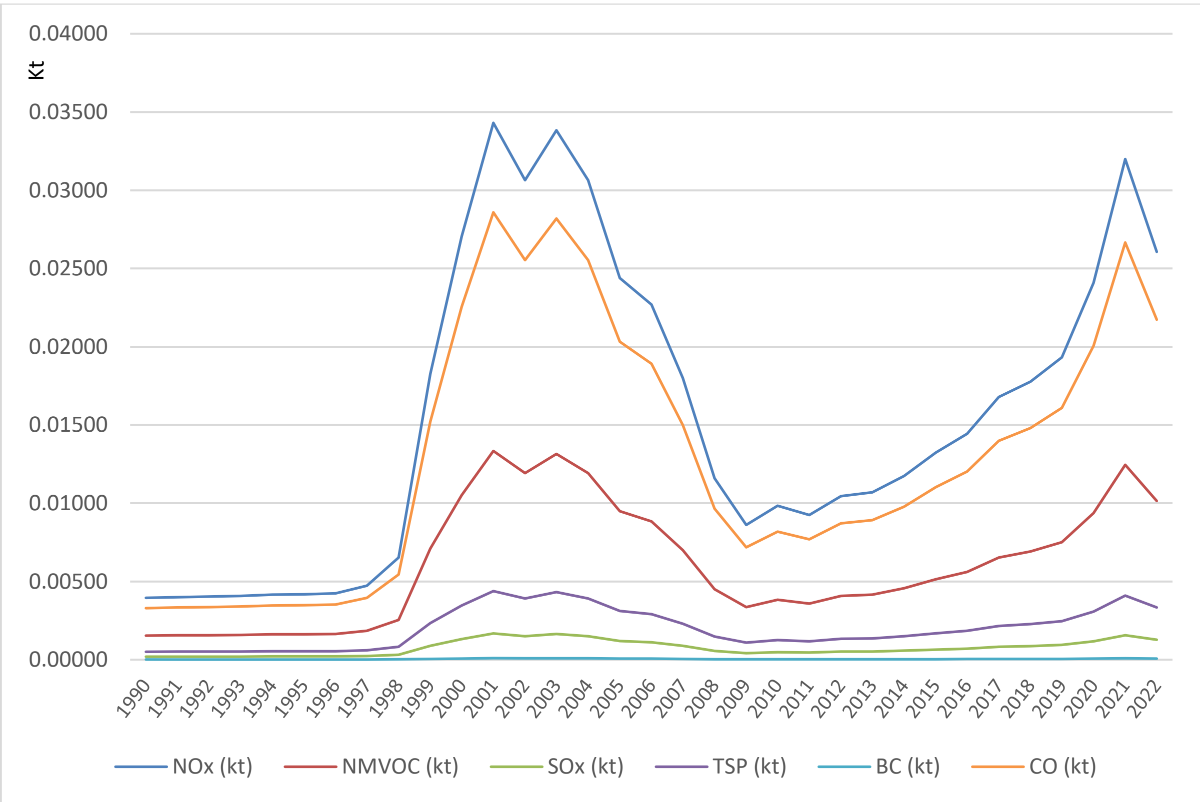


Figure 6.5.2 Trend Main Pollutants for 5.C.1.b.iii Clinical waste incineration (kt)

Emission trends for NOx, NMVOC, SOx, TSP, BC and CO follow the clinical waste incineration activity data trend.

Table 6.5.3 Emission trends Heavy Metals (*t for Pb, Cd, Hg, As, Cr, Cu, Ni*)
for NFR 5.C.1.b.iii Clinical waste incineration

Year	Pb (t)	Cd (t)	Hg (t)	As (t)	Cr (t)	Cu (t)	Ni (t)
1990	0.00079	0.00026	0.00356	0.00000	0.00004	0.00540	0.00066
1991	0.00080	0.00027	0.00360	0.00000	0.00004	0.00547	0.00067
1992	0.00081	0.00027	0.00362	0.00000	0.00004	0.00550	0.00067
1993	0.00082	0.00027	0.00368	0.00000	0.00004	0.00558	0.00068
1994	0.00083	0.00028	0.00374	0.00000	0.00004	0.00568	0.00069
1995	0.00084	0.00028	0.00376	0.00000	0.00004	0.00571	0.00070
1996	0.00085	0.00028	0.00381	0.00000	0.00004	0.00578	0.00071
1997	0.00095	0.00032	0.00427	0.00000	0.00004	0.00648	0.00079
1998	0.00131	0.00044	0.00588	0.00000	0.00006	0.00893	0.00109
1999	0.00365	0.00122	0.01644	0.00001	0.00016	0.02497	0.00304
2000	0.00541	0.00180	0.02435	0.00002	0.00024	0.03698	0.00451
2001	0.00686	0.00229	0.03088	0.00002	0.00030	0.04689	0.00572
2002	0.00613	0.00204	0.02758	0.00002	0.00027	0.04189	0.00511
2003	0.00677	0.00226	0.03044	0.00002	0.00030	0.04623	0.00564
2004	0.00613	0.00204	0.02758	0.00002	0.00027	0.04188	0.00511
2005	0.00488	0.00163	0.02195	0.00001	0.00022	0.03334	0.00407
2006	0.00454	0.00151	0.02043	0.00001	0.00020	0.03102	0.00378
2007	0.00360	0.00120	0.01619	0.00001	0.00016	0.02459	0.00300
2008	0.00232	0.00077	0.01044	0.00001	0.00010	0.01585	0.00193
2009	0.00172	0.00057	0.00776	0.00000	0.00008	0.01178	0.00144
2010	0.00197	0.00066	0.00885	0.00001	0.00009	0.01344	0.00164
2011	0.00185	0.00062	0.00831	0.00001	0.00008	0.01262	0.00154
2012	0.00209	0.00070	0.00941	0.00001	0.00009	0.01430	0.00174
2013	0.00214	0.00071	0.00962	0.00001	0.00010	0.01461	0.00178
2014	0.00235	0.00078	0.01057	0.00001	0.00010	0.01605	0.00196
2015	0.00265	0.00088	0.01191	0.00001	0.00012	0.01809	0.00221
2016	0.00289	0.00096	0.01299	0.00001	0.00013	0.01973	0.00241
2017	0.00336	0.00112	0.01511	0.00001	0.00015	0.02295	0.00280
2018	0.00355	0.00118	0.01599	0.00001	0.00016	0.02429	0.00296
2019	0.00386	0.00129	0.01738	0.00001	0.00017	0.02639	0.00322
2020	0.00482	0.00161	0.02167	0.00001	0.00021	0.03290	0.00401
2021	0.00640	0.00213	0.02880	0.00001	0.00028	0.04373	0.00533
2022	0.00522	0.00174	0.02347	0.00001	0.00023	0.03564	0.00435

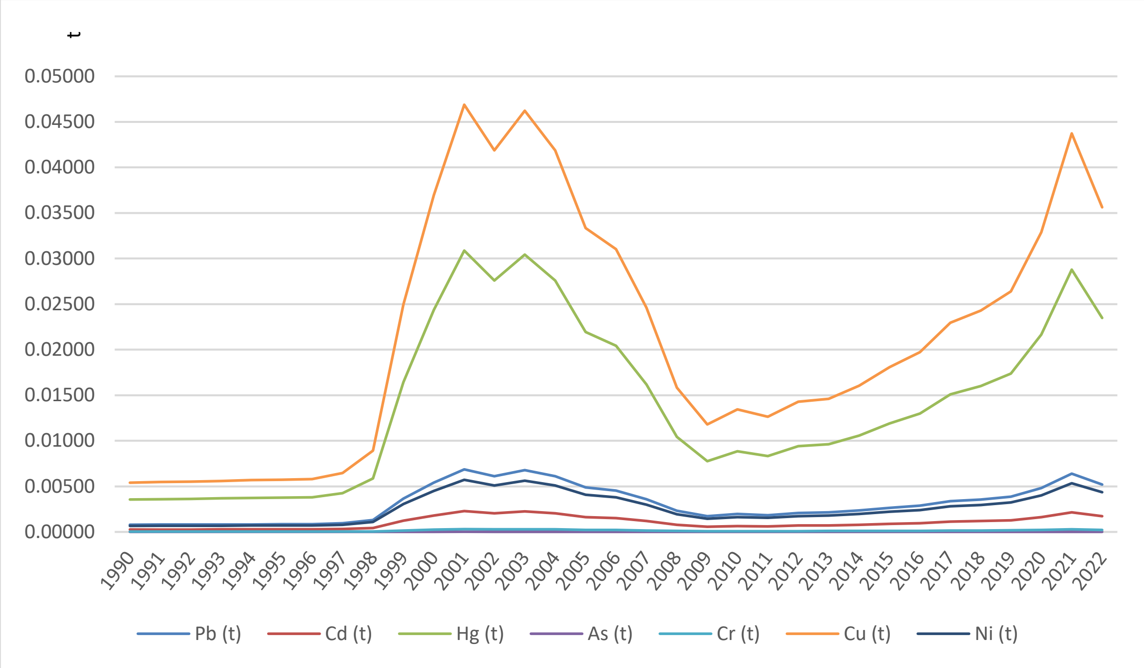


Figure 6.5.3 Trend Heavy Metals for 5.C.1.b.iii Clinical waste incineration (t)

Emission trends for Heavy Metals follow the clinical waste incineration activity data trend.

Table 6.5.4 Emission trends for POPs (*PCDD/PCDF (g I-TEQ), PAHs (t), HCB (kg)*
for NFR 5.C.1.b.iii Clinical waste incineration

Year	PCDD/PCDF (g I-TEQ)	PAHs (t)	HCB (kg)
1990	87.8510	0.000000088	0.2196
1991	88.8969	0.000000089	0.2222
1992	89.4919	0.000000089	0.2237
1993	90.7537	0.000000091	0.2269
1994	92.3279	0.000000092	0.2308
1995	92.9102	0.000000093	0.2323
1996	94.0400	0.000000094	0.2351
1997	105.3200	0.000000105	0.2633
1998	145.2000	0.000000145	0.3630
1999	405.9656	0.000000406	1.0149
2000	601.2400	0.000000601	1.5031
2001	762.3600	0.000000762	1.9059
2002	681.0636	0.000000681	1.7027
2003	751.6872	0.000000752	1.8792
2004	681.0564	0.000000681	1.7026
2005	542.0456	0.000000542	1.3551
2006	504.4580	0.000000504	1.2611
2007	27.9910	0.000000400	0.9997
2008	18.0376	0.000000258	0.6442
2009	13.4120	0.000000192	0.4790
2010	15.2924	0.000000218	0.5462
2011	14.3692	0.000000205	0.5132

Year	PCDD/PCDF (g I-TEQ)	PAHs (t)	HCB (kg)
2012	16.2708	0.000000232	0.5811
2013	16.6348	0.000000238	0.5941
2014	18.2700	0.000000261	0.6525
2015	20.5856	0.000000294	0.7352
2016	22.4560	0.000000321	0.8020
2017	26.1240	0.000000373	0.9330
2018	27.6434	0.000000395	0.9873
2019	30.0409	0.000000429	1.0729
2020	37.4500	0.000000535	1.3375
2021	49.7812	0.000000711	1.7779
2022	40.5636	0.000000579	1.4487

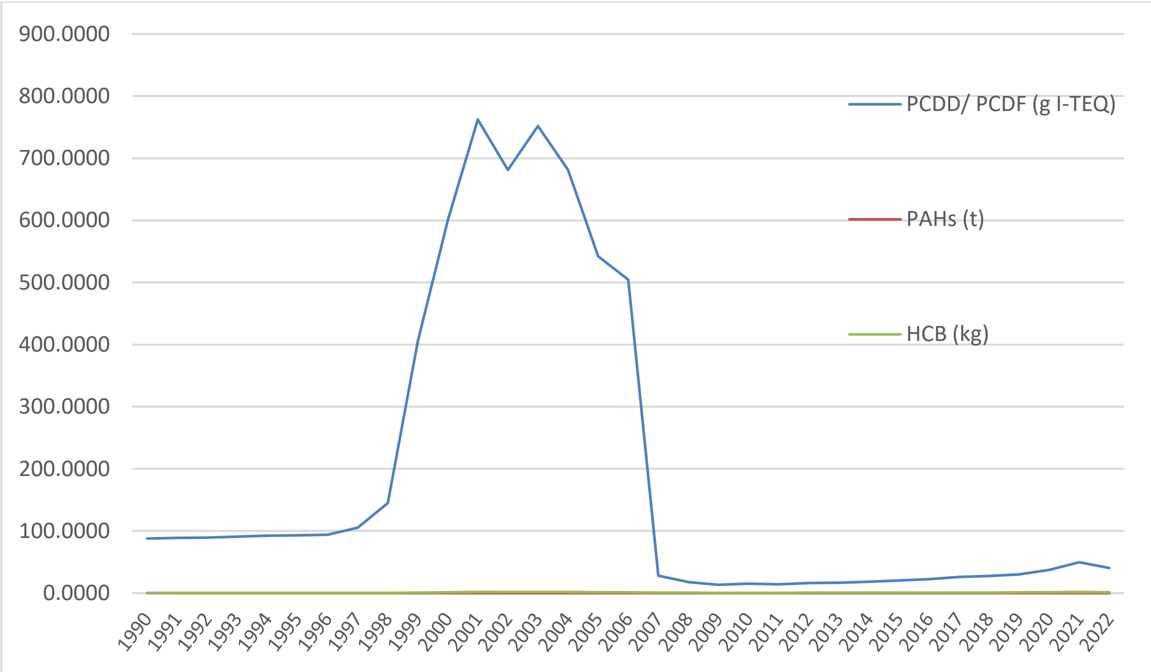


Figure 6.5.4 Trend POPs for 5.C.1.b.iii Clinical waste incineration

Emission trends for POPs follow the clinical waste incineration activity data trend.

