ROMANIA'S INFORMATIVE INVENTORY REPORT 2023

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 1990-2021

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EXECUTIVE SUMMARY

The Romanian Informative Inventory Report (IIR) contains information on the Romania's inventories for the years 1990 to 2021, including descriptions of methods, data sources, key categories analysis and trends analysis.

New NFR categories were estimated and some recalculations for period 1990-2021 have been carried out, due to updated statistics and correlations with the activity data, according with the Emission Inventory review conducted in 2022.

New NFR categories were estimated and recalculations for period 1990-2021 on the following criteria:

- the recommendations from TERT in the NECD Review 2022;
- updated statistics;
- consistency/correlation with all relevant inventories.

Following the Emission Inventory Reviews in 2017-2022, 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 fuel combustion in energy industry and in manufacturing industry, transport, small combustion, including off-road mobile machinery and fugitive emissions from fuels (NFRs 1A-1B).

The shares of the emissions from the energy sector in the national total in 2021 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	84.13%	Hg	84.75%
NMVOC	53.46%	As	68.16%
SOx	97.98%	Cr	61.65%
NH3	6.63%	Cu	98.82%
PM2.5	94.34%	Ni	85.80%
PM10	73.87%	Se	94.16%
TSP	53.70%	Zn	87.38%
BC	97.89%	PCDD/ PCDF	55.72%
CO	95.50%	PAHs	88.17%
Pb	44.88%	HCB	47.53%
Cd	81.61%	PCBs	27.75%

The estimation 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.

The public power sector was in 2021 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 85% for NOx, 95% for SOx and 92% for PM2.5. Compared to 2005, the emissions decreased with 78% for NOx, 94% for SOx, 92% for PM10 and 89% for PM2.5. 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 2021 national total with 84% for PM2.5, 80.16% for PAH, 72.6% for BC, 63.5% for PM10, 45.22% for TSP, 33.7% for NMVOC, 54.3% for Zn, 56.8% for CO, 56.5% for Cd and 50.5% for PCDD/PCDF. 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 2010-2021. 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. Compared to 2005, the biomass consumption increased in 2021 with 16%.

The road transport sector contributed to the total national emissions in 2021, for NOx with 39.4% of the total, NMVOC with 8.3% of total, BC with 16.0% of the total, CO with 13.3% of the total, Pb with 19.2% of total, Cr with 22.8% of total, Cu with 93.4% of the total and Zn with 17.6% of the total.

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).

The industrial sector only covers process related emissions arising from industrial processes. Industrial processes and product use sector mainly contributes to the PCBs emissions of the Inventory (70.5% of National Total), Pb emissions (55% of National Total), Cr emissions (38.3% National Total), NMVOC emissions (20.7% of National Total), TSP emissions (30.5% of National Total), As (30% of National Total) for the year 2021. The estimation was largely based on emission factors from the EMEP/EEA 2019 Pollutant Emission Inventory Guide, except for NOx emissions (NFR 2.B.2) and NMVOC emissions (NFR 2.D.3.d, 2.D.3.g, 2.D.3.h 2.D.3.i, 2.G) which are provided by operators.

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 NH_3 emission (89.18%) is related to the agricultural sector. For the year 2021, the distribution of NH_3 emissions by agriculture sources was as follows: 37.69% from manure management, 62.3% 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 2021, the contribution of NMVOC share from agriculture accounts for 24.79% of the national total. The distribution of NMVOC emissions by agricultural sources was as follows: 53.62% from manure management, 46.33% 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 2013-2021. Also, for the first time, the emissions of the categories of turkeys and other poultry were reported for the entire time period 1990-2021. The emission of ammonia from inorganic fertiliser, estimated with the Tier 2 methodology, contributes in 2021 with 21.22% to the emission from the agricultural sector, and nitrogen oxide emission contributes in 2021 with a weight of 66.47%, 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 new source NFR 5.B.2 Biological treatment of waste by anaerobic digestion at biogas plants, covers emissions from the biological treatment of waste by anaerobic digestion at biogas plants.

The waste sector contributes to the PCDD/PCDF emissions of the Inventory (29.1% of National Total) and HCB emissions (49.5% National Total), for the year 2021.

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

NFR	Source/sector name	PM emissions: the condensable component is included	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)”

NFR	Source/sector name	PM emissions: the condensable component is included	excluded	EF reference and comments
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 industry)			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 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

NFR	Source/sector name	PM emissions: the condensable component is included	excluded	EF reference and comments
				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 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, Table 3.1, "The mass of particles collected on a filter kept below 52 °C during diluted exhaust sampling. This corresponds to total (filterable and condensable) $PM_{2.5}$. Coarse exhaust PM (i.e. > 2.5 μm diameter) is considered to be negligible, hence $PM=PM_{2.5}$"
2C.1	Iron and steel production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions only (excluding any condensable fraction)". These data are confidential.
2.C.2	Ferroalloys production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions only (excluding any condensable fraction)". These data are confidential.
2.C.3	Aluminium production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions only (excluding any condensable fraction)". These data are confidential.
2.C.5	Lead production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions

NFR	Source/sector name	PM emissions: the condensable component is included	excluded	EF reference and comments
				only (excluding any condensable fraction)". These data are confidential.
2.C.6	Zinc production		x	2019 EMEP/EEA Guidebook, - „These PM factors represent filterable PM emissions only (excluding any condensable fraction)". These data are confidential.
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". These data are confidential.
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"

Significant recalculations and improvements were developed on the following categories:

NFR	Timeseries	Pollutants	Reason
1A1c	1990-2020	PM10, TSP, BC	Correction of emission factors.
1A2f	2005-2020	All	Recalculation with Tier 2 approach (Review RO-1A2f-2022-0001)
1A3a	2017-2020	NOx, NMVOC, SOx, PM, CO	Data update by Eurocontrol for 2017-2020.
1A3bi-1A3biv	1991-2004	NOx, NMVOC, NH3, PM2.5, PM10, TSP, BC, CO, Pb, PAHs	Changed EFs for 1990-2004 applying a linear regression between maxim Tier 1 EFs (the year 1990) and the COPERT 5.6.1 EFs (the year 2005).
1A3bi-1A3biv	2000-2004	SO2	Correction of error in SO2 emission estimation based on sulphur content in fuels.
1A3bi-1A3bvii	2005-2020	All	Recalculated using COPERT 5.6.1 and national NCV, changed fuel consumption for 2009-2011 and 2013.
1A4cii	1992-2020	SOx	Slight correction of emissions from gasoline.

NFR	Timeseries	Pollutants	Reason
1B2aiv	1990-2020	Benzo(a), benzo(b), benzo(k), indeno, Total PAH	Error in the calculation unit of measure.
2D3a	1990-2020	NMVOC	Recalculated using AD=population EUROSTAT and EF from ESIG.
2D3b	1990-2020	NMVOC, PM2.5, PM10, TSP	Recalculation with Tier 2 approach (Review RO-2D3b-2022-0002)
2D3g	1990-2020	NMVOC	Activity data update (new SNAP 060301) / recalculation.
2D3h	2018; 2020	NMVOC	Correction of activity data (total solvents).
2D3i	1990-2020	NMVOC	Activity data update by EUROSTAT (total population for 1991-2001 and 2013, 2014, 2018, 2020). Correction of activity data (total solvents) for 2019 and 2020. New calculation algorithm for time 1990-2007 for SNAP 060404 (activity data - total edible oils) by N.I.S. / recalculation.
2G	2008-2020	NMVOC	Activity data update for SNAP 060603, “Use of shoes” activity.
2H2	1990-2020	NMVOC	Correction of the activity data with new SNAP, recalculation the NMVOC emissions.
3B2	2020	NMVOC	Error in the calculation.
3B3	1990-2004	NH3	Recalibration with new version of “N-flow tool –Jan 2021” values.
3B4gii	1990-2020	NOx, NMVOC, NH3, PM2.5, PM10, TSP	Activity data changed by decreasing the number of poultry corresponding to NFR 3B4giii, 3B4giv.
3B4giii	1990-2020	NOx, NMVOC, NH3, PM2.5, PM10, TSP	New activity data calculation for 1990-2018 and recalculation for 2019- 2020.
3B4giv	1990-2020	NOx, NMVOC, NH3, PM2.5, PM10, TSP	New activity data calculation for 1990-2018 and recalculation for 2019-2020.
3Da1	2019, 2020	NH3	Activity data update by IFA.

NFR	Timeseries	Pollutants	Reason
3Da2a	1990-2020	NMVOC, NH3	Activity data changed by decreasing the number of poultry corresponding to NFR 3B4giii, 3B4giv.
3Da3	1990-2020	NMVOC, NH3	Activity data changed by decreasing the number of poultry corresponding to NFR 3B4giii, 3B4giv.
5A	2020	NMVOC	Correction of activity data (total CH4).
5B2	2019-2020	NH3	Correction of activity data.
5C1bi	2020	All	Correcting of activity data/recalculating of all pollutant emissions.
5C2	2020	All	Activity data update by N.I.S./recalculation all pollutant emissions.
5D3	1990-2020	NH3	New calculation algorithm for latrines (NH3 emissions) – review RO-5D3-2022-0001.
5E	2020	All	Activity data update by IGSU (General Inspectorate for Emergency Situations of Romania).