PCDD/F emissions from this category are the key source, representing 21.8% of the total national emissions of PCDD/F in 2022.

HCB emissions from this category are the key source, representing 46.2% of the total national emissions of HCBs in 2022.

Recalculations and improvements:
- There were no recalculations and improvements for this category.

6.6 NFR 5.C.1.b.v Cremation

This chapter covers the atmospheric emissions from the incineration of human bodies in a crematorium.

Romania is a predominantly Christian-Orthodox country and according to the tradition and the Romanian Christian Church, the dead human bodies are buried; there are few incinerated human bodies (there are only 3 Human Crematoriums) The contribution of crematoria to national emissions is comparatively small for all pollutants.

The emissions for NFR 5.C.1.b.v were calculated using the 2019 Guidebook EMEP/EEA Tier 1 Table 3-1.

Emissions are calculated based on Tier 1 applying the general equation:

Epollutant = ARproduction × EFpollutant

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate (number corpses);
- EFpollutant is the emission factor for each pollutant.

The emission factors used to calculate NOx, NMVOC, $PM_{2.5}$, PM_{10}, TSP, CO, Heavy Metals, POPs, (PCDD/F, HCB, PCBs) emissions are from the 2019 EMEP/EEA, Guidebook, Tier1, Table 3-1.

Activity data represents the number of human bodies incinerated per year (the activity data were obtained from the 3 Human Crematoriums in Romania).

Table 6.6.1 Activity data trends (*number*) for NFR 5.C.1.v Cremation

Year/Activity data	Corpses (number)
1990	1408
1991	1577
1992	1636
1993	1659
1994	1445
1995	1410
1996	1434
1997	1394
1998	1200
1999	1195
2000	1170
2001	1073
2002	1121

Year/Activity data	Corpses (number)
2003	1002
2004	884
2005	820
2006	862
2007	796
2008	776
2009	788
2010	853
2011	854
2012	883
2013	941
2014	1041
2015	1322
2016	1588
2017	1848
2018	2116
2019	2368
2020	2644
2021	2791
2022	2430

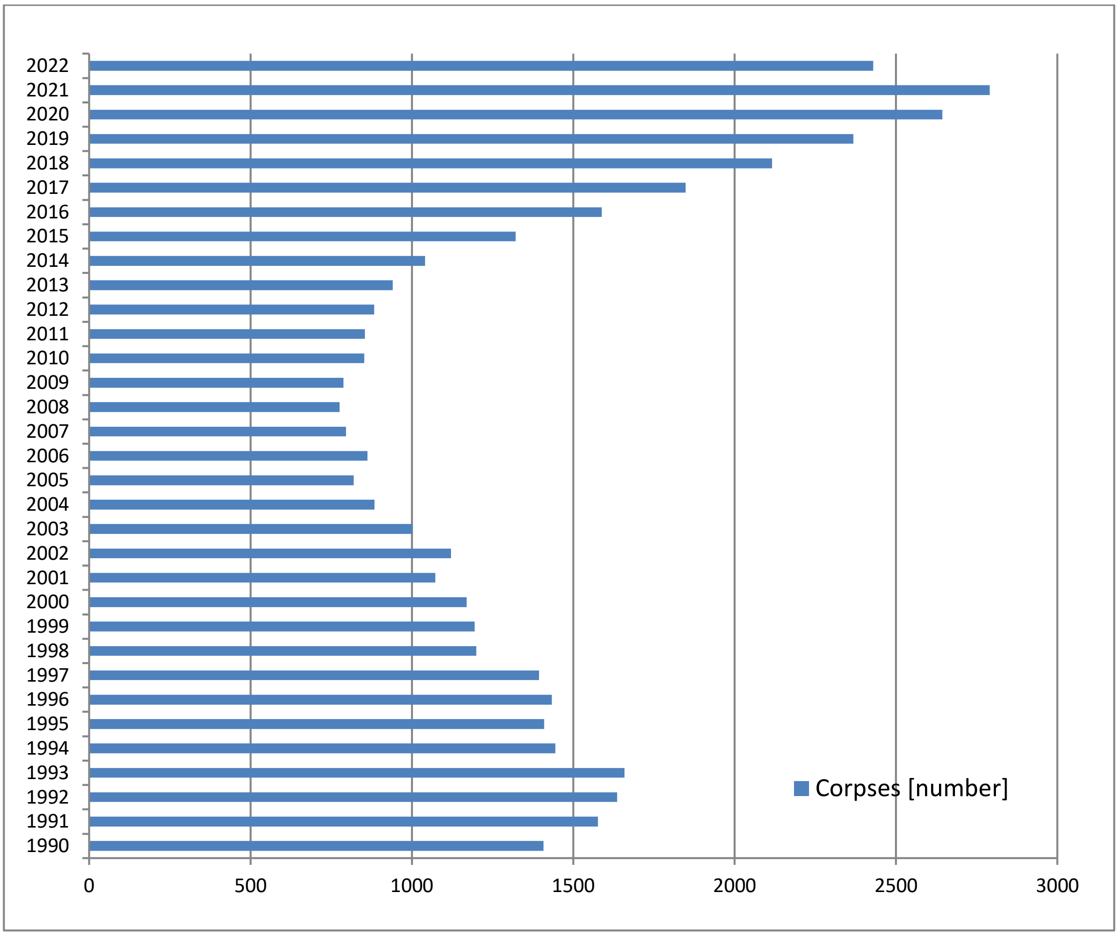


Figure 6.6.1 Activity data trends (*number corpses*) for NFR 5.C.1.b.v Cremation

Table 6.6.2. Emission trends *Kt for NOx, NMVOC, SOx, $PM_{2.5}$ and Hg (t))* for NFR 5.C.1.b.v Cremation

Year	NOx (kt)	NMVOC (kt)	SOx_5 (kt)	$PM_{2.5}$ (kt)	Hg (t)
1990	0.00116	0.00002	0.00016	0.00005	0.00210
1991	0.00130	0.00002	0.00018	0.00005	0.00235
1992	0.00135	0.00002	0.00018	0.00006	0.00244
1993	0.00137	0.00002	0.00019	0.00006	0.00247
1994	0.00119	0.00002	0.00016	0.00005	0.00215
1995	0.00116	0.00002	0.00016	0.00005	0.00210
1996	0.00118	0.00002	0.00016	0.00005	0.00214
1997	0.00115	0.00002	0.00016	0.00005	0.00208
1998	0.00099	0.00002	0.00014	0.00004	0.00179
1999	0.00099	0.00002	0.00014	0.00004	0.00178
2000	0.00097	0.00002	0.00013	0.00004	0.00174
2001	0.00089	0.00001	0.00012	0.00004	0.00160
2002	0.00092	0.00001	0.00013	0.00004	0.00167
2003	0.00083	0.00001	0.00011	0.00003	0.00149
2004	0.00073	0.00001	0.00010	0.00003	0.00132
2005	0.00068	0.00001	0.00009	0.00003	0.00122
2006	0.00071	0.00001	0.00010	0.00003	0.00128
2007	0.00066	0.00001	0.00009	0.00003	0.00119
2008	0.00064	0.00001	0.00009	0.00003	0.00116
2009	0.00065	0.00001	0.00009	0.00003	0.00117
2010	0.00070	0.00001	0.00010	0.00003	0.00127
2011	0.00070	0.00001	0.00010	0.00003	0.00127
2012	0.00073	0.00001	0.00010	0.00003	0.00132
2013	0.00078	0.00001	0.00011	0.00003	0.00140
2014	0.00086	0.00001	0.00012	0.00004	0.00155
2015	0.00109	0.00002	0.00015	0.00005	0.00197
2016	0.00131	0.00002	0.00018	0.00006	0.00237
2017	0.00152	0.00002	0.00021	0.00006	0.00275
2018	0.00175	0.00003	0.00024	0.00007	0.00315
2019	0.00195	0.00003	0.00027	0.00008	0.00353
2020	0.00218	0.00003	0.00030	0.00009	0.00394
2021	0.00230	0.00003	0.00031	0.00009	0.00415
2022	0.00200	0.00003	0.00027	0.00008	0.00362

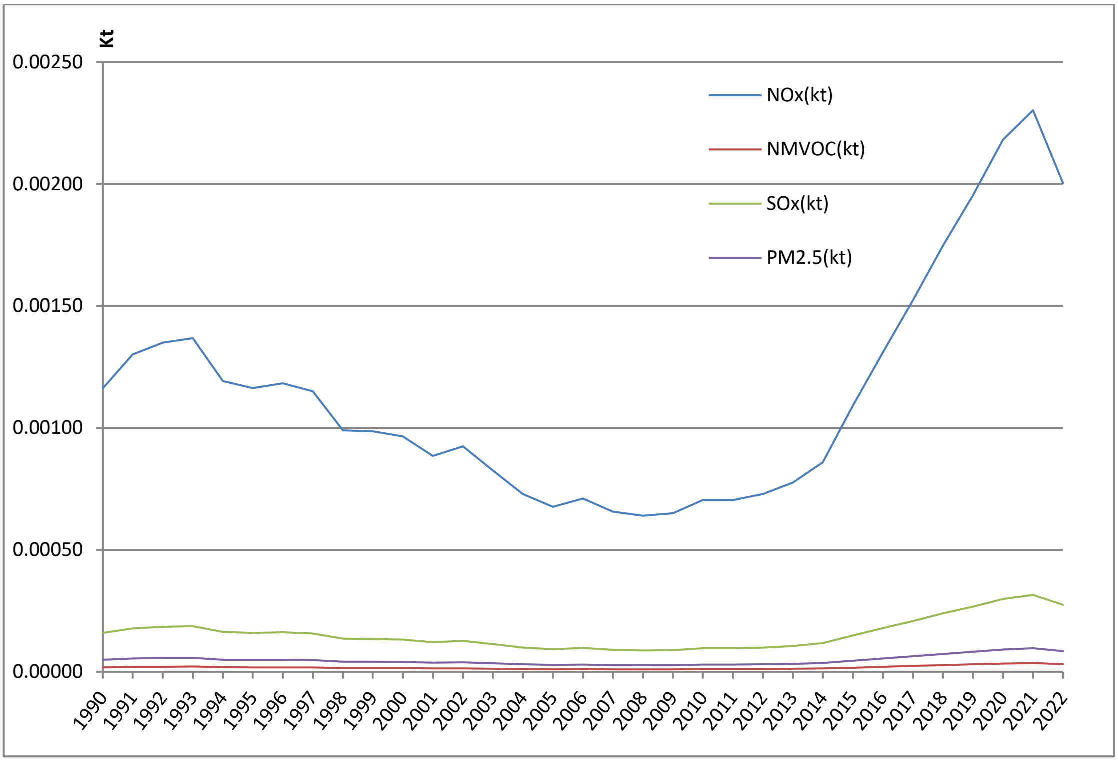


Figure 6.6.2.a. Emission trends (*Kt for NOx, NMVOC, $PM_{2.5}$ and SOx*) for NFR 5.C.1.b.v Cremation

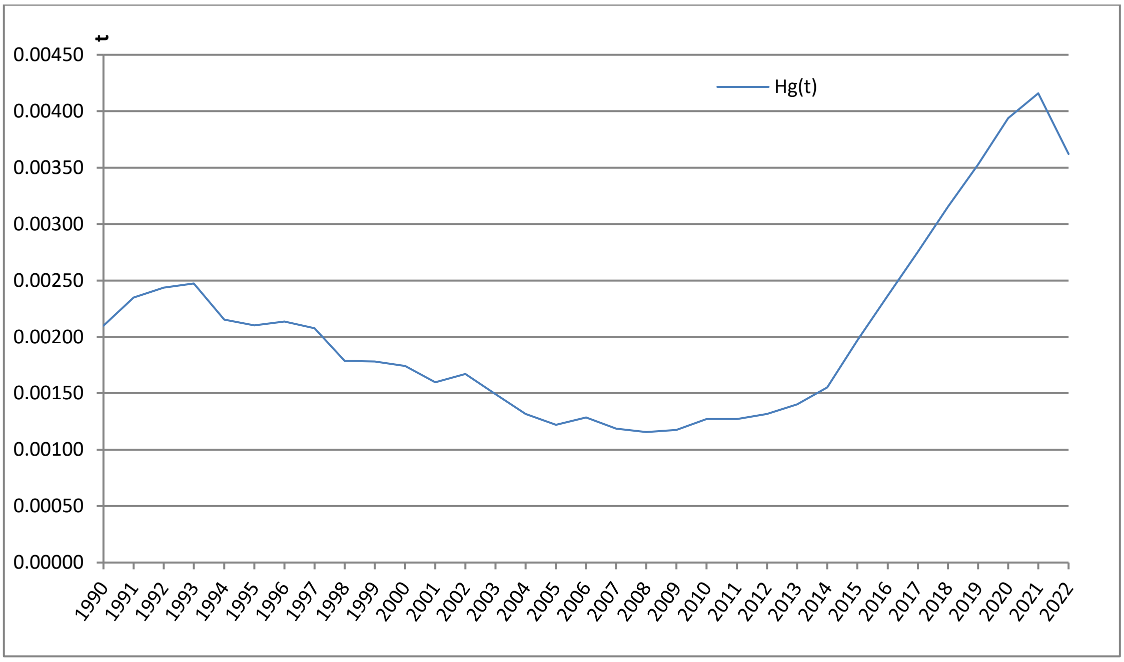


Figure 6.6.2.b. Emission trends (*t for Hg,*) for NFR 5.C.1.b.v Cremation

The contribution of crematoria to national emissions is comparatively small for all pollutants.