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.

The same institutional arrangements are also being used for reporting under the Revised NEC Directive – 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.

1.2. Institutional arrangements

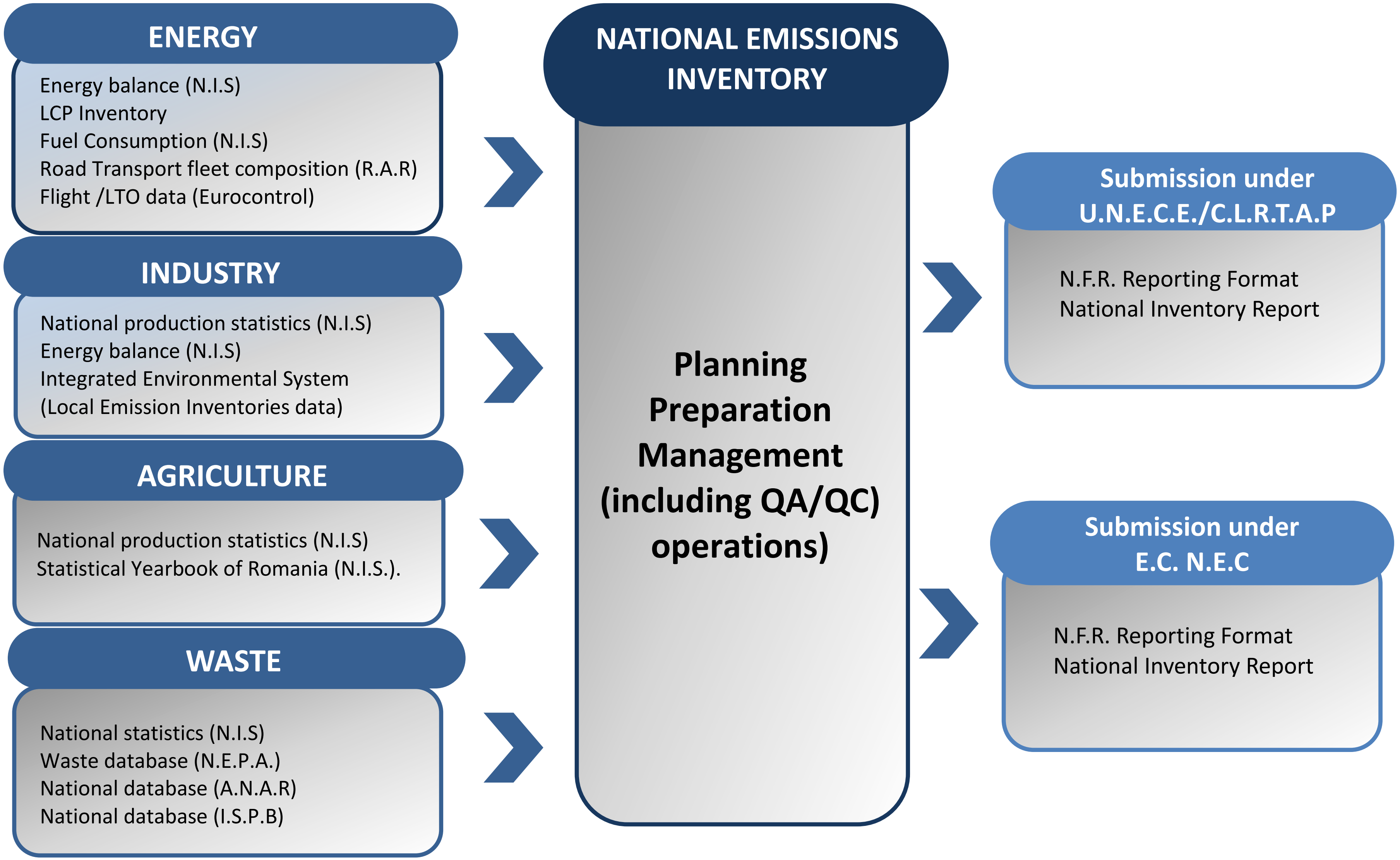
Romania prepares, maintains and reports on a yearly basis the National Emissions Inventory and the whole inventory time series, if required. Emission time series are resubmitted if any recalculation occurred due to the methodology/emission factors changes, new sources identification, updated activity 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: SOx, NOx, NH_3, NMVOC, CO, BC, TSP, PM_{10}, $PM_{2.5}$, Heavy Metals, (Cd, Pb, Hg, As, Cr, Cu, Ni, Se, Zn), POPs (HCB, PCB, dioxins/furans and PAHs).

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 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 have been updated to 2019 EMEP/EEA Guidebook.

The 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).

The resulting emissions from the road transport sector were exported directly into the reporting formats required by the UNECE/CLRTAP Secretariat using the "Export NFR" option of COPERT.

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
Waste	National statistics	NIS
Waste	Waste database	NEPA
Waste	National database	ANAR
Waste	Building and car fires	CTIF, IGSU-MIA
Waste	National database	ISPB

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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 1.3.1 Key Categories for NOx (2021)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A3biii	Road transport: Heavy duty vehicles and buses	41.292	19.28%	19.28%	1
1A3bi	Road transport: Passenger cars	31.035	14.49%	33.77%	2
1A1a	Public electricity and heat production	21.938	10.24%	44.02%	3
3Da1	Inorganic N-fertilizers (includes also urea application)	21.544	10.06%	54.08%	4
1A4bi	Residential: Stationary	15.579	7.27%	61.35%	5
1A3bii	Road transport: Light duty vehicles	11.927	5.57%	66.92%	6
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	11.407	5.33%	72.25%	7
3Da2a	Animal manure applied to soils	8.230	3.84%	76.09%	8
1A3c	Railways	6.760	3.16%	79.25%	9
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	5.805	2.71%	81.96%	10

Table 1.3.2 Key Categories for NMVOC (2021)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	78.9541	33.71%	33.71%	1
2D3g	Chemical products	16.8076	7.18%	40.89%	2
3Da2a	Animal manure applied to soils	14.9539	6.38%	47.27%	3
3B1a	Manure management - Dairy cattle	13.5288	5.78%	53.05%	4
3De	Cultivated crops	11.3647	4.85%	57.90%	5
1A3bi	Road transport: Passenger cars	11.1445	4.76%	62.66%	6
2D3a	Domestic solvent use including fungicides	9.9646	4.25%	66.91%	7
2H2	Food and beverages industry	8.2021	3.50%	70.41%	8
3B1b	Manure management - Non-dairy cattle	5.3734	2.29%	72.71%	9
2D3i	Other solvent use (please specify in the IIR)	4.5841	1.96%	74.67%	10
1B1a	Fugitive emission from solid fuels: Coal mining and handling	4.2486	1.81%	76.48%	11
1B2aiv	Fugitive emissions oil: Refining / storage	4.1330	1.76%	78.24%	12
2D3d	Coating applications	3.8232	1.63%	79.88%	13
3B4gii	Manure management - Broilers	3.4613	1.48%	81.35%	14

Table 1.3.3 Key Categories for SOx (2021)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	30.9949	46.8%	46.8%	1
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	20.5615	31.0%	77.8%	2
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	3.9694	6.0%	83.8%	3

Table 1.3.4 Key Categories for NH_3 (2021)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
3Da2a	Animal manure applied to soils	39.1495	24.69%	24.69%	1
3Da1	Inorganic N-fertilizers (includes also urea application)	30.0120	18.92%	43.61%	2
3Da3	Urine and dung deposited by grazing animals	18.8786	11.90%	55.51%	3
3B3	Manure management - Swine	15.9772	10.07%	65.59%	4
3B1a	Manure management - Dairy cattle	13.2158	8.33%	73.92%	5
1A4bi	Residential: Stationary	9.4122	5.93%	79.85%	6
5D3	Other wastewater handling	6.2751	3.96%	83.81%	7

Table 1.3.5 Key Categories for $PM_{2.5}$ (2021)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	97.3029	83.78%	83.78%	1

Table 1.3.6 Key Categories for PM_{10} (2021)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	99.8880	63.53%	63.53%	1
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	20.6150	13.11%	76.64%	2
2A5a	Quarrying and mining of minerals other than coal	4.9897	3.17%	79.81%	3
2D3b	Road paving with asphalt	3.1115	1.98%	81.79%	4

Table 1.3.7 Key Categories for TSP (2021)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	105.1182	45.22%	45.22%	1
2D3b	Road paving with asphalt	23.3364	10.04%	55.26%	2
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	20.6150	8.87%	64.13%	3
2B10a	Chemical industry: Other (please specify in the IIR)	17.9660	7.73%	71.86%	4
2A5a	Quarrying and mining of minerals other than coal	10.1789	4.38%	76.24%	5
3B4gi	Manure management - Laying hens	7.9872	3.44%	79.68%	6
2A2	Lime production	7.0510	3.03%	82.71%	7

Table 1.3.8 Key Categories for BC (2021)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total	Rank
1A4bi	Residential: Stationary	9.9686	72.59%	72.59%	1
1A3bi	Road transport: Passenger cars	0.9102	6.63%	79.22%	2
1A3biii	Road transport: Heavy duty vehicles and buses	0.6000	4.37%	83.59%	3