There were no recalculations and improvements for this category.

6.7 NFR 5.C.2 Open Burning of Waste

This activity covers emissions from open burning of agricultural waste.

Activity data represents the amount of (agricultural) waste burned.

In Romania, it is forbidden to burn forest waste (*Law 211/2011 and OUG 92/2021 Burning any type of waste and/or substance or object is prohibited, constitutes a crime and is punishable by law.)*

Residues from clearing / cutting trees from the forest fund (forests, plantations) public or private property or from orchards are considered by-products that can be transformed into pellets or briquettes that are used as fuel for heating.

The methodology used to obtain the amount of (agricultural) waste burned is to the 2019 Guidebook EMEP/EEA.

The area cultivated with cereals (ha) was obtained from N.I.S. (statistical crops production).

The average amount of waste burned for arable farmland is estimated to be 25 kg/ha (the 2019 Guidebook EMEP/EEA).

The methodology used to derive the amount of (agricultural) waste burned:

The area cultivated with cereals (ha) x 25kg/ha = the amount of waste burned (kg).

The emissions for NFR 5.C.2 were calculated using the 2019 Guidebook EMEP/EEA Tier 1 Table 3-1.

Emissions are calculated based on Tier 1 applying the general equation:

$E_{pollutant} = AR_{production} \times EF_{pollutant}$

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate (amount of waste burned);
- EFpollutant is the emission factor for each pollutant.

The emission factors used to calculate the emissions are from the 2019 EMEP/EEA Guidebook, Tier 1, Table 3-1.

Table 6.7.1 Activity data trends (*kt product*) for NFR 5.C.2 Small scale waste burning

Year	Amount of waste burned (kt)
1990	142.60
1991	151.22
1992	144.35
1993	159.87
1994	163.94
1995	161.12
1996	146.07
1997	157.99
1998	148.01
1999	134.27
2000	141.38
2001	157.37
2002	150.95
2003	138.55
2004	156.63
2005	146.64
2006	127.86
2007	128.23
2008	130.27
2009	132.06
2010	126.02
2011	130.62
2012	136.01
2013	135.53
2014	136.08
2015	136.71
2016	137.17
2017	129.81
2018	131.43
2019	139.23
2020	133.45
2021	133.79
2022	129.60

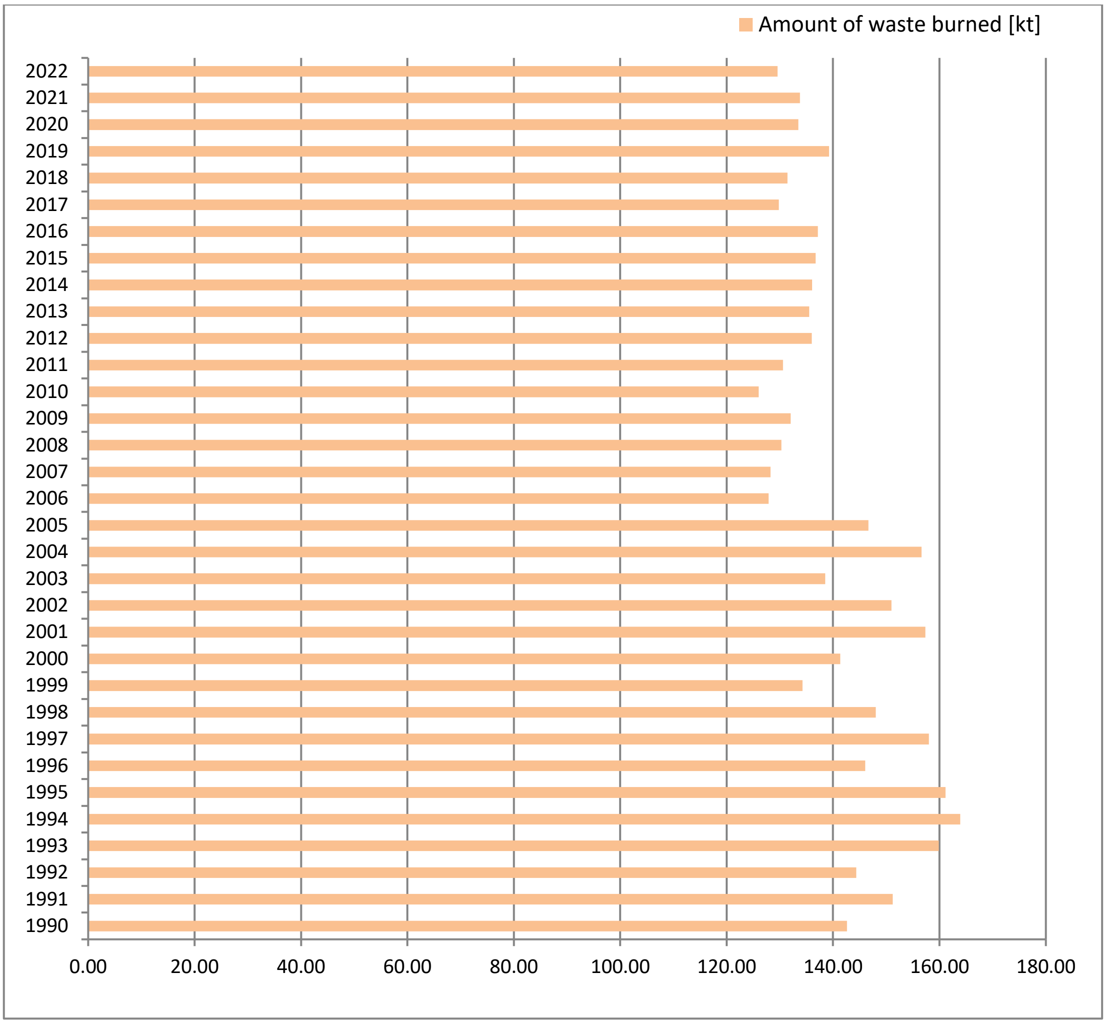


Figure 6.7.1 Activity data trends (*kt product*) for NFR 5.C.2 Small scale waste burning

Table 6.7.2 Emission trends (*kt for NOx, NMVOC, $PM_{2.5}$ and PM_{10}, g I-TEQfor PCDD/F and t for Total PAHs*) for NFR 5.C.2 Small scale waste burning

Year	NOx (kt)	NMVOC (kt)	$PM_{2.5}$ (kt)	PM_{10} (kt)	PCDD/F (g I-TEQ)	Total PAHs (t)
1990	0.453	0.175	0.597	0.643	1.426	0.009
1991	0.481	0.186	0.634	0.682	1.512	0.009
1992	0.459	0.178	0.605	0.651	1.443	0.009
1993	0.508	0.197	0.670	0.721	1.599	0.010
1994	0.521	0.202	0.687	0.739	1.639	0.010
1995	0.512	0.198	0.675	0.727	1.611	0.010
1996	0.465	0.180	0.612	0.659	1.461	0.009
1997	0.502	0.194	0.662	0.713	1.580	0.010
1998	0.471	0.182	0.620	0.668	1.480	0.009
1999	0.427	0.165	0.563	0.606	1.343	0.008
2000	0.450	0.174	0.592	0.638	1.414	0.009
2001	0.500	0.194	0.659	0.710	1.574	0.010
2002	0.480	0.186	0.632	0.681	1.510	0.009
2003	0.441	0.170	0.581	0.625	1.385	0.008
2004	0.498	0.193	0.656	0.706	1.566	0.010
2005	0.466	0.180	0.614	0.661	1.466	0.009
2006	0.407	0.157	0.536	0.577	1.279	0.008

Year	NOx (kt)	NMVOC (kt)	$PM_{2.5}$ (kt)	PM_{10} (kt)	PCDD/F (g I-TEQ)	Total PAHs (t)
2007	0.408	0.158	0.537	0.578	1.282	0.008
2008	0.414	0.160	0.546	0.588	1.303	0.008
2009	0.420	0.162	0.553	0.596	1.321	0.008
2010	0.401	0.155	0.528	0.568	1.260	0.008
2011	0.415	0.161	0.547	0.589	1.306	0.008
2012	0.433	0.167	0.570	0.613	1.360	0.008
2013	0.431	0.167	0.568	0.611	1.355	0.008
2014	0.433	0.167	0.570	0.614	1.361	0.008
2015	0.435	0.168	0.573	0.617	1.367	0.008
2016	0.436	0.169	0.575	0.619	1.372	0.008
2017	0.413	0.160	0.544	0.585	1.298	0.008
2018	0.418	0.162	0.551	0.593	1.314	0.008
2019	0.443	0.171	0.583	0.628	1.392	0.008
2020	0.424	0.164	0.559	0.602	1.335	0.008
2021	0.425	0.165	0.561	0.603	1.338	0.008
2022	0.412	0.159	0.543	0.584	1.296	0.008

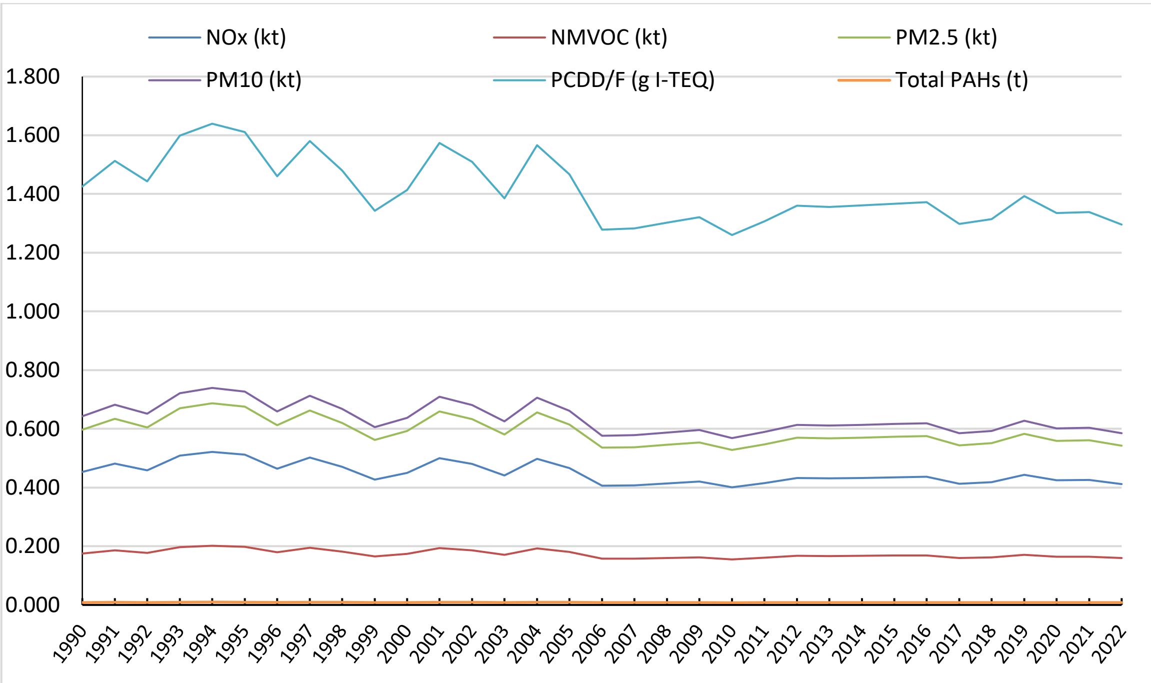


Figure 6.7.2 Emission trends (*kt for NOx, NMVOC, $PM_{2.5}$ and PM_{10}, g I-TEQ for PCDD/F and t for Total PAHs*) for NFR 5.C.2 Small scale waste burning

The emissions from this category (NMVOC, $PM_{2.5}$, PM_{10}, PCDD/F and Total PAHs) follow the activity data trend of NFR 5.C.2. Open Burning of Waste.

Recalculations and improvements:

There were no recalculations and improvements for this category.

6.8 NFR 5.D.3 Wastewater handling Latrines

Activities from NFR 5.D.3 includes SNAP 0910 - water handling and SNAP 091007-latrines.

The pollutant emissions have been estimated: NMVOC for NFR 5.D.3.-water handling and NH_3 for NFR 5.D.3. - latrines.

NFR 5.D.3. - SNAP 0910 - water handling

The emissions were calculated based on Tier 1 methodology applying the general equation:

Epollutant = ARproduction× EFpollutant

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate (total water handling in 1000mc);
- EFpollutant is the emission factor for this pollutant.

The emission factors used to calculate the NMVOC emissions are from the 2019 EMEP/EEA Guidebook, Tier 1, Table 3-1.

The activity data is represented by the water handling taken from the A.N.A.R. (for 1990 - 1993 period the A.N.A.R does not have any information).

NFR 5.D.3. - SNAP 091007 - latrines

The emissions are calculated based on the Tier 2 methodology applying the general equation:

Epollutant = ARproduction× EFpollutant

where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate (latrines);
- EFpollutant is the emission factor for this pollutant.

The emission factors used to calculate the NH_3 emissions are from the 2019 EMEP/EEA Guidebook, Tier 2, Table 3-1.

The activity data for NFR 5.D.3. – latrines represent the rural population using latrines. The activity data were calculated using as working algorithm the rural population to which a percentage representing the households with a sanitary group was applied. For the period 1990-2007, linear interpolation was done.

Statistical data on the rural population and rural households with sanitation are estimated using statistical data from the N.I.S. sanitary installation (data obtained from National Institute of Statistics N.I.S)

The NFR 5.D.1. Domestic wastewater handling was assimilated with the SNAP 091007-Latrines and was included under NFR 5.D.3 Other wastewater handling Latrines.

The NFR 5.D.2. Industrial wastewater handling was assimilated with the SNAP 0910-wastewater handling and included under NFR 5.D.3 Other wastewater handling Latrines.

Table 6.8.1 Activity data trends (*waste water handling -1000 m^3*)
for NFR 5.D.3 Wastewater handling

Year	*Waste water handling [1000m3]*
1993	2600160.00
1994	2094070.00
1995	1976470.00
1996	1996000.00
1997	3137220.00
1998	2050930.00
1999	2092970.00
2000	2020840.00
2001	1679670.00
2002	2031810.00
2003	1559910.00
2004	1484200.00
2005	1432288.00
2006	1230988.00
2007	1417751.00
2008	1249768.00
2009	1394457.00
2010	1291500.00
2011	1471220.00
2012	1577620.00
2013	1977613.00
2014	1581360.13
2015	1578513.36
2016	1619318.61
2017	2146200.00
2018	2151350.00
2019	2188540.00
2020	1553760.00
2021	1673350.00
2022	1630360.00

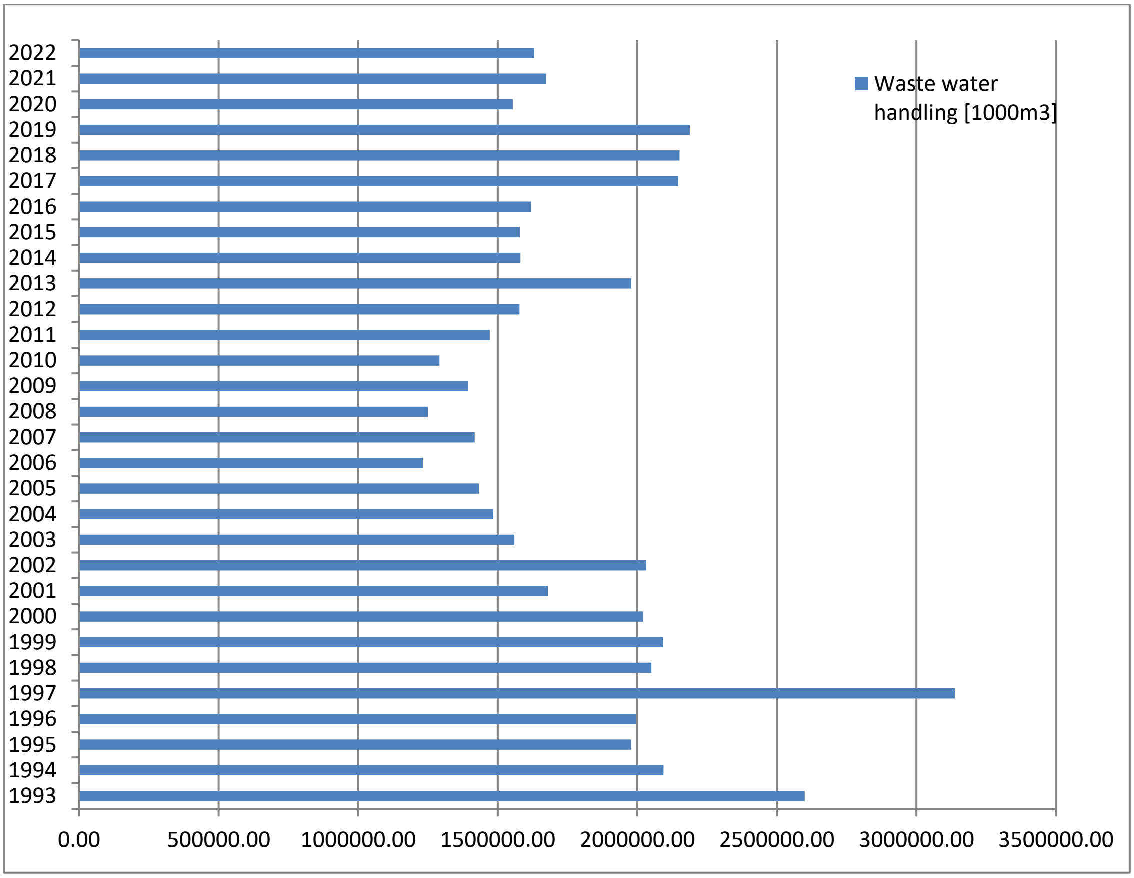


Figure 6.8.1 Activity data trends (*water handling 1000 m^3*) for NFR 5.D.3 Wastewater handling

Table 6.8.2 Emission trends *(kt for NMVOC*) for NFR 5.D.3 Wastewater handling

Year	NMVOC (kt)
1993	0.039
1994	0.031
1995	0.030
1996	0.030
1997	0.047
1998	0.031
1999	0.031
2000	0.030
2001	0.025
2002	0.030
2003	0.023
2004	0.022
2005	0.021
2006	0.018
2007	0.021
2008	0.019
2009	0.021
2010	0.019
2011	0.022
2012	0.024
2013	0.030
2014	0.024
2015	0.024
2016	0.024

Year	NMVOC (kt)
2017	0.032
2018	0.032
2019	0.033
2020	0.023
2021	0.025
2022	0.024

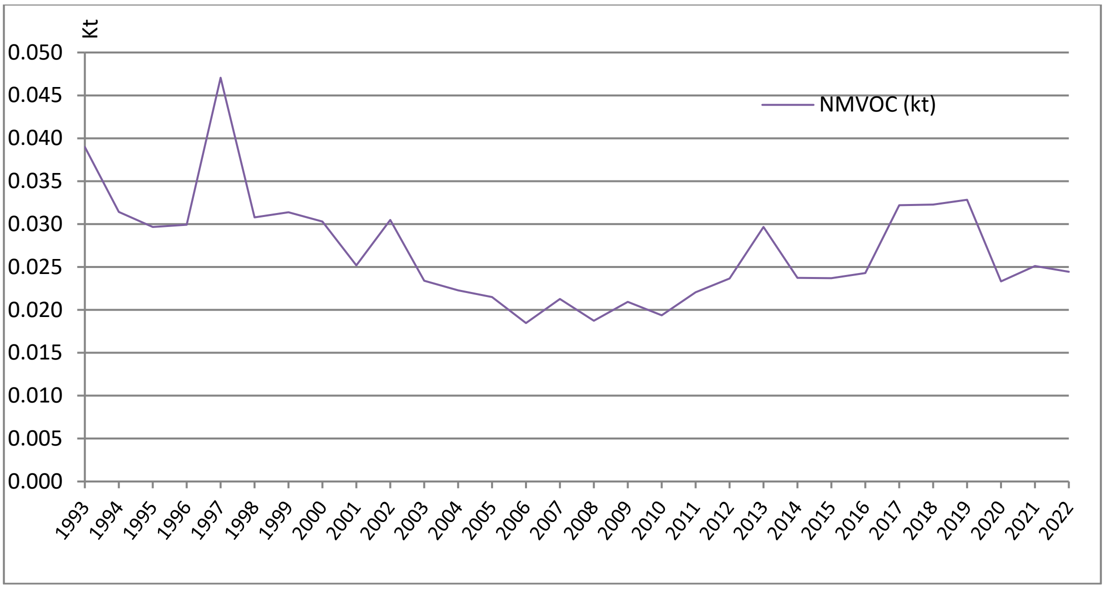


Figure 6.8.2 Emission trends (*kt for NMVOC*) for NFR 5.D.3 Wastewater handling

The NMVOC emissions from NFR 5.D.3 - wastewater handling follow the activity data trend.

Table 6.8.3 Activity data trends (*caput*) for NFR 5.D.3 Wastewater handling-Latrines

Year/Activity data	*Latrines [caput]*
1990	9626727
1991	9538798
1992	9450869
1993	9362940
1994	9275011
1995	9187081
1996	9099152
1997	9011223
1998	8923294
1999	8835365
2000	8747436
2001	8659507
2002	8571578
2003	8483649
2004	8395720
2005	8307791
2006	8219862
2007	8131933

Year/Activity data	*Latrines [caput]*
2008	7826069
2009	7866196
2010	7663854
2011	7309167
2012	6988721
2013	6679662
2014	6437036
2015	6296871
2016	6057444
2017	5611492
2018	5148297
2019	4646982
2020	4334978
2021	3921941
2022	3367672

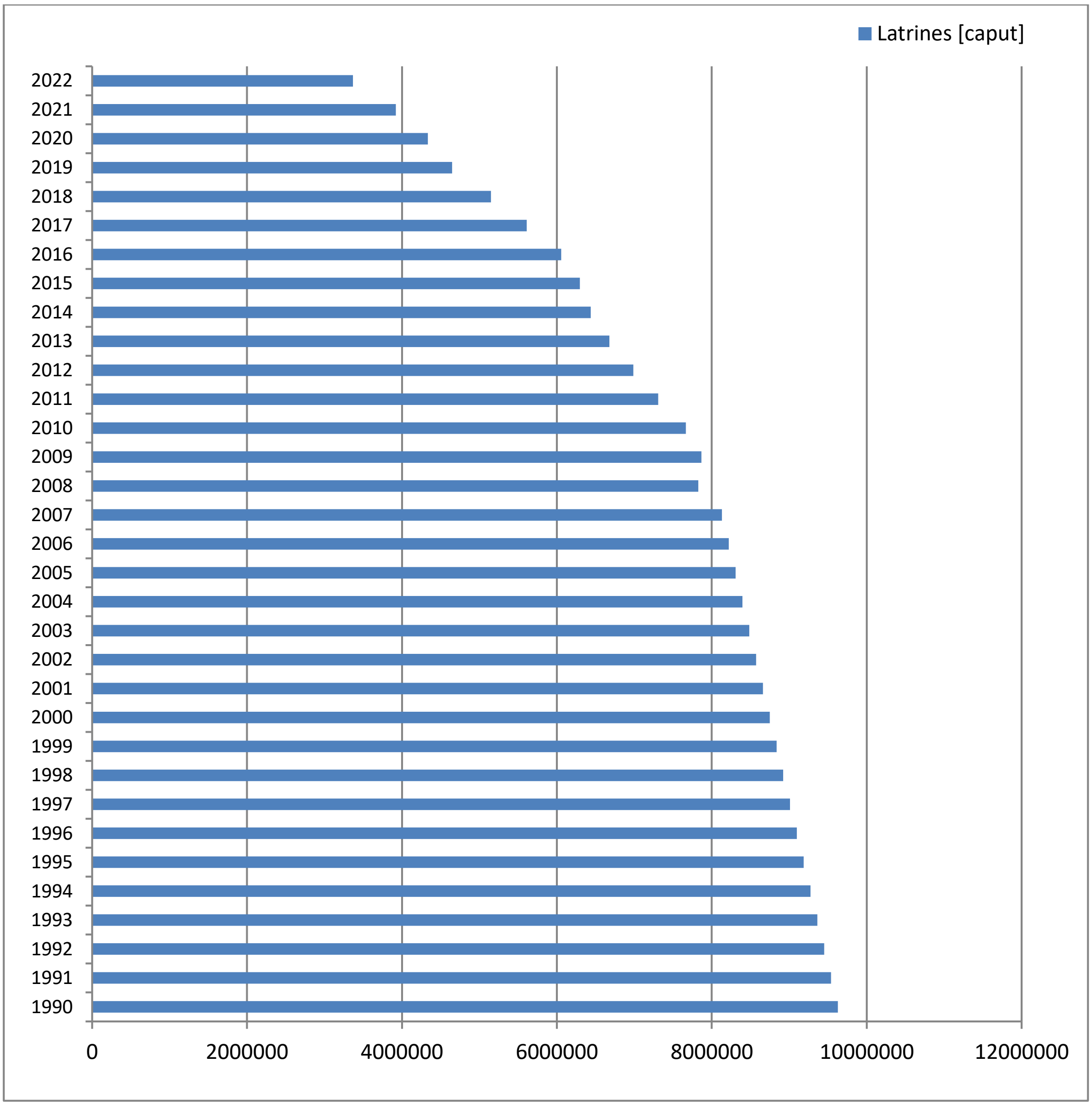


Figure 6.8.3 Activity data trends (*caput*) for NFR 5.D.3 Wastewater handling-Latrines

Table 6.8.4 Emission trends (*kt for NH_3*) for NFR 5.D.3 Wastewater handling-Latrines

Year/Pollutant	NH_3 (kt)
1990	15.403
1991	15.262
1992	15.121
1993	14.981
1994	14.840
1995	14.699
1996	14.559
1997	14.418
1998	14.277
1999	14.137
2000	13.996
2001	13.855
2002	13.715
2003	13.574
2004	13.433
2005	13.292
2006	13.152
2007	13.011
2008	12.522
2009	12.586
2010	12.262
2011	11.695
2012	11.182
2013	10.687
2014	10.299
2015	10.075
2016	9.692
2017	8.978
2018	8.237
2019	7.435
2020	6.936
2021	6.275
2022	5.388

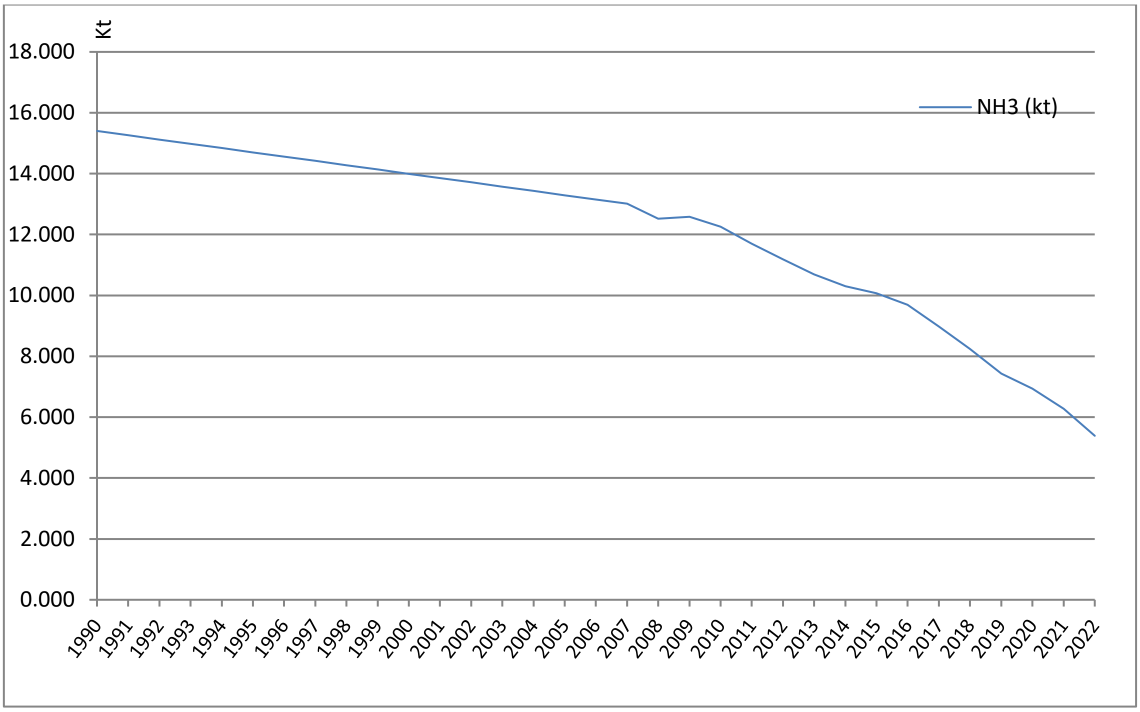


Figure 6.8.4 Emission trends (*kt for NH_3*) for NFR 5.D.3 Wastewater handling-Latrines

The NH_3 emissions from NFR 5.D.3. – latrines, decreased compared to 1990 emission data and follow the activity data trend.
Recalculations and improvements:

There were no recalculations and improvements for this category.