Table 1.3.9 Key Categories for CO (2021)

NFR CODE	CATEGORY	Latest year estimate (kt)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	547.7205	56.80%	56.80%	1
1B2aiv	Fugitive emissions oil: Refining / storage	132.1960	13.71%	70.51%	2
1A3bi	Road transport: Passenger cars	94.6591	9.82%	80.32%	3

Table 1.3.10 Key Categories for Pb (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
2C1	Iron and steel production	23.9826	51.68%	51.68%	1
1A3bvi	Road transport: Automobile tyre and brake wear	8.9254	19.23%	70.91%	2
1A4bi	Residential: Stationary	3.9295	8.47%	79.38%	3
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	3.0592	6.59%	85.98%	4

Table 1.3.11 Key Categories for Cd (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	1.7731	56.52%	56.52%	1
2C1	Iron and steel production	0.3783	12.06%	68.57%	2
1A1a	Public electricity and heat production	0.2502	7.97%	76.55%	3
1B2aiv	Fugitive emissions oil: Refining / storage	0.2135	6.81%	83.35%	4

Table 1.3.12 Key Categories for Hg (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	0.3972	23.20%	23.20%	1
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	0.3969	23.18%	46.37%	2
1B2aiv	Fugitive emissions oil: Refining / storage	0.2373	13.86%	60.23%	3
2C1	Iron and steel production	0.2213	12.92%	73.16%	4
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	0.1939	11.32%	84.48%	5

Table 1.3.13 Key Categories for As (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	1.9379	53.08%	53.08%	1
2C1	Iron and steel production	1.0193	27.92%	81.00%	2

Table 1.3.14 Key Categories for Cr (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
2C1	Iron and steel production	5.5794	37.56%	37.56%	1
1A3bvi	Road transport: Automobile tyre and brake wear	3.3379	22.47%	60.03%	2
1A4bi	Residential: Stationary	3.1538	21.23%	81.26%	3

Table 1.3.15 Key Categories for Cu (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A3bvi	Road transport: Automobile tyre and brake wear	73.3412	93.31%	93.31%	1

Table 1.3.16 Key Categories for Ni (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	2.3619	19.95%	19.95%	1
1B2aiv	Fugitive emissions oil: Refining / storage	2.0677	17.46%	37.41%	2
1A5a	Other stationary (including military)	1.8639	15.74%	53.15%	3
1A1c	Manufacture of solid fuels and other energy industries	1.6156	13.64%	66.79%	4
2C1	Iron and steel production	1.3353	11.28%	78.07%	5
1A3bvi	Road transport: Automobile tyre and brake wear	0.5086	4.30%	82.37%	6

Table 1.3.17 Key Categories for Se (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A1a	Public electricity and heat production	5.7349	84.11%	84.11%	1

Table 1.3.18 Key Categories for Zn (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	70.144	54.28%	54.28%	1
1A3bvi	Road transport: Automobile tyre and brake wear	22.587	17.48%	71.75%	2
2C1	Iron and steel production	13.504	10.45%	82.20%	3
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	4.585	3.55%	85.75%	4

Table 1.3.19 Key Categories for PCDD/PCDF (2021)

NFR CODE	CATEGORY	Latest year estimate (g I-TEQ)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	106.441	50.52%	50.52%	1
5C1biii	Clinical waste incineration	49.781	23.63%	74.15%	2
2C1	Iron and steel production	31.852	15.12%	89.27%	3

Table 1.3.20 Key Categories for Total PAHs (2021)

NFR CODE	CATEGORY	Latest year estimate (t)	Level assessment (%)	Cumulative total (%)	Rank
1A4bi	Residential: Stationary	47.689	80.16%	80.16%	1

Table 1.3.21 Key Categories for HCB (2021)

NFR CODE	CATEGORY	Latest year estimate (kg)	Level assessment (%)	Cumulative total (%)	Rank
5C1biii	Clinical waste incineration	1.778	49.48%	49.48%	1
1A1a	Public electricity and heat production	0.899	25.01%	74.50%	2
1A4bi	Residential: Stationary	0.682	18.98%	93.48%	3

Table 1.3.22 Key Categories for PCBs (2021)

NFR CODE	CATEGORY	Latest year estimate (kg)	Level assessment (%)	Cumulative total (%)	Rank
2C1	Iron and steel production	13.943	70.45%	70.45%	1
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	3.881	19.61%	90.06%	2

Table 1.3.23 Key Categories by activity/pollutant – Main pollutants (2021)

Category		Main Pollutants (%)								
		NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
1A1a	Public electricity and heat production	10.24%		46.76%						
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	2.71%		31.02%						
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals	5.33%		5.99%						
1A3bi	Road transport: Passenger cars	14.49%	4.76%						6.63%	9.82%
1A3bii	Road transport: Light duty vehicles	5.57%								
1A3biii	Road transport: Heavy duty vehicles and buses	19.28%							4.37%	
1A3c	Railways	3.16%								
1A4bi	Residential: Stationary	7.27%	33.71%		5.93%	83.78%	63.53%	45.22%	72.59%	56.80%
1B1a	Fugitive emission from solid fuels: Coal mining and handling		1.81%							
1B2aiv	Fugitive emissions oil: Refining and storage		1.76%							13.71%
2A2	Lime production							3.03%		
2A5a	Quarrying and mining of minerals other than coal						3.17%	4.38%		
2B10a	Chemical industry: Other (please specify in the IIR)							7.73%		
2D3a	Domestic solvent use including fungicides		4.25%							
2D3b	Road paving with asphalt						1.98%	10.04%		
2D3d	Coating applications		1.63%							
2D3g	Chemical products		7.18%							
2D3i	Other solvent use (please specify in the IIR)		1.96%							
2H2	Food and beverages industry		3.50%							
3B1a	Manure management - Dairy cattle		5.78%		8.33%					
3B1b	Manure management - Non-dairy cattle		2.29%							
3B3	Manure management - Swine				10.07%					
3B4gi	Manure management - Laying hens							3.44%		
3B4gii	Manure management - Broilers		1.48%							
3Da1	Inorganic N-fertilizers (includes also urea application)	10.06%			18.92%					
3Da2a	Animal manure applied to soils	3.84%	6.38%		24.69%					
3Da3	Urine and dung deposited by grazing animals				11.90%					
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products						13.11%	8.87%		

Category		Main Pollutants (%)								
		NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	PM_{10}	TSP	BC	CO
3De	Cultivated crops		4.85%							
5D3	Other wastewater handling				3.96%					
Cumulatively		81.96%	81.35%	83.77%	83.81%	83.78%	81.79%	82.71%	83.59%	80.32%

Table 1.3.24 Key Categories by activity/pollutant – Heavy Metals (2021)

Category		Heavy Metals (%)								
		Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
1A1a	Public electricity and heat production		7.97%	23.20%	53.08%			19.95%	84.11%	NK
1A1c	Manufacture of solid fuels and other energy industries							13.64%		NK
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel	6.59%		11.32%						3.55%
1A2f	Stationary combustion in manufacturing industries and construction: Non-metallic minerals			23.18%						NK
1A3bvi	Road transport: Automobile tyre and brake wear	19.23%				22.47%	93.31%	4.30%		17.48%
1A4bi	Residential: Stationary	8.47%	56.52%			21.23%				54.28%
1A5a	Other stationary (including military)							15.74%		NK
1B2aiv	Fugitive emissions oil: Refining and storage		6.81%	13.86%				17.46%		NK
2C1	Iron and steel production	51.68%	12.06%	12.92%	27.92%	37.56%		11.28%		10.45%
Cumulatively		85.98%	83.35%	84.48%	81.00%	81.26%	93.31%	82.37%	84.11%	85.75%

Table 1.3.25 Key Categories by activity/pollutant – POPs (2021)

Category		POPs (%)			
		PCDD/F	Total PAHs	HCB	PCBs
1A1a	Public electricity and heat production			25.01%	
1A2a	Stationary combustion in manufacturing industries and construction: Iron and steel				19.61%
1A4bi	Residential: Stationary	50.52%	80.16%	18.98%	
2C1	Iron and steel production	15.12%			70.45%
5C1biii	Clinical waste incineration	23.63%		49.48%	
Cumulatively		89.27%	80.16%	93.48%	90.06%

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 minimising 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 analysed, 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, NH3 and PM2.5) 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 2021
and trend for 1990 -2021

Pollutant	Unit	Emissions 2021	Level uncertainty 2021 (%)	Trend uncertainty 2021 (%)
NOx, (as NO_2)	kt	214.16	18.46%	5.79%
NMVOC	kt	234.22	45.58%	23.25%
SOx , (as SO_2)	kt	66.28	16.55%	0.98%
NH_3	kt	158.60	37.31%	6.64%
$PM_{2.5}$	kt	116.14	52.38%	58.87%