6.9 NFR 5.E. Other Waste (car fires and house fires)

The source category other waste NFR 5.E. covers the emissions from the activities for car fires and house fires. Car and house fires include mostly unwanted fires in cars and various type of house. Types of fires house that are covered are: detached house fire (represents 40% of the house fires), non-detached house fire (represents 5% of the house fires), apartment building fire (represents 33% of the house fires) and industrial building fire (represents 22% of the house fires). Activity data were obtained from the fire statistics by CTIF (Centre of Fire Statistics) - Report – World Fire Statistics and IGSU (Romanian General Inspectorate for Emergency Situations – structure subordinated to the Ministry of Internal Affairs).

The Tier 2 EMEP/EEA methodology and recommended Tier 2 emissions factor from Guidebook 2019 are used for emission calculation.

The emissions are calculated based on the Tier 2 methodology applying the general equation:

Epollutant = ARproduction× EFpollutant where:

- Epollutant is the emission of the specified pollutant;
- ARproduction is the activity rate;
- EFpollutant is the emission factor for this pollutant.

The emission factors used to calculate the $PM_{2.5}$, PM_{10}, TSP, Pb, Cd, Hg, As, Cr, Cu, PCDD/F emissions are from the 2019 EMEP/EEA Guidebook, Tier 2, Table 3-2 (for “car fire”), Table 3-3 (for “detached house fire”), Table 3-4 (for “non-detached house”), Table 3-5 (for “apartment building fire”), Table 3-6 (for “industrial building fire”).

Table 6.9.1 Activity data trends (*no. of fire for Car fire and House fire*) for NFR 5.E. Other waste

Year	Car fire (no. of fire)	House fire (no. of fires)
1995	787	3191
1996	839	5483
1997	2617	3816
1998	3717	3246
1999	919	7226
2000	1119	4995
2001	993	4017
2002	900	4552
2003	912	3631
2004	944	3650
2005	1030	2981
2006	930	3020
2007	1392	1952
2008	1796	7975
2009	1075	5235
2010	1848	7150
2011	1362	11633
2012	1399	13334
2013	1246	6035
2014	1255	6047
2015	1744	2402
2016	1955	2976
2017	1998	6914
2018	1964	6911
2019	1575	11814
2020	1344	11214
2021	1899	11350
2022	1843	11533

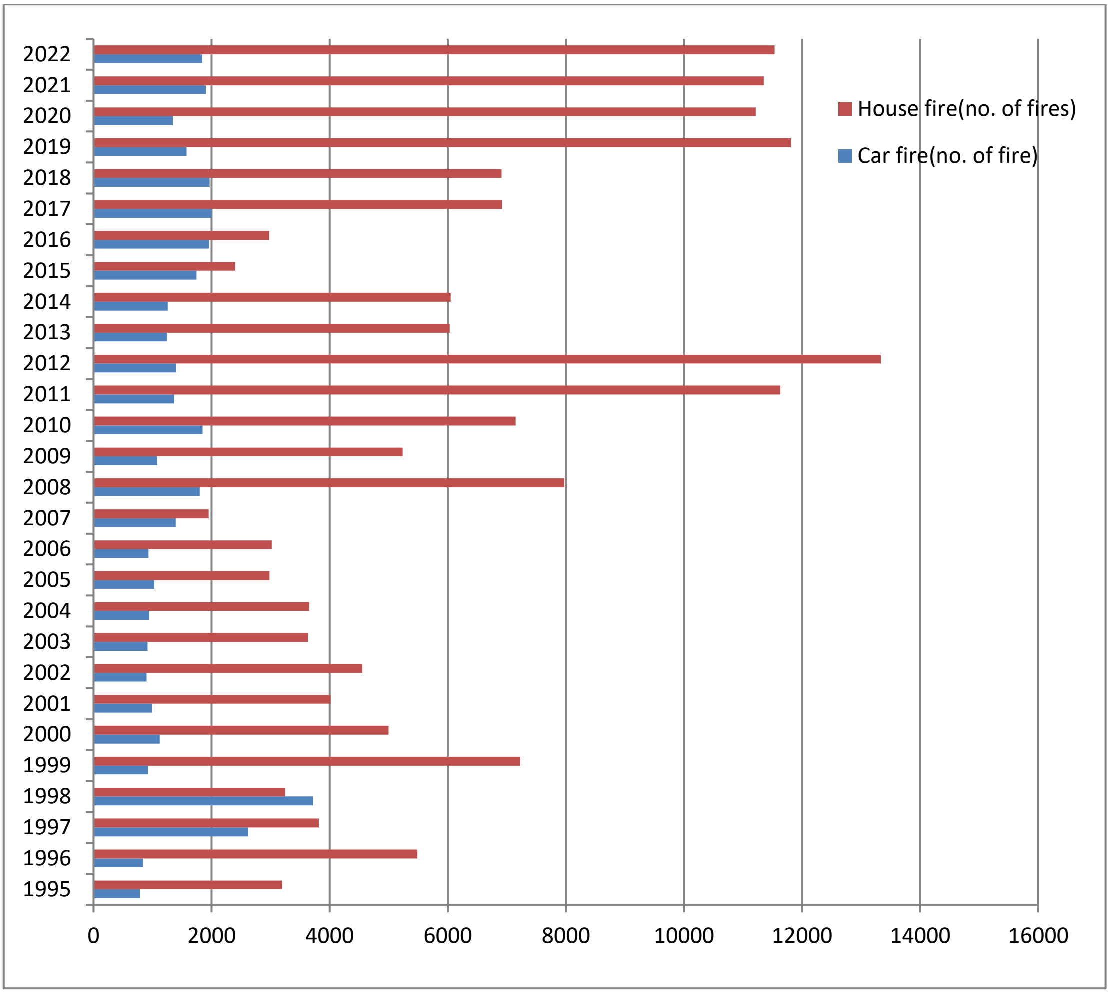


Figure 6.9.1 Activity data trends (*no. of fire*) for NFR 5.E. Other waste (car fire and house fire)

Table 6.9.2 Emission trends for NFR 5.E. Other waste (car fire and house fire)

Year/Pollutant	$PM_{2.5}$ [kt]	Pb [t]	Cd [t]	Hg [t]	As [t]	Cr[t]	Cu [t]	PCDD/F (g I-TEQ)
1995	0.2604	0.0008	0.0015	0.0015	0.0024	0.0023	0.0054	2.6276
1996	0.4463	0.0013	0.0026	0.0026	0.0042	0.0040	0.0092	4.4903
1997	0.3153	0.0009	0.0018	0.0018	0.0029	0.0028	0.0064	3.2227
1998	0.2716	0.0008	0.0016	0.0016	0.0025	0.0024	0.0055	2.8129
1999	0.5878	0.0017	0.0035	0.0035	0.0055	0.0052	0.0122	5.9087
2000	0.4074	0.0012	0.0024	0.0024	0.0038	0.0036	0.0084	4.1077
2001	0.3278	0.0010	0.0019	0.0019	0.0031	0.0029	0.0068	3.3079
2002	0.3710	0.0011	0.0022	0.0022	0.0035	0.0033	0.0077	3.7376
2003	0.2964	0.0009	0.0017	0.0017	0.0028	0.0026	0.0061	2.9907
2004	0.2980	0.0009	0.0017	0.0017	0.0028	0.0026	0.0062	3.0077
2005	0.2440	0.0007	0.0014	0.0014	0.0023	0.0022	0.0050	2.4688
2006	0.2469	0.0007	0.0014	0.0014	0.0023	0.0022	0.0051	2.4957
2007	0.1614	0.0005	0.0009	0.0009	0.0015	0.0014	0.0033	1.6511
2008	0.6505	0.0019	0.0038	0.0038	0.0061	0.0058	0.0134	6.5587

Year/Pollutant	$PM_{2.5}$ [kt]	Pb [t]	Cd [t]	Hg [t]	As [t]	Cr[t]	Cu [t]	PCDD/F (g I-TEQ)
2009	0.4268	0.0012	0.0025	0.0025	0.0040	0.0038	0.0088	4.3003
2010	0.5837	0.0017	0.0034	0.0034	0.0054	0.0052	0.0121	5.8916
2011	0.9460	0.0028	0.0056	0.0056	0.0088	0.0084	0.0196	9.5067
2012	1.0839	0.0032	0.0064	0.0064	0.0101	0.0097	0.0225	10.8890
2013	0.4920	0.0014	0.0029	0.0029	0.0046	0.0044	0.0102	4.9578
2014	0.4930	0.0014	0.0029	0.0029	0.0046	0.0044	0.0102	4.9680
2015	0.1987	0.0006	0.0012	0.0012	0.0018	0.0017	0.0040	2.0332
2016	0.2457	0.0007	0.0014	0.0014	0.0023	0.0022	0.0050	2.5092
2017	0.5650	0.0016	0.0033	0.0033	0.0052	0.0050	0.0117	5.7073
2018	0.5646	0.0016	0.0033	0.0033	0.0052	0.0050	0.0116	5.7032
2019	0.9611	0.0028	0.0057	0.0057	0.0090	0.0086	0.0199	9.6638
2020	0.9119	0.0026	0.0053	0.0053	0.0085	0.0081	0.0189	9.1657
2021	0.9242	0.0026	0.0054	0.0054	0.0086	0.0082	0.0191	9.3028
2022	0.9390	0.0027	0.0055	0.0055	0.0088	0.0084	0.0194	9.4486

Emission trends for $PM_{2.5}$ follow the activity data (car fires and house fires) trend.

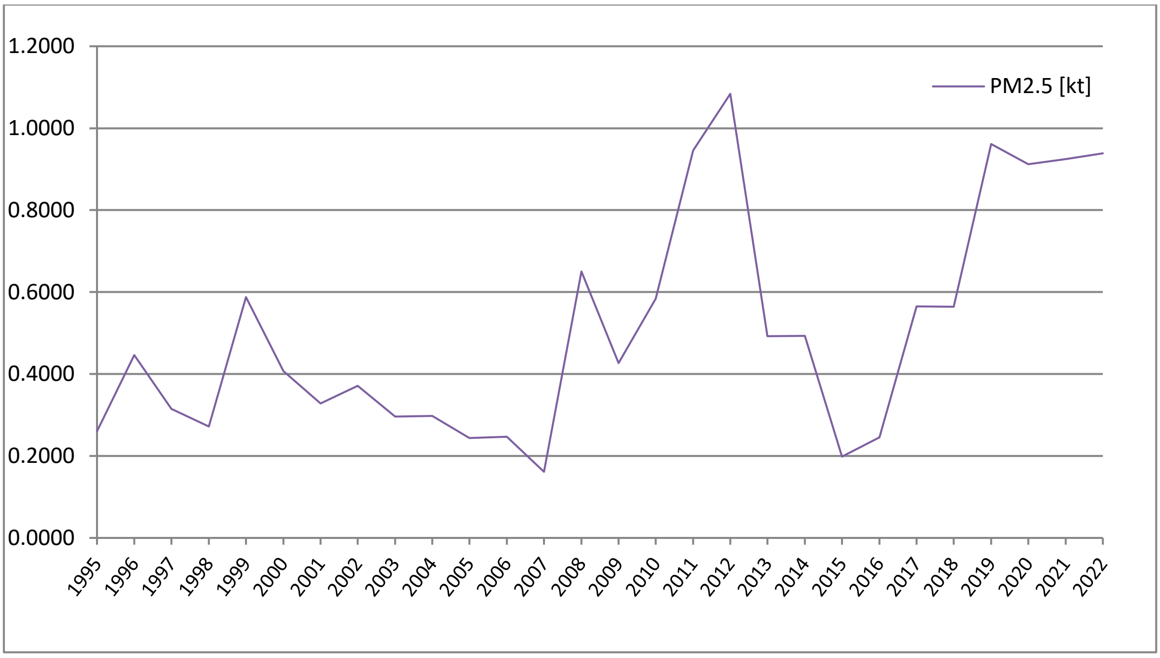


Figure 6.9.2 Emission trends (*kt for $PM_{2.5}$*) for NFR 5.E. Other waste (car fire and house fire)

Emission trends for heavy metals follow the activity data (car fires and house fires) trend.