Uncertainty estimation of NOx emissions 1990 and 2021

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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	21.938	3	20	20.0	4.196	-0.093	0.046	-1.844	0.196	3.438
1A1b Liquid Fuels	NOx	1.494	0.100	3	65	65.1	0.001	-0.001	0.000	-0.079	0.001	0.006
1A1b Gaseous Fuels	NOx	5.943	1.521	3	55	55.1	0.153	-0.002	0.003	-0.135	0.014	0.018
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	3.955	3	112	112.0	4.281	0.008	0.008	0.888	0.035	0.789
1A1c Gaseous Fuels	NOx	0.000	0.364	3	50	50.1	0.007	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	3.949	3	51	51.1	0.888	-0.006	0.008	-0.292	0.035	0.087
1A2a Gaseous Fuels	NOx	12.863	1.856	3	50	50.1	0.188	-0.008	0.004	-0.418	0.017	0.175
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	0.022	3	50	50.1	0.000	0.000	0.000	0.002	0.000	0.000
1A2c Solid Fuels	NOx	1.206	0.011	3	51	51.1	0.000	-0.001	0.000	-0.057	0.000	0.003
1A2c Gaseous Fuels	NOx	24.770	4.108	3	50	50.1	0.923	-0.015	0.009	-0.748	0.037	0.560
1A2c Biomass	NOx	0.000	0.016	3	38	38.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2d Solid Fuels	NOx	0.000	0.024	3	51	51.1	0.000	0.000	0.000	0.003	0.000	0.000
1A2d Gaseous Fuels	NOx	0.000	0.443	3	50	50.1	0.011	0.001	0.001	0.047	0.004	0.002
1A2d Biomass	NOx	0.000	0.017	3	38	38.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2e Liquid Fuels	NOx	0.000	0.004	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Solid Fuels	NOx	0.223	0.064	3	51	51.1	0.000	0.000	0.000	-0.004	0.001	0.000
1A2e Gaseous Fuels	NOx	0.000	1.068	3	50	50.1	0.062	0.002	0.002	0.113	0.010	0.013
1A2e Biomass	NOx	0.000	0.101	3	38	38.1	0.000	0.000	0.000	0.008	0.001	0.000
1A2f clinker	NOx	0.000	9.636	3	101	101.0	20.672	0.020	0.020	2.054	0.086	4.227
1A2f Liquid Fuels	NOx	0.000	0.559	3	50	50.1	0.017	0.001	0.001	0.059	0.005	0.004

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	$K^2 + L^2$
1A2f Solid Fuels	NOx	0.491	0.193	3	51	51.1	0.002	0.000	0.000	-0.003	0.002	0.000
1A2f Gaseous Fuels	NOx	0.000	1.017	3	50	50.1	0.057	0.002	0.002	0.107	0.009	0.012
1A2f Biomass	NOx	0.000	0.001	3	38	38.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2gvii	NOx	0.000	3.823	3	100	100.0	3.190	0.008	0.008	0.807	0.034	0.652
1A2gviii Liquid Fuels	NOx	31.171	0.042	3	50	50.1	0.000	-0.030	0.000	-1.481	0.000	2.195
1A2gviii Solid Fuels	NOx	1.486	0.003	3	51	51.1	0.000	-0.001	0.000	-0.072	0.000	0.005
1A2gviii Gaseous Fuels	NOx	18.268	1.691	3	50	50.1	0.156	-0.014	0.004	-0.693	0.015	0.480
1A2gviii Biomass	NOx	0.000	0.616	3	38	38.1	0.012	0.001	0.001	0.049	0.006	0.002
1A3ai(i)	NOx	0.401	0.431	5	50	50.2	0.010	0.001	0.001	0.026	0.006	0.001
1A3aii(i)	NOx	0.013	0.061	5	50	50.2	0.000	0.000	0.000	0.006	0.001	0.000
1A3bi	NOx	59.421	31.035	3	50	50.1	52.690	0.009	0.066	0.440	0.278	0.271
1A3bii	NOx	4.192	11.927	3	50	50.1	7.782	0.021	0.025	1.059	0.107	1.132
1A3biii	NOx	38.209	41.292	3	50	50.1	93.271	0.051	0.087	2.533	0.370	6.552
1A3biv	NOx	0.235	0.075	3	50	50.1	0.000	0.000	0.000	-0.003	0.001	0.000
1A3c	NOx	7.019	6.760	5	56	56.2	3.149	0.008	0.014	0.424	0.101	0.190
1A3dii	NOx	22.596	3.673	5	100	100.1	2.950	-0.014	0.008	-1.380	0.055	1.906
1A4ai Liquid Fuels	NOx	0.000	0.051	3	112	112.0	0.001	0.000	0.000	0.012	0.000	0.000
1A4ai Solid Fuels	NOx	0.000	0.019	3	51	51.1	0.000	0.000	0.000	0.002	0.000	0.000
1A4ai Gaseous Fuels	NOx	0.000	2.666	3	50	50.1	0.389	0.006	0.006	0.281	0.024	0.080
1A4ai Biomass	NOx	0.000	0.355	3	38	38.1	0.004	0.001	0.001	0.028	0.003	0.001
1A4aii	NOx	0.000	0.372	3	100	100.0	0.030	0.001	0.001	0.079	0.003	0.006
1A4bi Liquid Fuels	NOx	0.186	0.035	3	50	50.1	0.000	0.000	0.000	-0.005	0.000	0.000
1A4bi Solid Fuels	NOx	3.599	0.214	3	54	54.1	0.003	-0.003	0.000	-0.161	0.002	0.026
1A4bi Gaseous Fuels	NOx	5.331	8.155	3	50	50.1	3.638	0.012	0.017	0.606	0.073	0.373
1A4bi Biomass	NOx	1.234	7.176	3	90	90.0	9.104	0.014	0.015	1.257	0.064	1.584

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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 Liquid Fuels	NOx	0.038	0.956	3	112	112.0	0.250	0.002	0.002	0.222	0.009	0.049
1A4ci Solid Fuels	NOx	0.113	0.128	3	51	51.1	0.001	0.000	0.000	0.008	0.001	0.000
1A4ci Gaseous Fuels	NOx	2.570	0.392	3	50	50.1	0.008	-0.002	0.001	-0.081	0.004	0.007
1A4ci Biomass	NOx	0.000	0.028	3	38	38.1	0.000	0.000	0.000	0.002	0.000	0.000
1A4cii	NOx	0.000	1.835	3	100	100.0	0.735	0.004	0.004	0.387	0.016	0.150
1A5a Liquid Fuels	NOx	0.140	4.563	3	112	112.0	5.698	0.009	0.010	1.064	0.041	1.133
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	0.678	2	51	51.0	0.026	0.001	0.001	0.035	0.004	0.001
1B2c	NOx	0.263	0.145	2	80	80.0	0.003	0.000	0.000	0.004	0.001	0.000
2B1	NOx	2.178	0.439	2	120	120.0	0.061	-0.001	0.001	-0.138	0.003	0.019
2B2	NOx	9.708	0.281	5	55	55.2	0.005	-0.009	0.001	-0.477	0.004	0.227
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	0.158	2	44	44.0	0.001	0.000	0.000	-0.001	0.001	0.000
2C3	NOx	0.168	0.202	2	100	100.0	0.009	0.000	0.000	0.027	0.001	0.001
2G	NOx	0.049	0.045	2	50	50.0	0.000	0.000	0.000	0.002	0.000	0.000
2H1	NOx	0.380	0.000	2	86	86.0	0.000	0.000	0.000	-0.031	0.000	0.001
3B1a	NOx	2.191	0.565	10	300	300.2	0.628	-0.001	0.001	-0.269	0.017	0.073
3B1b	NOx	0.487	0.114	10	300	300.2	0.026	0.000	0.000	-0.067	0.003	0.005
3B2	NOx	0.169	0.121	10	300	300.2	0.029	0.000	0.000	0.028	0.004	0.001
3B3	NOx	0.403	0.080	10	300	300.2	0.012	0.000	0.000	-0.065	0.002	0.004
3B4a	NOx	0.005	0.002	10	300	300.2	0.000	0.000	0.000	-0.001	0.000	0.000
3B4d	NOx	0.012	0.018	10	300	300.2	0.001	0.000	0.000	0.008	0.001	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	$K^2 + L^2$
3B4e	NOx	0.168	0.094	10	300	300.2	0.017	0.000	0.000	0.011	0.003	0.000
3B4gi	NOx	0.721	0.589	10	300	300.2	0.680	0.001	0.001	0.166	0.018	0.028
3B4gii	NOx	1.887	0.994	10	300	300.2	1.941	0.000	0.002	0.089	0.030	0.009
3B4giii	NOx	0.000	0.025	2	300	300.0	0.001	0.000	0.000	0.016	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	21.544	25	100	103.1	107.527	0.020	0.045	2.042	1.608	6.756
3Da2a	NOx	19.126	8.230	20	100	102.0	15.359	-0.001	0.017	-0.088	0.491	0.249
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	255	255.8	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	0.032	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	0.425	2	83	83.0	0.027	0.000	0.001	0.039	0.003	0.001
Total		**473.801**	**214.16**				**340.88**					**33.51**
Total Uncertainties						**Uncertainty in total inventory %:**	**18.46**				**Trend uncertainty %:**	**5.79**