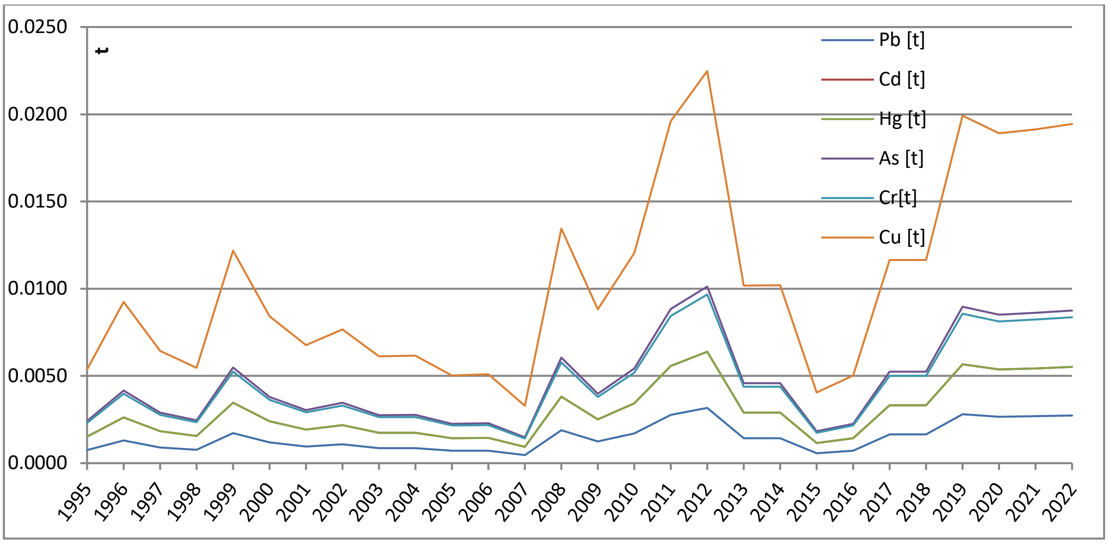


Figure 6.9.3 Emission trends (*t for heavy metals)* for NFR 5.E. Other waste

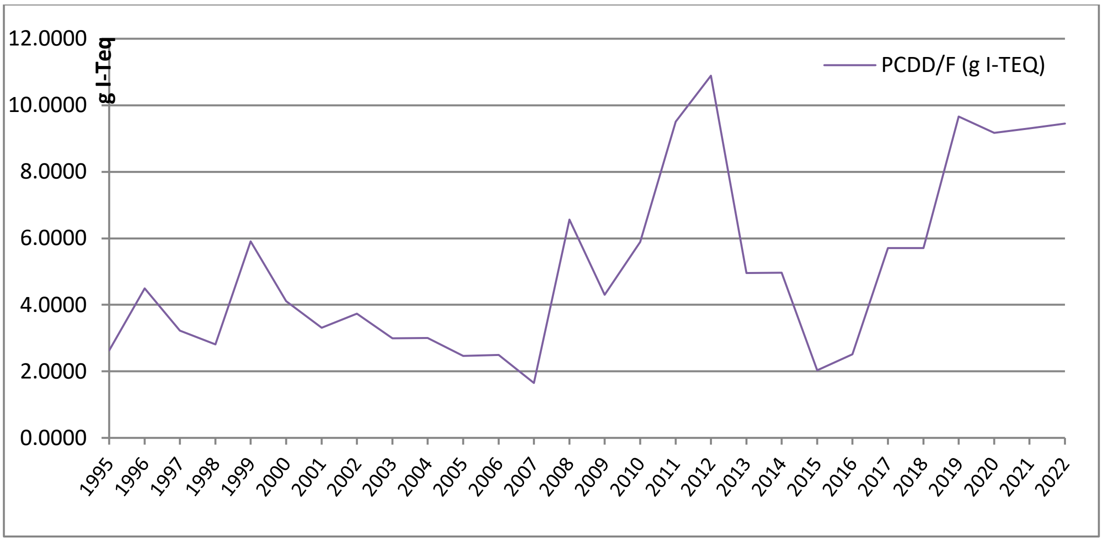


Figure 6.9.4 Emission trends (g I-TEQ for PCDD/F) for NFR 5.E. Other waste

Emission trends for PCDD/F follow the activity data (car fires and house fires) trend.

For 1990 -1995 period the IGSU (Romanian General Inspectorate for Emergency Situations) does not have any information.

Recalculations and improvements:

There were no recalculations and improvements for this category.

7. OTHER AND NATURAL EMISSIONS

Emissions from Other and Natural emissions are not estimated for Romania.

8. RECALCULATIONS AND IMPROVEMENTS

8.1 Recalculations

The main objective of recalculation is to improve the emissions inventory and the quality of the reports.

Following the Emission Inventory Reviews in 2017-2023, large part of recommendations from TERT were assessed and implemented.
Recalculations and improvements were developed on the following categories:

NFR	Timeseries	Pollutants	Reason
1A3bi	1991-2004	NOx, NMVOC, CO	Slight change of EFs from COPERT 5.6.1 to the COPERT 5.7.3
1A3bii	1991-2004	NMVOC, CO	Slight change of EFs from COPERT 5.6.1 to the COPERT 5.7.3
1A3bi-1A3bvii	2005-2021	All polutants	Recalculated using COPERT 5.7.3
1A3di(ii)	2005-2022	All (except NH3)	Estimate for the first time
1A3dii	1990-2021	PAHs	Updated to Guidebook 2023
1A4ai	1992-2021	NOx, NMVOC, $PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, As, Cr, Cu, Ni, Se, Zn, CO, PCDD/ PCDF, PAHs.	Change of EFs from Tier 1 (Table 3-8 Guidebook 2019) to Tier2 (Table 3-26 Guidebook 2023).
1A4bi	1990 – 2021	NOX, NMVOC, NH3, PM2.5, PM10, TSP, BC, DIOX,CO, Benzo(a), Benzo(b), Benzo(k), Indeno, total4PAHs, PCBs	Slight corrections of shares of technologies for biomass (stoves, pellets and boilers). Low impact on emissions.
1B2c	2021	All pollutants	Activity data update and recalculation
2A5b	2021	PM, TSP	Slight review of activity data by NIS
2D3a	1990-2021	NMVOC	Recalculated using EF from ESIG.
2D3d	1990-2021	NMVOC	Correction of activity data (total solvents),

			time period 2018-2021 New activity data SNAP 060105 coil coating, time period 2018-2021 New activity data SNAP 060106 boat building, time period 1990-2007 New activity data SNAP 060103+060104 domestic and building application time period 2003-2021.
2D3e	1990-2021	NMVOC	New activity data Xilen
2D3g	1990-2007 2021	NMVOC NMVOC	New activity data for SNAP 060306 Pharmaceutical products manufacturing Activity data update for SNAP 060301 Polyester processing
2D3h	2003-2007	NMVOC	New estimation activity data
2D3i	2021	NMVOC	Activity data update for SNAP 060407.
2G	2008-2021	NMVOC	Activity data update for SNAP 060603, "Use of shoes" activity.
2H2	1990-2021 2018-2021	PM10 NMVOC	New activity data for Handling of agricultural products (grains, soya) Activity data update for margarine.
3B1a, 3B1b, 3B3	2006-2013	NOx, NH3, NMVOC	Interpolation of AWMS percentage values at TERT recommendation
3B1a, 3B1b	2021	PM2.5, PM10, TSP	Error filling in the values
3B4gi	2021	NMVOC, NH3	Error of completion activity data
3B4gii, 3B4giii, 3B4giv	2008-2021	All pollutants	Recalculation of the activity data (as a result of the answers to the questionnaires in the country)
3Da1	2020, 2021 2021	NH3 NOx	Activity data update by NIS and IFA.
3Da2a	1990-2020	NOx	Activity data update
3Dc	2021	PM, TSP	Activity data update by NIS

3De	1990-2021	NMVOC	New calculation algorithm (Review RO_3De_2023-0001)
3F	1991-2021	NOx,NMVOC, SOx, NH3, PM2.5, PM10, TSP, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, benzo(a) pyrene, benzo(b), benzo(k), Indeno (1,2,3-cd).	Activity data update
5A	2021	PM10, PM2,5,TSP	Activity data update
5B1	2021	NH3	Activity data update

8.2 Planned improvements

Improvements, for the next submission, will include:

- updating emission factors according with Guidebook EMEP/EEA 2023;
- studying the possibility of obtaining activity data for historical time series for the calculation of pollutant emissions using the Tier 2 methodology for key categories;
- studying for introducing and applying country-specific data for all pollutants as much as possible for a real estimation of emissions for agriculture sector.
- a quantitative analysis of the uncertainty for the remaining pollutants will be processed in the following submissions.

Further research is necessary to gather the data and information necessary to implement the recommendations not yet implemented, specified in the following table. Program of improvement is focused on the many tasks like gathering additional activity data to include new emission sources, correlation with other reporting and improvement of QA/QC actions.

The recommendations from TERT in the NECD Review 2023 and the comments of Romania on the recommendations are presented below:

8.3 Status of implementation of ERTs in-depth review recommendations (NECD review and CLRTAP stage 3 review)

All recommendations, revised estimates, technical corrections and unquantified potential technical corrections including those additionally made during the NECD Review 2023 and those not implemented from previous reviews.

Table 8.3.1 Recommendations from the NECD Review 2023

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
RO-1A3di(ii)-2023-0001	No	1A3di(ii) International inland waterways, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, PM_{10}, 1990-2021	For category 1A3di(ii) International inland waterways, SO_2, NO_x, NH_3, NMVOC, $PM_{2.5}$ and PM_{10} for all years, the TERT notes that emissions are included in 1A3di(i) International maritime navigation - Memo item. As a result, "national" emissions are being accounted for "outside" the national totals, resulting in the National totals being under-estimated. In response to a question raised during the review Romania provided revised estimates, which indicate that the issue is below the threshold of significance. However, the TERT cannot fully understand and validate the choice of proxy data made by Romania, for example, why river traffic was not considered from the following source (https://apdmgalati.ro/activitate-portuara/trafic-portuar/), when comparing the international maritime cargo traffic from CN Administrația Porturilor Dunării Maritime Galați against CN Administrația Porturilor Maritime SA Constanța. Moreover, the TERT is unable to check one of the data sources used as the following weblink (http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table) provided by Romania does not appear to be working. The TERT decided to calculate a technical correction for the years 2005, 2019, 2020 and 2021. The technical correction was not accepted by Romania. The technical correction was calculated using % share of inland waterways vs % share of maritime in total freight transport (tonne-kilometres) from Eurostat as proxy data to disaggregate emissions between 1A3di(ii) International inland waterways and 1A3di(i) International maritime navigation. It should be noted that this proxy solution has its shortcomings as the % tonne-km for Maritime are 'territorialised' to the countries (covers national transport) and passenger movement is not considered. Nonetheless, it provides a temporary solution to split the emissions while Romania works on its improvement plan (e.g. gathering port statistics and vessel types information) to improve emissions estimates for this sector. The	Yes	3.15 NFR 1.A.3.d. Navigation

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
			estimates demonstrate that the issue is above the threshold of significance. As the TERT cannot fully understand the estimation made by Romania (RO-1A3di(ii)-2023-0001.xlsx), which suggests that the issue is below the threshold of significance, further work is required from Romania to create an estimate that follows best practice. The TERT strongly recommends that Romania include a thoroughly documented revised emission dataset with clear explanation of the assumptions made in the 2024 submission.		
RO-2D3a-2017-0001	Yes	2D3a Domestic solvent use including fungicides, NMVOC, 1990-2021	For category 2D3a Domestic solvent use, for pollutant NMVOC and for years 1990-2021 the TERT noted that Romania did not use the most recent information of emission estimates from solvent use provided by ESIG and that there is a potential under-estimate of emissions with an impact on total emissions that is above the threshold of significance. The TERT decided to calculate a technical correction for the years 2005 and 2019-2021 which was accepted by Romania. The technical correction was calculated using the latest ESIG data provided in 2023. The estimates demonstrate that the issue is above the threshold of significance. While this is an improvement to the existing inventory, further work is required from Romania to create an estimate that follows best practice. The TERT strongly recommends that Romania include a revised emission calculation in the 2024 submission.	yes	4.19 NFR 2D3a Domestic solvent use including fungicides
RO-2D3d-2020-0001	Yes	2D3d Coating applications, NMVOC, 2005-2021	For category 2D3d Coating applications, for pollutant NMVOC and years 2005-2021, the TERT noted that there was an inconsistent time series and that the three activities were missing (SNAP 060102 car repairing, SNAP 060103 building and SNAP 060104 domestic uses of paints). This issue is related to an under-estimate with an impact on total emissions that is above the threshold of significance. Similar issues were raised during the 2020, 2021, 2022 NECD inventory reviews. In response to a question raised during the review, Romania explained that they will analyse the proposed revised estimate made by the TERT and especially the estimation of decorative paint consumption for Romania, based on decorative paint consumption per capita observed in Greece as a surrogate consumption coming from a neighbouring country. Romania provided revised estimates for the years 2005-2021 by completing the time series for SNAP 060106, SNAP 060107 and SNAP 060108 for 2005 and introducing new statistical data to fill the gaps for decorative paints from 2005 to 2021. The TERT agreed with the proposal provided by Romania as it is an improvement to the inventory, however, the TERT notes that the impacts of import and export of coatings to the emission estimates are not included in this estimate. Transparency could also be improved with the reporting of sources of statistics of used paint production as well as information on the national regulation	yes	4.22 NFR 2D3d Coating applications