Uncertainty estimation of NMVOC emissions 1990 and 2021

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	$K^2 + L^2$
1A1a	NMVOC	2.011	0.600	3	100	100.0	0.066	-0.001	0.002	-0.150	0.006	0.022
1A1b Liquid Fuels	NMVOC	0.024	0.002	3	50	50.1	0.000	0.000	0.000	-0.002	0.000	0.000
1A1b Gaseous Fuels	NMVOC	0.174	0.044	3	106	106.0	0.000	0.000	0.000	-0.016	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	0.258	3	88	88.1	0.009	0.001	0.001	0.054	0.003	0.003
1A1c Gaseous Fuels	NMVOC	0.000	0.113	3	51	51.1	0.001	0.000	0.000	0.015	0.001	0.000
1A1c Biomass	NMVOC	0.000	0.000	3	42	42.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2a Solid Fuels	NMVOC	7.566	2.027	3	87	87.1	0.568	-0.006	0.005	-0.540	0.022	0.292
1A2a Gaseous Fuels	NMVOC	3.998	0.577	3	51	51.1	0.016	-0.005	0.001	-0.231	0.006	0.053
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	0.001	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	-0.079	0.000	0.006
1A2c Gaseous Fuels	NMVOC	7.699	1.277	3	51	51.1	0.078	-0.008	0.003	-0.424	0.014	0.180
1A2c Biomass	NMVOC	0.000	0.053	3	42	42.1	0.000	0.000	0.000	0.006	0.001	0.000
1A2d Solid Fuels	NMVOC	0.000	0.013	3	87	87.1	0.000	0.000	0.000	0.003	0.000	0.000
1A2d Gaseous Fuels	NMVOC	0.000	0.138	3	51	51.1	0.001	0.000	0.000	0.018	0.001	0.000
1A2d Biomass	NMVOC	0.000	0.055	3	42	42.1	0.000	0.000	0.000	0.006	0.001	0.000
1A2e Liquid Fuels	NMVOC	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Solid Fuels	NMVOC	0.115	0.033	3	87	87.1	0.000	0.000	0.000	-0.008	0.000	0.000
1A2e Gaseous Fuels	NMVOC	0.000	0.332	3	51	51.1	0.005	0.001	0.001	0.043	0.004	0.002
1A2e Biomass	NMVOC	0.000	0.334	3	42	42.1	0.004	0.001	0.001	0.036	0.004	0.001
1A2f clinker	NMVOC	0.000	0.140	3	195	195.0	0.014	0.000	0.000	0.069	0.002	0.005
1A2f Liquid Fuels	NMVOC	0.000	0.027	3	50	50.1	0.000	0.000	0.000	0.003	0.000	0.000
1A2f Solid Fuels	NMVOC	0.252	0.099	3	87	87.1	0.001	0.000	0.000	-0.011	0.001	0.000
1A2f Gaseous Fuels	NMVOC	0.000	0.316	3	51	51.1	0.005	0.001	0.001	0.041	0.003	0.002
1A2f Biomass	NMVOC	0.000	0.004	3	42	42.1	0.000	0.000	0.000	0.000	0.000	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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	0.845	3	100	100.0	0.130	0.002	0.002	0.214	0.009	0.046
1A2gviii Liquid Fuels	NMVOC	1.519	0.002	3	50	50.1	0.000	-0.002	0.000	-0.114	0.000	0.013
1A2gviii Solid Fuels	NMVOC	0.763	0.002	3	87	87.1	0.000	-0.001	0.000	-0.099	0.000	0.010
1A2gviii Gaseous Fuels	NMVOC	5.678	0.525	3	51	51.1	0.013	-0.007	0.001	-0.366	0.006	0.134
1A2gviii Biomass	NMVOC	0.000	2.029	3	42	42.1	0.133	0.005	0.005	0.216	0.022	0.047
1A3ai(i)	NMVOC	0.049	0.022	5	50	50.2	0.000	0.000	0.000	-0.001	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	11.145	3	50	50.1	5.681	-0.073	0.028	-3.630	0.120	13.190
1A3bii	NMVOC	2.905	1.970	3	50	50.1	0.177	0.001	0.005	0.031	0.021	0.001
1A3biii	NMVOC	3.762	2.504	3	50	50.1	0.287	0.001	0.006	0.035	0.027	0.002
1A3biv	NMVOC	7.983	0.637	3	50	50.1	0.019	-0.010	0.002	-0.518	0.007	0.268
1A3bv	NMVOC	3.919	3.071	3	50	50.1	0.431	0.002	0.008	0.095	0.033	0.010
1A3c	NMVOC	0.623	0.600	5	54	54.2	0.019	0.001	0.002	0.032	0.011	0.001
1A3dii	NMVOC	0.546	0.089	5	100	100.1	0.001	-0.001	0.000	-0.059	0.002	0.004
1A4ai Liquid Fuels	NMVOC	0.000	0.003	3	88	88.1	0.000	0.000	0.000	0.001	0.000	0.000
1A4ai Solid Fuels	NMVOC	0.000	0.010	3	87	87.1	0.000	0.000	0.000	0.002	0.000	0.000
1A4ai Gaseous Fuels	NMVOC	0.000	0.829	3	51	51.1	0.033	0.002	0.002	0.107	0.009	0.012
1A4ai Biomass	NMVOC	0.000	0.608	3	42	42.1	0.012	0.002	0.002	0.065	0.007	0.004
1A4aii	NMVOC	0.000	1.544	3	100	100.0	0.435	0.004	0.004	0.391	0.017	0.153
1A4bi Liquid Fuels	NMVOC	0.003	0.000	3	51	51.1	0.000	0.000	0.000	0.000	0.000	0.000
1A4bi Solid Fuels	NMVOC	15.835	0.941	3	56	56.1	0.051	-0.021	0.002	-1.195	0.010	1.429
1A4bi Gaseous Fuels	NMVOC	0.199	0.304	3	49	49.1	0.004	0.000	0.001	0.023	0.003	0.001
1A4bi Biomass	NMVOC	14.218	77.708	3	126	126.0	1748.600	0.175	0.197	22.076	0.834	488.051
1A4ci Liquid Fuels	NMVOC	0.002	0.062	3	88	88.1	0.001	0.000	0.000	0.014	0.001	0.000
1A4ci Solid Fuels	NMVOC	0.058	0.066	3	87	87.1	0.001	0.000	0.000	0.007	0.001	0.000
1A4ci Gaseous Fuels	NMVOC	0.799	0.122	3	51	51.1	0.001	-0.001	0.000	-0.045	0.001	0.002
1A4ci Biomass	NMVOC	0.000	0.092	3	42	42.1	0.000	0.000	0.000	0.010	0.001	0.000
1A4cii	NMVOC	0.000	0.502	3	100	100.0	0.046	0.001	0.001	0.127	0.005	0.016

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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	0.298	3	88	88.1	0.013	0.001	0.001	0.065	0.003	0.004
1A5a Solid Fuels	NMVOC	1.082	0.000	0	0	0.0	0.000	-0.002	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	4.249	3	68	68.1	1.524	-0.041	0.011	-2.759	0.046	7.616
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	2.015	3	801	801.0	47.493	-0.002	0.005	-1.676	0.022	2.811
1B2aiv	NMVOC	3.359	4.133	2	77	77.0	1.847	0.005	0.010	0.417	0.030	0.175
1B2av	NMVOC	4.721	0.552	3	2	3.6	0.000	-0.006	0.001	-0.011	0.006	0.000
1B2b	NMVOC	3.567	1.250	3	1550	1550.0	68.459	-0.002	0.003	-3.384	0.013	11.449
1B2c	NMVOC	0.338	0.018	2	74	74.0	0.000	0.000	0.000	-0.034	0.000	0.001
2A3	NMVOC	0.013	0.011	5	145	145.1	0.000	0.000	0.000	0.001	0.000	0.000
2B10a	NMVOC	14.772	3.433	2	57	57.0	0.699	-0.013	0.009	-0.767	0.025	0.588
2C1	NMVOC	1.546	0.540	2	71	71.0	0.027	-0.001	0.001	-0.068	0.004	0.005
2D3a	NMVOC	14.288	9.965	3	40	40.1	2.912	0.004	0.025	0.152	0.107	0.034
2D3b	NMVOC	0.007	0.025	3	161	161.0	0.000	0.000	0.000	0.009	0.000	0.000
2D3c	NMVOC	0.013	0.000	3	85	85.1	0.000	0.000	0.000	-0.002	0.000	0.000
2D3d	NMVOC	1.058	3.823	2	2	2.8	0.002	0.008	0.010	0.016	0.027	0.001
2D3e	NMVOC	2.557	0.000	3	39	39.1	0.000	-0.004	0.000	-0.149	0.000	0.022
2D3f	NMVOC	1.242	0.175	3	50	50.1	0.001	-0.001	0.000	-0.071	0.002	0.005
2D3g	NMVOC	19.061	16.808	2	45	45.0	10.449	0.014	0.043	0.627	0.120	0.408
2D3h	NMVOC	0.000	0.607	2	2	2.8	0.000	0.002	0.002	0.003	0.004	0.000
2D3i	NMVOC	5.971	4.584	2	8	8.2	0.026	0.003	0.012	0.021	0.033	0.002
2G	NMVOC	0.131	0.507	2	51	51.0	0.012	0.001	0.001	0.055	0.004	0.003
2H1	NMVOC	0.760	0.001	3	63	63.1	0.000	-0.001	0.000	-0.072	0.000	0.005
2H2	NMVOC	10.009	8.202	3	237	237.0	68.894	0.006	0.021	1.362	0.088	1.862
3B1a	NMVOC	30.163	13.529	10	100	100.5	33.698	-0.011	0.034	-1.098	0.484	1.439
3B1b	NMVOC	17.906	5.373	10	100	100.5	5.316	-0.013	0.014	-1.324	0.192	1.790
3B2	NMVOC	2.423	1.738	10	200	200.2	2.209	0.001	0.004	0.153	0.062	0.027
3B3	NMVOC	7.710	2.339	10	200	200.2	3.998	-0.006	0.006	-1.128	0.084	1.279