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
			implemented to align with the Directive 2004/42/EC (VOC content in decorative paints, varnishes and vehicle refinishing products) including information on the impacts of the enforcement of this EU directive on NMVOC emissions (SNAP 060103 and SNAP 060104. The TERT recommends that Romania include a revised estimate for category 2D3d Coating applications in the 2024 submission and integrate import and export statistics in the determination of paint consumption, and report information of the sources of statistics of used paint production and on the national regulation in the next submission. In addition, the TERT also recommends that Romania examine consistency of figures reported in its NFR tables and its calculation files for 2D3d.		
RO-3De-2023-0001	Yes	3De Cultivated crops, NMVOC, 1990-2021	For category 3De Cultivated crops, pollutant NMVOC and all years, the TERT noted that in section 5.17 of the IIR a Tier 1 method was used for a key category, which is not best practice and could result in an over-estimate of emissions that is above the threshold of significance. In response to a question raised during the review, Romania provided a revised estimate for all years in the time series. The TERT agreed with the revised estimate provided by Romania. The TERT recommends that Romania include the revised estimate in the 2024 submission.	Yes	5.17 NFR 3.D.e Cultivated crops
RO-1A3c-2023-0001	Yes	1A3c Railways, NO_X, 2021	For 1A3c Railways, pollutant NO_X, year 2021 the TERT notes that a Tier 1 method is used for a key category. In response to a question raised during the review, Romania explained that they have initiated collection of information within a national database, directly from operators. However, this bottom-up approach needs further validation and work is in progress to move to a Tier 2 method, and that they will recalculate NO_X emissions in their next submission. This finding could be related to an over-/under-estimate of emissions with an impact on total emissions that is above the threshold of significance. Romania has not provided a revised estimate which has been accepted by the TERT. It is currently not possible for the TERT to provide a numerical emission estimate with an adequate level of certainty as the TERT has no activity data available. Therefore, this has been flagged as an unquantified potential technical correction, and will be assessed as a high priority item in future reviews. The TERT strongly recommends that Romania develop a Tier 2 method for NO_X emissions from 1A3c Railways for inclusion in the 2024 submission.	No	3.14 NFR 1.A.3.c Railways

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
RO-2A5a-2023-0001	Yes	2A5a Quarrying and mining of minerals other than coal, $PM_{2.5}$, PM_{10}, TSP, 1990-2021	For category 2A5a Quarrying and mining of minerals other than coal, $PM_{2.5}$, PM_{10} and TSP and all years, the TERT notes that a Tier 1 method is used for a key category. The TERT acknowledges the answers provided during this review and the challenges in implementing the Tier 2 approach from the 2019 EMEP/EEA Guidebook. However, the TERT notes that several Member States have succeeded in implementing a Tier 2 method by using national data for some of the variables combined with assumptions for other variables. The TERT will also flag the difficulties experienced by many countries in implementing the current Tier 2 methodology of the 2019 EMEP/EEA Guidebook to the Task Force on Emission Inventories and Projections (TFEIP) to highlight the benefit of refining the methodological guidance for this source category. In response to a question raised during the review, Romania explained that it intends to estimate emissions using Tier 2, but there is a lack of information on activity data needed for emission estimation. Romania has initiated the collection of information at national level and depending on their availability, will present the progress in the 2024 submission. This finding could be related to an over- or under-estimate of emissions with an impact on total emissions that is above the threshold of significance. Romania has not provided a revised estimate which has been accepted by the TERT. It is currently not possible for the TERT to provide a numerical emission estimate with an adequate level of certainty as the TERT has no activity data available. Therefore, this will be flagged as potential technical correction, and will be assessed as a high priority item in future reviews. The TERT strongly recommends that Romania develop a higher tier method for PM_{10} (and $PM_{2.5}$ and TSP) emissions from category 2A5a Quarrying and mining of minerals other than coal for inclusion in the 2024 submission.	No	4.4 NFR 2.A.5.a Quarrying and mining of minerals other than coal
RO-1A1-2023-0001	No	1A1 Energy production, $PM_{2.5}$, PM_{10}, 1990 - 2021	For 1A1a Public electricity and heat production, pollutants $PM_{2.5}$ and PM_{10} and for all years, the TERT notes that there is a lack of transparency on page 9 of the 2023 IIR as to whether the emission estimates include the filterable or condensable PM component. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Romania explained that there was an error in the information provided and that all PM emissions in category 1A1a refer to filterable emissions. The TERT recommends that Romania update their current text on page 9 of the IIR to provide the correct information in the 2024 submission.	Yes	EXECUTIVE SUMMARY Correction in the table on page 10, at NFR 1A1a (“excluded” checked instead “included”).

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
RO-1A2a-2023-0001	Yes	1A2a Stationary combustion in manufacturing industries and construction: Iron and steel, SO_2, NO_X, 1990-2021	For category 1A2a Stationary combustion in manufacturing industries and construction: Iron and steel, for pollutants NO_X and SO_2 and all years, the TERT notes that a Tier 1 methodology is being used when on p.79-80 of the 2023 IIR it is stated that this is a key category for these pollutants. In the IIR it is also stated that emissions from NFR 1A2b – Combustion in non-ferrous metals industry, are included in NFR 1A2a – Iron and Steel. The reason is that the fuel consumption for this category is not recorded separately in the available energy statistics. The TERT notes that Table 3.5.1.3 on page 96 of the IIR provides fuel consumption for NFR 1A2a and therefore it is unclear why a Tier 2 cannot be used. This was also raised during the 2021 and 2022 NECD inventory reviews. In response to a question raised during the 2023 review, Romania explained that this recommendation will be included in the Improvement Plan and that the 2024 submission will contain information about the progress and the results obtained. The TERT reiterates the recommendation that Romania use a Tier 2 methodology for 1A2a as it is a key category, in the 2024 submission.	No	3.5.1 NFR 1.A.2.a Iron and steel. Stationary combustion.
RO-1A3di(i)-2023-0001	No	1A3di(i) International maritime navigation - Memo Item, NO_X, NMVOC, SO_2, $PM_{2.5}$, PM_{10}, 1990-2006	For category 1A3di(i) International maritime navigation - Memo Item, NO_X, NMVOC, SO_2, $PM_{2.5}$ and PM_{10}, years 1990 to 2006, the TERT noted that the notation key 'NE' (not estimated) is used. The TERT also notes that this may be because no activity data was available to estimate emissions before 2007 (as stated in the IIR page 159). In response to a question raised during the review, Romania said that they will investigate further to obtain data for the other years or to use surrogate data, and this recommendation will be included in IIR's improvement plan as a long-term goal. The TERT notes that the issue is also linked to the potential technical correction for observation RO-1A3di(ii)-2023-0001 and therefore recommends that Romania implement its improvement plan for this sector in conjunction with issues identified in RO-1A3di(ii)-2023-0001**.**	Yes	3.15 NFR 1.A.3.d. Navigation
RO-1A5a-2023-0001	No	1A5a Other stationary (including military), NH_3, 1990-2021	For 1A5a Other stationary (including military), pollutant NH_3 and years 1990-2021, the TERT notes that there is a lack of transparency regarding why emissions of this pollutant have not been estimated when a Tier 1 method is available in the 2019 EMEP/EEA Guidebook for biomass consumption and the IIR refers to the relevant emission factor tables. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Romania explained that incorrect information is currently provided in the IIR and that the text should only refer to Tables 3.7 to 3.9 and exclude Table 3.10 (which relates to biomass). The TERT recommends that Romania correct the text in the 2024 IIR**.**	Yes	3.11 NFR 1.A.5 - Other stationary (including military). Correction of table numbers (from “Tables 3.7–3.10” to “Tables 3-7, 3-8”
RO-2D-2022-0001	No	2D Non-energy products from fuels and solvent	For category 2D3 Non-energy products from fuels and solvent uses, for pollutant NMVOC and years 2005-2021, the TERT notes that there is a lack of transparency	yes	4.27 NFR 2.D.3.i Other solvent use

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
		uses, NMVOC, 2005-2021	regarding the sources of uncertainty factors associated with the activity data. This issue was raised during 2022 NECD inventory review. In response to a question raised during the review, Romania confirmed that this was omitted, and that Romania will include these sources in the 2024 submission. The TERT recommends that Romania include the sources of uncertainty factors used in the 2024 IIR submission.		
RO-2D3e-2023-0002	No	2D3e Degreasing, NMVOC, 2005-2021	For category 2D3e Degreasing, pollutant NMVOC and years 2005-2021, the TERT notes that activity data only included TRI as solvent used in degreasing. In response to a question raised during the review, Romania confirmed that investigations on this issue will be made by examining, for example, the use of xylen. The TERT notes that the issue is probably below the threshold of significance for a technical correction. The TERT recommends that Romania include the consumption of potential other solvents in its 2024 submission**.**	yes	4.23 NFR 2D3e Degreasing
RO-2D3g-2019-0001	Yes	2D3g Chemical products, NMVOC, 1990-2021	For 2D3g Chemical Products and NMVOC for all years, the TERT noted that the time series is not consistent and in 2005 the activity SNAP 060306 Pharmaceutical product manufacturing and SNAP 060313 Leather tanning are missing. In response to a question raised during the review, Romania provided information that allowed the TERT to undertake calculations that showed the issue is below the threshold of significance for a technical correction. However, the TERT recommends that Romania include the improved calculations in their 2024 submission to ensure completeness and time series consistency of their emission estimates.	yes	4.25 NFR 2D3g Chemical products
RO-2D3h-2023-0001	No	2D3h Printing, NMVOC, 1990-2021	For category 2D3h Printing, pollutant NMVOC and all years, the TERT identified inconsistent times series due to the use of different estimation methods from 2005 to 2007 (the emission factor from the Guidebook is 0.5 kg VOC/kg ink) and then, from 2008 to 2021, the use of emissions reported by plant operators. The TERT identified a potential under-estimate which is below the threshold of significance for NMVOC emissions in 2005. The TERT prepared a proposal (file RO-2D3h-TERT-proposal_2023.xlsx) for Romania on how to revise these emissions in 2005. To ensure that all activities in the printing industry are covered, a comparison should be made on solvent and ink consumptions reported by plant operators with international trade data (import/export/production) of Black printing inks [PRCCODE: 20302450], Printing inks (excluding black) [PRCCODE: 20302470], (import+production-export=use). The TERT recommends that Romania implement the completeness check above and improve the consistency of its times series for category 2D3h Printing for the 2024 submission.	yes	4.26 NFR 2D3h Printing
RO-2H2-2022-	No	2H2 Food and beverages	For category 2H2 Food and Beverages, PM_{10} and all years, the TERT notes that the	Yes	4.30 NFR 2H2 Food

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
0001		industry, PM_{10}, 1990-2021	IIR page 350 indicates that the recommendation from the 2022 NECD inventory review to collect activity data for handling of agricultural products to allow estimation of PM_{10} emissions was not implemented. This was raised during the 2022 NECD inventory review. In response to a question raised during the review, Romania explained that the inclusion of PM_{10} emissions is a planned improvement of the inventory, but obtaining suitable activity data had been an issue. Romania provided estimates of grain use from statistics for beer and flour production and explained that these will be included in the next submission. The TERT notes that the issue is below the threshold of significance for a technical correction.		and beverages industry
RO-3B1a-2022-0001	Yes	3B1a Manure management - Dairy cattle, NO_X, NH_3, NMVOC, 1990-2021	For categories 3B1a Manure management - Dairy cattle and 3B1b Manure management - Non-dairy cattle, for pollutants NH_3, NO_X and NMVOCs and years 1990-2021 the TERT noted that there is a lack of transparency in the calculation of emissions. In the IIR, the proportion of livestock storage on slurry-based system is as follows: dairy cattle, non-dairy cattle – 3% until 2013, 30% since 2014. The TERT is of the view that interpolation of AWMS percentage values may be more appropriate i.e. 3% in 2005, with interpolation to 30% in 2014 in the case of cattle and non-dairy cattle and that the method utilized by Romania may lead to an under-estimate of emissions that may be above the threshold of significance for the years 1990-2021. In response to a question raised during the review Romania provided revised estimates for the non-mandatory years 2006-2014 using interpolation between the two animal waste management studies undertaken in 2005 and 2014. The TERT recommends that Romania revise estimates of NH_3 for categories 3B1a Manure management – Dairy cattle and 3B1b Manure management - Non-dairy cattle on the basis of interpolation of the results of the two manure management surveys undertaken in 2005 and 2014 for its next annual submission. The TERT also recommends that the effect of these changes on NO_X and NMVOC emissions be taken into account**.**	Yes	5. NFR 3 AGRICULTURE 3B Manure Management Description; Annex A Table 4
RO-3B3-2023-0001	Yes	RO-3B3-2023-0001	For category 3B3 Manure management – Swine, pollutants NO_X, NH_3, NMVOC and $PM_{2.5}$ for years 1990-2021, the TERT noted that there is a lack of transparency in the calculation of NH_3 emissions from this category. In the IIR, the proportion of livestock storage on slurry-based system is as follow: finishing pigs – 40% until 2013, 60% since 2014; sows – 30% until 2013, 60% since 2014. The TERT is of the view that interpolation of AWMS percentage values may be more appropriate i.e. 40% in 2005, with interpolation to 60% in 2014 in the case of finishing pigs and that the method utilized by Romania may lead to an under-estimate of emissions that may be above the threshold of significance for the years 1990-2021. In response to a question raised during the review Romania provided revised estimates for the	Yes	5. NFR 3 AGRICULTURE 3B Manure Management Description; Annex A Table 4