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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	0.081	10	200	200.2	0.005	0.000	0.000	-0.044	0.003	0.002
3B4d	NMVOC	0.547	0.813	10	200	200.2	0.483	0.001	0.002	0.247	0.029	0.062
3B4e	NMVOC	2.864	1.601	10	200	200.2	1.873	0.000	0.004	-0.049	0.057	0.006
3B4gi	NMVOC	2.230	1.705	10	100	100.5	0.535	0.001	0.004	0.097	0.061	0.013
3B4gii	NMVOC	6.569	3.461	10	100	100.5	2.206	-0.001	0.009	-0.109	0.124	0.027
3B4giii	NMVOC	0.003	0.455	2	200	200.0	0.151	0.001	0.001	0.229	0.003	0.053
3B4giv	NMVOC	0.010	0.022	2	200	200.0	0.000	0.000	0.000	0.008	0.000	0.000
3B4h	NMVOC	0.078	0.014	10	200	200.2	0.000	0.000	0.000	-0.016	0.000	0.000
3Da2a	NMVOC	39.505	14.954	10	100	100.5	41.172	-0.021	0.038	-2.136	0.535	4.850
3Da3	NMVOC	1.467	0.592	10	100	100.5	0.065	-0.001	0.001	-0.070	0.021	0.005
3De	NMVOC	10.416	11.365	2	106	106.0	26.463	0.013	0.029	1.392	0.081	1.945
3F	NMVOC	0.024	0.022	5	250	250.0	0.001	0.000	0.000	0.005	0.000	0.000
5A	NMVOC	0.650	2.048	20	56	59.5	0.270	0.004	0.005	0.235	0.147	0.077
5C1bi	NMVOC	0.002	0.020	20	253	253.8	0.000	0.000	0.000	0.012	0.001	0.000
5C1biii	NMVOC	0.002	0.012	20	61	64.2	0.000	0.000	0.000	0.002	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	0.165	2	84	84.0	0.003	0.000	0.000	0.013	0.001	0.000
5D3	NMVOC	0.000	0.025	2	92	92.0	0.000	0.000	0.000	0.006	0.000	0.000
Total		**395.30**	**234.22**				**2077.65**					**540.53**
Total Uncertainties						**Uncertainty in total inventory %:**	**45.58**				**Trend uncertainty %:**	**23.25**

Uncertainty estimation of SOx emissions 1990 and 2021

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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	SOx	646.896	30.995	3	20	20.2	89.430	-0.026	0.038	-0.517	0.160	0.293
1A1b Liquid Fuels	SOx	5.207	0.350	3	93	93.0	0.241	0.000	0.000	-0.008	0.002	0.000
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	1.215	3	45	45.1	0.683	0.001	0.001	0.066	0.006	0.004
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	20.545	3	40	40.1	154.575	0.017	0.025	0.699	0.106	0.501
1A2a Gaseous Fuels	SOx	0.116	0.017	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	0.002	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2c Solid Fuels	SOx	6.275	0.058	3	40	40.1	0.001	-0.001	0.000	-0.022	0.000	0.000
1A2c Gaseous Fuels	SOx	0.224	0.037	3	50	50.1	0.001	0.000	0.000	0.001	0.000	0.000
1A2c Biomass	SOx	0.000	0.002	3	46	46.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2d Solid Fuels	SOx	0.000	0.127	3	40	40.1	0.006	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	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Solid Fuels	SOx	1.162	0.333	3	40	40.1	0.041	0.000	0.000	0.012	0.002	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	0.012	3	46	46.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2f clinker	SOx	0.000	2.904	3	50	50.1	4.816	0.004	0.004	0.177	0.015	0.032
1A2f Liquid Fuels	SOx	0.000	0.051	3	50	50.1	0.002	0.000	0.000	0.003	0.000	0.000
1A2f Solid Fuels	SOx	2.552	1.005	3	40	40.1	0.370	0.001	0.001	0.039	0.005	0.002

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	$K^2 + L^2$
1A2f Gaseous Fuels	SOx	0.000	0.009	3	50	50.1	0.000	0.000	0.000	0.001	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	0.004	3	50	50.1	0.000	0.000	0.000	-0.014	0.000	0.000
1A2gviii Solid Fuels	SOx	7.731	0.017	3	40	40.1	0.000	-0.001	0.000	-0.030	0.000	0.001
1A2gviii Gaseous Fuels	SOx	0.165	0.015	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2gviii Biomass	SOx	0.000	0.074	3	46	46.1	0.003	0.000	0.000	0.004	0.000	0.000
1A3ai(i)	SOx	0.029	0.026	5	20	20.6	0.000	0.000	0.000	0.001	0.000	0.000
1A3aii(i)	SOx	0.001	0.004	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
1A3bi	SOx	0.707	0.061	3	20	20.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3bii	SOx	0.100	0.016	3	20	20.2	0.000	0.000	0.000	0.000	0.000	0.000
1A3biii	SOx	0.798	0.040	3	20	20.2	0.000	0.000	0.000	-0.001	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	0.003	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
1A3dii	SOx	17.658	0.102	5	40	40.3	0.004	-0.002	0.000	-0.065	0.001	0.004
1A4ai Liquid Fuels	SOx	0.000	0.016	3	45	45.1	0.000	0.000	0.000	0.001	0.000	0.000
1A4ai Solid Fuels	SOx	0.000	0.092	3	43	43.1	0.004	0.000	0.000	0.005	0.000	0.000
1A4ai Gaseous Fuels	SOx	0.000	0.024	3	50	50.1	0.000	0.000	0.000	0.001	0.000	0.000
1A4ai Biomass	SOx	0.000	0.043	3	109	109.0	0.005	0.000	0.000	0.006	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	0.048	3	50	50.1	0.001	0.000	0.000	0.002	0.000	0.000
1A4bi Solid Fuels	SOx	29.444	1.751	3	36	36.1	0.910	-0.001	0.002	-0.028	0.009	0.001
1A4bi Gaseous Fuels	SOx	0.031	0.048	3	50	50.1	0.001	0.000	0.000	0.003	0.000	0.000
1A4bi Biomass	SOx	0.265	1.498	3	109	109.0	6.071	0.002	0.002	0.196	0.008	0.039
1A4ci Liquid Fuels	SOx	0.012	0.294	3	45	45.1	0.040	0.000	0.000	0.016	0.002	0.000
1A4ci Solid Fuels	SOx	0.548	0.621	3	43	43.1	0.163	0.001	0.001	0.030	0.003	0.001

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	K² + L²
1A4ci Gaseous Fuels	SOx	0.023	0.004	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A4ci Biomass	SOx	0.000	0.003	3	109	109.0	0.000	0.000	0.000	0.000	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	1.402	3	43	43.1	0.831	0.002	0.002	0.073	0.007	0.005
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	0.849	2	66	66.0	0.715	0.000	0.001	0.033	0.003	0.001
1B2c	SOx	0.002	0.193	2	50	50.0	0.021	0.000	0.000	0.012	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	0.062	2	64	64.0	0.004	0.000	0.000	0.004	0.000	0.000
2C3	SOx	0.839	1.010	2	250	250.0	14.501	0.001	0.001	0.287	0.003	0.083
2C4	SOx	0.000	0.179	2	226	226.0	0.372	0.000	0.000	0.049	0.001	0.002
2C5	SOx	0.019	0.067	2	64	64.0	0.004	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	0.003	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	-0.004	0.000	0.000
3F	SOx	0.002	0.002	20	268	268.7	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	0.002	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	0.015	2	82	82.0	0.000	0.000	0.000	0.001	0.000	0.000
Total		**819.34**	**66.28**				**273.82**					**0.97**
Total Uncertainties						**Uncertainty in total inventory %:**	**16.55**				**Trend uncertainty %:**	**0.98**

Uncertainty estimation of NH_3 emissions 1990 and 2021

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	$K^2 + L^2$
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	0.008	3	50	50.1	0.000	0.000	0.000	0.001	0.000	0.000
1A3bi	NH3	2.825	0.809	3	50	50.1	0.065	-0.002	0.003	-0.092	0.011	0.009
1A3bii	NH3	0.122	0.055	3	50	50.1	0.000	0.000	0.000	-0.001	0.001	0.000
1A3biii	NH3	0.018	0.067	3	50	50.1	0.000	0.000	0.000	0.009	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	0.144	3	62	62.1	0.003	0.000	0.000	0.028	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	-0.008	0.000	0.000
1A4bi biomass	NH3	1.691	9.412	3	63	63.1	14.009	0.027	0.029	1.686	0.125	2.860
1A4ci biomass	NH3	0.000	0.011	3	62	62.1	0.000	0.000	0.000	0.002	0.000	0.000
1A4cii	NH3	0.000	0.002	3	200	200.0	0.000	0.000	0.000	0.001	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 (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	K² + L²
1B2aiv	NH3	0.628	0.003	2	49	49.0	0.000	-0.001	0.000	-0.047	0.000	0.002
2A3	NH3	0.037	0.030	5	121	121.1	0.001	0.000	0.000	0.005	0.001	0.000
2B1	NH3	0.022	0.004	5	95	95.1	0.000	0.000	0.000	-0.002	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	0.184	2	160	160.0	0.034	0.001	0.001	0.092	0.002	0.008
2G	NH3	0.112	0.103	2	50	50.0	0.001	0.000	0.000	0.007	0.001	0.000
3B1a	NH3	32.471	13.216	10	100	100.5	70.133	-0.009	0.041	-0.893	0.584	1.138
3B1b	NH3	16.171	6.178	10	100	100.5	15.328	-0.006	0.019	-0.571	0.273	0.400
3B2	NH3	6.832	4.901	10	100	100.5	9.644	0.005	0.015	0.474	0.216	0.271
3B3	NH3	51.838	15.977	10	100	100.5	102.503	-0.030	0.050	-3.021	0.705	9.623
3B4a	NH3	0.278	0.079	10	150	150.3	0.006	0.000	0.000	-0.027	0.003	0.001
3B4d	NH3	0.402	0.597	10	150	150.3	0.320	0.001	0.002	0.186	0.026	0.035
3B4e	NH3	4.690	2.621	10	150	150.3	6.172	0.001	0.008	0.140	0.116	0.033
3B4gi	NH3	5.772	4.413	10	100	100.5	7.820	0.005	0.014	0.485	0.195	0.273
3B4gii	NH3	9.084	4.787	10	150	150.3	20.586	0.001	0.015	0.135	0.211	0.063
3B4giii	NH3	0.003	0.521	2	100	100.0	0.108	0.002	0.002	0.162	0.005	0.026
3B4giv	NH3	0.009	0.021	2	100	100.0	0.000	0.000	0.000	0.005	0.000	0.000
3B4h	NH3	0.027	0.005	10	100	100.5	0.000	0.000	0.000	-0.003	0.000	0.000
3Da1	NH3	41.569	30.012	25	100	103.1	380.481	0.029	0.094	2.940	3.313	19.618
3Da2a	NH3	94.607	39.150	10	100	100.5	615.443	-0.024	0.122	-2.396	1.729	8.727
3Da2b	NH3	0.019	0.073	25	100	103.1	0.002	0.000	0.000	0.020	0.008	0.000
3Da3	NH3	35.054	18.879	10	100	100.5	143.112	0.005	0.059	0.474	0.834	0.920
3F	NH3	0.014	0.014	20	250	250.8	0.000	0.000	0.000	0.005	0.001	0.000

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	$K^2 + L^2$
5B1	NH3	0.000	0.023	2	83	83.0	0.000	0.000	0.000	0.006	0.000	0.000
5B2	NH3	0.000	0.015	10	58	58.9	0.000	0.000	0.000	0.003	0.001	0.000
5D3	NH3	15.403	6.275	2	63	63.0	6.220	-0.004	0.020	-0.266	0.055	0.074
Total		**320.29**	**158.60**				**1391.99**					**44.08**
Total Uncertainties					**Uncertainty in total inventory %:**		**37.31**				**Trend uncertainty %:**	**6.64**

Uncertainty estimation of $PM_{2.5}$ emissions 1990 and 2021

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	$K^2 + L^2$
1A1a	PM2.5	16.263	1.317	3	3	4.2	0.002	-0.299	0.017	-0.896	0.072	0.808
1A1b Liquid Fuels	PM2.5	0.203	0.014	3	118	118.0	0.000	-0.004	0.000	-0.445	0.001	0.198
1A1b Gaseous Fuels	PM2.5	0.059	0.015	3	50	50.1	0.000	-0.001	0.000	-0.048	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	0.233	3	84	84.1	0.028	0.003	0.003	0.210	0.013	0.044
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	0.000	3	63	63.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2a Solid Fuels	PM2.5	9.202	2.465	3	65	65.1	1.908	-0.147	0.032	-9.546	0.135	91.136
1A2a Gaseous Fuels	PM2.5	0.136	0.020	3	50	50.1	0.000	-0.002	0.000	-0.119	0.001	0.014
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	0.001	3	50	50.1	0.000	0.000	0.000	0.001	0.000	0.000
1A2c Solid Fuels	PM2.5	0.753	0.007	3	65	65.1	0.000	-0.015	0.000	-0.946	0.000	0.895
1A2c Gaseous Fuels	PM2.5	0.261	0.043	3	50	50.1	0.000	-0.005	0.001	-0.226	0.002	0.051
1A2c Biomass	PM2.5	0.000	0.025	3	62	62.1	0.000	0.000	0.000	0.020	0.001	0.000
1A2d Solid Fuels	PM2.5	0.000	0.015	3	65	65.1	0.000	0.000	0.000	0.013	0.001	0.000
1A2d Gaseous Fuels	PM2.5	0.000	0.005	3	50	50.1	0.000	0.000	0.000	0.003	0.000	0.000
1A2d Biomass	PM2.5	0.000	0.026	3	62	62.1	0.000	0.000	0.000	0.021	0.001	0.000
1A2e Liquid Fuels	PM2.5	0.000	0.000	3	50	50.1	0.000	0.000	0.000	0.000	0.000	0.000
1A2e Solid Fuels	PM2.5	0.139	0.040	3	65	65.1	0.000	-0.002	0.001	-0.143	0.002	0.020
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	0.156	3	62	62.1	0.007	0.002	0.002	0.125	0.009	0.016
1A2f Liquid Fuels	PM2.5	0.000	0.022	3	50	50.1	0.000	0.000	0.000	0.014	0.001	0.000
1A2f Solid Fuels	PM2.5	0.306	0.121	3	65	65.1	0.005	-0.004	0.002	-0.286	0.007	0.082
1A2f Gaseous Fuels	PM2.5	0.000	0.011	3	50	50.1	0.000	0.000	0.000	0.007	0.001	0.000
1A2f Biomass	PM2.5	0.000	0.002	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 (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	K² + L²
1A2gvii	PM2.5	0.000	0.168	3	100	100.0	0.021	0.002	0.002	0.218	0.009	0.047
1A2gviii Liquid Fuels	PM2.5	1.215	0.002	3	50	50.1	0.000	-0.024	0.000	-1.180	0.000	1.393
1A2gviii Solid Fuels	PM2.5	0.928	0.002	3	65	65.1	0.000	-0.018	0.000	-1.171	0.000	1.371
1A2gviii Gaseous Fuels	PM2.5	0.193	0.018	3	50	50.1	0.000	-0.004	0.000	-0.176	0.001	0.031
1A2gviii Biomass	PM2.5	0.000	0.947	3	62	62.1	0.256	0.012	0.012	0.760	0.052	0.580
1A3ai(i)	PM2.5	0.004	0.005	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
1A3aii(i)	PM2.5	0.000	0.000	5	20	20.6	0.000	0.000	0.000	0.000	0.000	0.000
1A3bi	PM2.5	0.284	1.166	3	50	50.1	0.253	0.010	0.015	0.478	0.064	0.232
1A3bii	PM2.5	0.249	0.564	3	50	50.1	0.059	0.002	0.007	0.123	0.031	0.016
1A3biii	PM2.5	1.567	1.030	3	50	50.1	0.198	-0.017	0.013	-0.856	0.057	0.737
1A3biv	PM2.5	0.132	0.012	3	50	50.1	0.000	-0.002	0.000	-0.120	0.001	0.014
1A3bvi	PM2.5	0.374	1.133	3	50	50.1	0.239	0.007	0.015	0.370	0.062	0.141
1A3bvii	PM2.5	0.214	0.494	3	50	50.1	0.045	0.002	0.006	0.111	0.027	0.013
1A3c	PM2.5	0.184	0.177	5	130	130.1	0.039	-0.001	0.002	-0.167	0.016	0.028
1A3dii	PM2.5	1.530	0.051	5	40	40.3	0.000	-0.029	0.001	-1.164	0.005	1.355
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	0.012	3	65	65.1	0.000	0.000	0.000	0.010	0.001	0.000
1A4ai Gaseous Fuels	PM2.5	0.000	0.028	3	50	50.1	0.000	0.000	0.000	0.018	0.002	0.000
1A4ai Biomass	PM2.5	0.000	0.384	3	63	63.1	0.043	0.005	0.005	0.313	0.021	0.098
1A4aii	PM2.5	0.000	0.049	3	100	100.0	0.002	0.001	0.001	0.064	0.003	0.004
1A4bi Liquid Fuels	PM2.5	0.007	0.001	3	49	49.1	0.000	0.000	0.000	-0.006	0.000	0.000
1A4bi Solid Fuels	PM2.5	13.021	0.774	3	35	35.1	0.055	-0.243	0.010	-8.497	0.042	72.199
1A4bi Gaseous Fuels	PM2.5	0.125	0.192	3	50	50.1	0.007	0.000	0.002	0.002	0.011	0.000
1A4bi Biomass	PM2.5	17.572	96.336	3	63	63.1	2737.170	0.903	1.247	56.876	5.289	3262.880
1A4ci Liquid Fuels	PM2.5	0.002	0.056	3	84	84.1	0.002	0.001	0.001	0.058	0.003	0.003
1A4ci Solid Fuels	PM2.5	0.070	0.080	3	65	65.1	0.002	0.000	0.001	-0.022	0.004	0.000
1A4ci Gaseous Fuels	PM2.5	0.027	0.004	3	50	50.1	0.000	0.000	0.000	-0.024	0.000	0.001