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
			non-mandatory years 2006-2014 using interpolation between the two animal waste management studies undertaken in 2005 and 2014. The TERT recommends that Romania revise estimates of NH_3 on the basis of interpolation of the results of the two manure management surveys undertaken in 2005 and 2014 for its next annual submission. The TERT also recommends that the effect of these changes on NO_X and NMVOC emissions are reported.		
RO-3B4gii-2023-0001	Yes	3B4gii Manure management - Broilers, NO_X, NH_3, NMVOC, $PM_{2.5}$, 1990-2021	For 3B4gii Manure management - Broilers, pollutants NH_3, NO_X, NMVOCs and $PM_{2.5}$ and for all years, the TERT notes that on page 274 of the IIR it is stated that the broilers heads counts for the entire time series were corrected by subtracting new values from turkeys (NFR 3B4giii) and other poultry (NFR 3B4giv) from the NIS values for poultry. In response to a question raised during the review, Romania provided the TERT with a breakdown of poultry statistics across the last three submissions to show how poultry statistics have improved over time. The TERT recommends that Romania report population statistics for each of the subcategories of poultry that exist in Romania (e.g. laying hens, broilers, turkeys and other poultry), rather than the current approach of reporting poultry statistics broken down into turkeys and other poultry only, in the 2024 submission.	Yes	5. NFR 3 AGRICULTURE 3B Manure Management Description; Annex A Table 1
RO-5B2-2022-0001	No	5B2 Biological treatment of waste - Anaerobic digestion at biogas facilities, NH_3, 2002-2020	For 5B2 Anaerobic digestion at biogas facilities, pollutant NH_3 and years 2002-2020 the TERT notes that Romania expanded the time series with the period 2013-2018 and additionally reported that the emissions for 2019 and 2020 are recalculated. However, in the 2022 review the TERT found that from Romania's NIR 2022, it is clear that the use of anaerobic digestion is practiced since 2002 and that this is confirmed in the NIR 2023. No explanation is found in the IIR 2023 on the issue of non-reporting of NH_3 from this source for the years 2002-2012. This was raised during the 2022 NECD inventory review. Additionally, the TERT notes that the implied emission factor in 2019 is 884% higher than in 2018 and 2020. In response to questions raised during the 2023 review, Romania explained that the large cogeneration biogas plants operate since 2002 and that they are completely closed (including the feedstock and digestate storage), so no emission of NH_3 will occur. Since 2012 there are also smaller biogas plants operating that have open digestate storage and thus NH_3-emissions are calculated from these as of 2013 and that the NH_3 emission reported in 2019 is a (typing) error that will be corrected in the 2024 submission. The TERT notes that the issue is below the threshold of significance for a technical correction. The TERT recommends that Romania in the next submission enhance the explanation in the IIR with the additional details supplied to the TERT on this issue, and correct the typing error in the NH_3 emissions in 2019.	yes	6.3 NFR 5B2 Biological Treatment of Waste - Anaerobic Digestion at Biogas Facilities

Table 8.3.2 Recommendations from the CLRTAP stage 3 Review 2023

ID	Pollutants	NFR category	Key Category	Tier level	Type	TAC1C2C3	Implemented	Section in IIR covered in
RO-2023-3B-1	All	3B	Yes	Tier 2	R	T	Yes	3B Manure Management Description, page 267
The ERT noticed that the IIR lacks detailed description on the sources and input data behind the activity data. For instance, the IIR refers to a questionnaire at local level used to collect activity data for manure management (3B4giii and 3B4giv). Romania responded that the questionnaire is sent by local agencies to the farmers. The questionnaires provide data on the annual average number of poultry heads: (NFR 3B4giii) Turkeys and (NFR 3B4giv) Other poultry. For other poultry category, it was explained that this category refers to any other poultry except laying hens, broilers and turkeys. The ERT recommends Romania to include more detailed information on the questionnaire (e.g., % response, coverage, time span it represents, etc.) in the 2023 submission to enhance the quality of the IIR and contribute to improved transparency.								
RO-2023-3B-2	NMVOC	3B	Yes	Tier 2	R	T	Yes	3B Manure Management Description, pages 267-269
In the same line as with RO-2023-3B-2, the ERT emphasizes the lack of detailed description on the sources and input data behind the activity data. The IIR states that for the estimates of NMVOC emissions, "The percent of silage feeding for dairy cattle, non-dairy cattle (10%), sheep, goats and buffalos (3%) according to the study "Romanian Projections for Pollutants Emissions to 2030" was used in calculation". However, neither details on the basis for these values nor the study was included in the reference list. Romania responded with the detailed information from the mentioned study, and that they would include the study in the reference list. The ERT recommends Romania to add the detailed information behind the percentage of silage feeding for the different livestock in the IIR in the 2023 submission, in addition to including the previously mentioned study in the reference list to enhance the quality of the IIR and contribute to improved transparency.								
RO-2023-3B-3	HCB	3Df	-	-	R	C_1	Yes	1.8.1 Sources reported as "NE", Table1.8.1
The ERT noticed that HCB emissions from pesticides (3Df) are not reported while a Tier 1 method is available in the EMEP/EEA Guidebook. In addition, the Stage 3 reviewed report (2013) for Romania strongly recommended that Romania report emission estimates from pesticide use in next submission. However, no information about pesticides was included in the IIR, and the notation NA was found in the IIR. Romania responded that in the next submissions, NE will be used instead of NA, and that further analysis is required to assess activity data for 3Df. The ERT encourages Romania to carry out the needed analysis to assess activity data and estimate HCB emissions from pesticides (3Df) for the 2023 submission. If this is not possible, then the ERT recommends Romania to use the notation key 'NE'.								
RO-2023-3B-4	NH_3	3B3	Yes	Tier 2	R	T	Yes	3B3 Manure Management- Swine, page

ID	Pollutants	NFR category	Key Category	Tier level	Type	TAC1C2C3	Implemented	Section in IIR covered in
								279

The ERT noticed a major time series inconsistency with a dip in 2001 in NH_3 from 3B3 Manure management – Swine, and the reason for these notable interannual variation in the time series was not described in the IIR. During the review, Romania provided a detailed description for such variations, which are mainly associated with changes in the number of swine heads and economic changes in the country over time.

The ERT recommends Romania to include in the IIR the analysis and reasons of the interannual variations in NH_3 from manure management - swine, which is a key category, to enhance the quality of the reporting and contribute to transparency.

9. ADJUSTMENTS

No adjustments.

IIR Appendices

References

- EIONET CDR – CLRTAP Emission Inventories of ROMANIA
- EMEP/EEA 2019 Air Pollution Inventory Guidebook
- ISPE - Institute of Energy Studies and Design, 2018, Study for "Romanian Projections for Pollutants Emissions to 2030"
- Romanian Ministerial Order No. 3.299/2012 for the approval of the methodology for compiling and reporting of air emissions inventories.

ANNEX A, 3B - Manure Management parameters calculations

Table 1. Activity data calculation for Broilers heads (= All poultry except laying hens – Turkeys - Other poultry)

Years	All other poultry except laying hens*	3B4giii Turkeys**	3B4giv Other poultry (ducks,gooses,etc.)**	3B4gii Broilers
1990	69904000	5466	19781	69878753
1991	55819000	4809	17405	55796786
1992	45319000	3997	14466	45300537
1993	38551281	4121	14913	38532247
1994	33923599	3931	14228	33905440
1995	41949833	4116	14896	41930821
1996	39595827	3640	13172	39579015
1997	31531489	3417	12368	31515704
1998	32207185	3684	13332	32190169
1999	30645805	2959	10709	30632137
2000	29315592	2981	10788	29301823
2001	29257713	2773	10036	29244904
2002	32712362	3156	11422	32697784
2003	32494585	2929	10601	32481055
2004	35125522	4875	15700	35104947
2005	36827000	4562	15554	36806884
2006	34712000	4789	16375	34690836
2007	36828000	3973	12858	36811169
2008	38844000	3295	19877	38820828
2009	38797258	2934	29444	38764880
2010	36341348	3457	28951	36308940
2011	34377799	18453	30378	34328968
2012	34733768	84675	33157	34615936
2013	36898951	67931	44901	36786119
2014	32708203	126435	47714	32534054
2015	34985492	784139	45361	34155992
2016	34856758	777875	64063	34014820
2017	34976585	750982	71912	34153691
2018	35859007	915825	65300	34877882
2019	34636147	1039975	77781	33518391
2020	34534953	937327	62689	33534937
2021	35110424	945764	56916	34107744
2022	36337266	1024255	55291	35257720

** source: Romanian National Institute of Statistics;*
***source: national questionnaires*

Table 2. Tier 2 NH3-N EFs and associated Parameters for the Tier 2 methodology used in "N-Flow Tool"

Livestock class	Dairy cows (100901)	Other cattle (100902)	Fattening pigs (100903)	Sows (100904)	Sheep (100905)	Laying hens (100907)
Animal Weight	**650**	**481**	**Table 3**	**125**	**60**	**1.9**
Nex (kg/yr)	83.038	61.448	Table 3	20.988	19.710	0.569
Prop TAN	0.6	0.6	0.7	0.7	0.5	0.7
Straw, kg/yr	1500	500	200	600	20	0
N added in bedding, kg/animal/yr	6	2	0.8	2.4	0.08	0
Housing period, days	180	180	365	365	30	365
% excreta on yards	25	10	0	0	2	0
EF NH_3 house, slurry	0.24	0.24	0.27	0.35	0	0.41
EF NH_3 house, solid	0.08	0.08	0.23	0.24	0.22	0.2
EF NH_3 yard	0.3	0.53	0.53	0	0.75	0
EF NH_3 storage, slurry	0.25	0.25	0.141	0.11	0	0.14
EF NH_3 storage, solid	0.32	0.32	0.29	0.29	0.28	0.08
EF N_2O storage, slurry	0	0	0	0	0	0
EF N_2O storage, solid	0.08	0.08	0.05	0.05	0.07	0.04
EF NO storage, slurry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
EF NO storage, solid	0.01	0.01	0.01	0.01	0.01	0.01
EF N_2 storage, slurry	0.003	0.003	0.003	0.003	0.003	0.003
EF N_2 storage, solid	0.3	0.3	0.3	0.3	0.3	0.3
EF storage leaching, solid	0	0	0	0	0	0
EF NH_3 application, slurry	0.55	0.55	0.4	0.29	0	0.69
EF NH_3 application, solid	0.68	0.68	0.45	0.45	0.9	0.45
EF NH_3 grazing	0.14	0.14	0	0.31	0.09	0

Table 3. Finishing pigs' Parameters introduced in "N-flow Tool"

Years	1990-2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Animal Weight(kg)	72.66	74.75	78.00	76.70	75.30	76.10	75.70	76.50	72.60	70.30	69.60	68.30	67.60	67.90	67.60	68.50	69.70	69.60	72.00	71.65
Nex (kg/yr)	14.59	15.01	15.66	15.40	15.12	15.28	15.20	15.36	14.57	14.11	13.97	13.71	13.57	13.63	13.57	13.75	13.99	13.97	14.45	14.38

Table 4. Interpolation for the proportion of livestock stocked in sludge-based system between the two national studies undertaken in 2005 and 2014

Proportion of manure deposited in houses which is "slurry"	1990-2005	2006	2007	2008	2009	2010	2011	2012	2013	2014-2022
Xhouse_slurry_Dairy cattle	0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24	0.27	0.3
Xhouse_slurry_Non-dairy cattle	0.03	0.06	0.09	0.12	0.15	0.18	0.21	0.24	0.27	0.3
Xhouse_slurry_Swine (finishing pigs)	0.4	0.4222	0.4444	0.4666	0.4888	0.511	0.5332	0.5554	0.5776	0.6
Xhouse_slurry_Swine (sows)	0.3	0.3333	0.3666	0.3999	0.4332	0.4665	0.4998	0.5331	0.5664	0.6

Table 5. Amount of AR.feedstock (kg) material used in biogas units resulted from national questionnaires

AR.feedstock Type/Year(kg)	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cattle slurry		916.474	3736.1688	8307.208	17478.261	20746.627	29444.002	31740.779	27771.926	20966.145
Pig slurry				561.6	2762.6023	972.288	184.896	193.536	330.336	367.8912
Solid cattle manure			1420.9	6000.8	23292.1	20967.96	24232.02	24397.337	26461.487	25608.01
Solid pig manure					9988.254	5926.7685	1411.5	273		
Poultry manure	84875	65012.5	9362.5	49787.5	39523.75	30835	27212.5	12166.875	16852.5	29202.688

Table 6. Parameter Feed intake used for NMVOC calculation Tier2, dairy cattle (NFR 3B1a)

Year	Feed intake (GE) (MJ/head/day)
1990	233.418
1991	243.447
1992	250.808
1993	255.280
1994	265.549
1995	269.602
1996	271.771
1997	275.026
1998	274.749
1999	274.495
2000	278.120
2001	282.701
2002	283.312
2003	286.684
2004	291.587
2005	287.975
2006	292.083
2007	290.206
2008	292.619
2009	288.435
2010	294.109
2011	298.767
2012	294.989
2013	295.610
2014	297.092
2015	293.894
2016	290.583
2017	290.606
2018	292.179
2019	291.702
2020	291.700
2021	293.440
2022	298.524

Parameter for Tier 2 estimation NMVOC calculation:
- Feed intake (GE) for non-dairy cattle, NFR 3B1b = 193.79 MJ/head/day
- Volatile excretion (VS) for poultry, NFR 3B4gi, 3B4gii = 0.01829 MJ/head/day.