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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
1A4ci Biomass	PM2.5	0.000	0.049	3	63	63.1	0.001	0.001	0.001	0.040	0.003	0.002
1A4cii	PM2.5	0.000	0.065	3	100	100.0	0.003	0.001	0.001	0.084	0.004	0.007
1A5a Liquid Fuels	PM2.5	0.008	0.268	3	84	84.1	0.038	0.003	0.003	0.278	0.015	0.078
1A5a Solid Fuels	PM2.5	1.315	0.000	0	0	0.0	0.000	-0.026	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	0.105	3	253	253.0	0.052	-0.002	0.001	-0.503	0.006	0.253
1B1b	PM2.5	0.242	0.000	0	0	0.0	0.000	-0.005	0.000	0.000	0.000	0.000
1B2aiv	PM2.5	0.943	0.814	2	60	60.0	0.177	-0.008	0.011	-0.468	0.030	0.220
1B2c	PM2.5	0.489	0.019	2	253	253.0	0.002	-0.009	0.000	-2.343	0.001	5.491
2A1	PM2.5	1.089	1.009	2	63	63.0	0.300	-0.008	0.013	-0.511	0.037	0.263
2A2	PM2.5	1.418	0.548	2	75	75.0	0.126	-0.020	0.007	-1.535	0.020	2.356
2A3	PM2.5	0.146	0.077	5	444	444.0	0.088	-0.002	0.001	-0.818	0.007	0.670
2A5a	PM2.5	0.127	0.499	5	63	63.2	0.074	0.004	0.006	0.251	0.046	0.065
2A5b	PM2.5	0.058	0.106	5	86	86.1	0.006	0.000	0.001	0.022	0.010	0.001
2B10a	PM2.5	0.015	0.066	2	63	63.0	0.001	0.001	0.001	0.036	0.002	0.001
2C1	PM2.5	2.407	0.411	2	57	57.0	0.041	-0.041	0.005	-2.364	0.015	5.589
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	0.081	5	126	126.1	0.008	0.000	0.001	-0.032	0.007	0.001
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	0.156	2	125	125.0	0.028	0.001	0.002	0.151	0.006	0.023
2D3c	PM2.5	0.008	0.000	2	84	84.0	0.000	0.000	0.000	-0.013	0.000	0.000
2G	PM2.5	0.729	0.727	2	46	46.0	0.083	-0.005	0.009	-0.219	0.027	0.049
2H1	PM2.5	0.228	0.000	2	81	81.0	0.000	-0.004	0.000	-0.359	0.000	0.129
3B1a	PM2.5	0.607	0.224	10	400	400.1	0.595	-0.009	0.003	-3.563	0.041	12.693
3B1b	PM2.5	0.205	0.066	10	400	400.1	0.052	-0.003	0.001	-1.254	0.012	1.572

NFR Sector	Pollutant	Base year emissions (1990)	Year emissions (2021)	Activity data uncertainty 2021	Emission factor uncertainty 2021	Combined uncertainty 2021	Combined uncertainty as % of total national emissions in year 2021	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)	$K^2 + L^2$
3B2	PM2.5	0.023	0.017	10	400	400.1	0.003	0.000	0.000	-0.094	0.003	0.009
3B3	PM2.5	0.076	0.023	10	400	400.1	0.006	-0.001	0.000	-0.471	0.004	0.222
3B4a	PM2.5	0.018	0.005	10	400	400.1	0.000	0.000	0.000	-0.110	0.001	0.012
3B4d	PM2.5	0.002	0.002	10	400	400.1	0.000	0.000	0.000	0.000	0.000	0.000
3B4e	PM2.5	0.046	0.026	10	400	400.1	0.008	-0.001	0.000	-0.226	0.005	0.051
3B4gi	PM2.5	0.154	0.126	10	400	400.1	0.189	-0.001	0.002	-0.548	0.023	0.301
3B4gii	PM2.5	0.140	0.074	2	400	400.0	0.064	-0.002	0.001	-0.706	0.003	0.498
3B4giii	PM2.5	0.000	0.019	2	400	400.0	0.004	0.000	0.000	0.095	0.001	0.009
3B4giv	PM2.5	0.000	0.001	10	400	400.1	0.000	0.000	0.000	0.002	0.000	0.000
3B4h	PM2.5	0.005	0.001	10	400	400.1	0.000	0.000	0.000	-0.036	0.000	0.001
3Dc	PM2.5	0.727	0.793	2	138	138.0	0.888	-0.004	0.010	-0.534	0.029	0.286
3F	PM2.5	0.036	0.034	5	250	250.0	0.005	0.000	0.000	-0.063	0.003	0.004
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	0.561	2	83	83.0	0.161	-0.004	0.007	-0.362	0.021	0.132
5E	PM2.5	0.000	0.924	2	65	65.0	0.268	0.012	0.012	0.777	0.034	0.605
Total		**77.28**	**116.14**				**2743.61**					**3466.01**
Total Uncertainties					**Uncertainty in total inventory %:**		**52.38**				**Trend uncertainty %:**	**58.87**

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 1.8.1-1 Explanation to the Notation key NE year 2021

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																			*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
1A1b				NE																			*Emissions have not been estimated due to 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*
1A3dii				NE																NE			*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
1A5a				NE																			*Emissions have not been estimated due to 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*
1B2av			NE																NE				*Emissions have not been estimated due to lack of emission factors in EMEP/EEA Guidebook 2019*
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*

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
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*
2K												NE										NE	*Emissions have not been estimated due to lack of activity data*
3I		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
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 1.8.2-1 Sources included elsewhere IE year 2021

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
1A3di(ii)	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	1A3di(i) memo
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	473.801	395.300	819.340	320.294	77.282	132.617	286.392	5.763	1208.091
1991	400.254	327.617	700.152	262.472	63.777	108.024	219.151	5.165	955.293
1992	411.795	301.005	696.996	230.138	62.237	100.755	223.572	7.260	817.324
1993	371.705	277.928	699.726	226.844	64.723	105.614	221.868	7.242	759.021
1994	373.474	283.178	665.391	213.037	67.788	107.613	213.580	8.260	762.180
1995	375.572	289.782	696.106	215.861	72.979	114.253	236.621	8.445	751.352
1996	421.239	338.590	698.734	215.927	110.675	152.692	278.311	13.093	1099.120
1997	402.653	343.665	614.069	201.538	130.489	168.808	259.633	15.094	1248.352
1998	354.237	319.045	494.464	196.268	117.245	152.795	220.711	13.769	1184.531
1999	306.633	288.803	474.732	185.313	108.522	140.746	220.452	12.418	1027.553
2000	316.122	305.923	491.785	176.033	106.347	139.198	233.873	12.529	1059.013
2001	329.646	297.211	509.391	170.075	86.936	121.315	211.240	10.706	1033.773
2002	335.854	299.427	509.055	176.038	89.889	123.656	213.824	11.353	1038.428
2003	341.395	314.893	587.861	179.040	105.903	144.041	259.117	12.746	1095.745
2004	343.716	324.103	558.257	187.943	118.920	161.230	288.876	13.854	1198.971
2005	333.052	325.591	603.238	193.811	119.878	157.768	297.912	14.100	1225.242
2006	332.633	309.818	648.774	193.804	115.154	153.885	272.575	13.736	1137.086
2007	313.348	289.027	516.824	194.387	113.142	154.634	295.563	13.684	1116.738
2008	308.002	307.479	521.558	192.268	132.494	171.010	316.219	15.416	1158.889
2009	261.637	276.843	441.769	186.066	125.181	160.508	270.973	14.645	1044.932
2010	248.045	263.394	355.405	169.429	128.626	164.691	287.709	14.963	1050.710
2011	259.035	257.237	327.299	168.270	118.820	156.557	285.717	13.932	1009.227
2012	251.377	255.555	257.428	163.057	120.769	160.351	283.964	14.226	977.822
2013	229.871	244.420	207.926	164.547	113.428	150.387	257.437	13.423	954.741
2014	221.755	241.850	181.047	165.482	113.635	150.723	259.618	13.351	959.002
2015	220.706	239.188	148.895	169.522	108.578	145.023	237.309	12.881	913.632
2016	211.220	231.889	98.076	165.817	108.750	142.972	218.688	13.044	935.195
2017	220.032	235.267	78.385	163.766	110.140	142.951	207.187	13.349	942.163
2018	222.454	231.370	70.970	161.695	109.395	145.689	224.887	13.155	943.463
2019	218.293	232.843	85.896	158.870	110.513	150.993	234.976	13.117	949.501
2020	205.009	231.577	60.887	156.155	109.597	149.066	241.190	12.896	910.146
2021	214.160	234.216	66.284	158.596	116.136	157.234	232.440	13.733	964.329

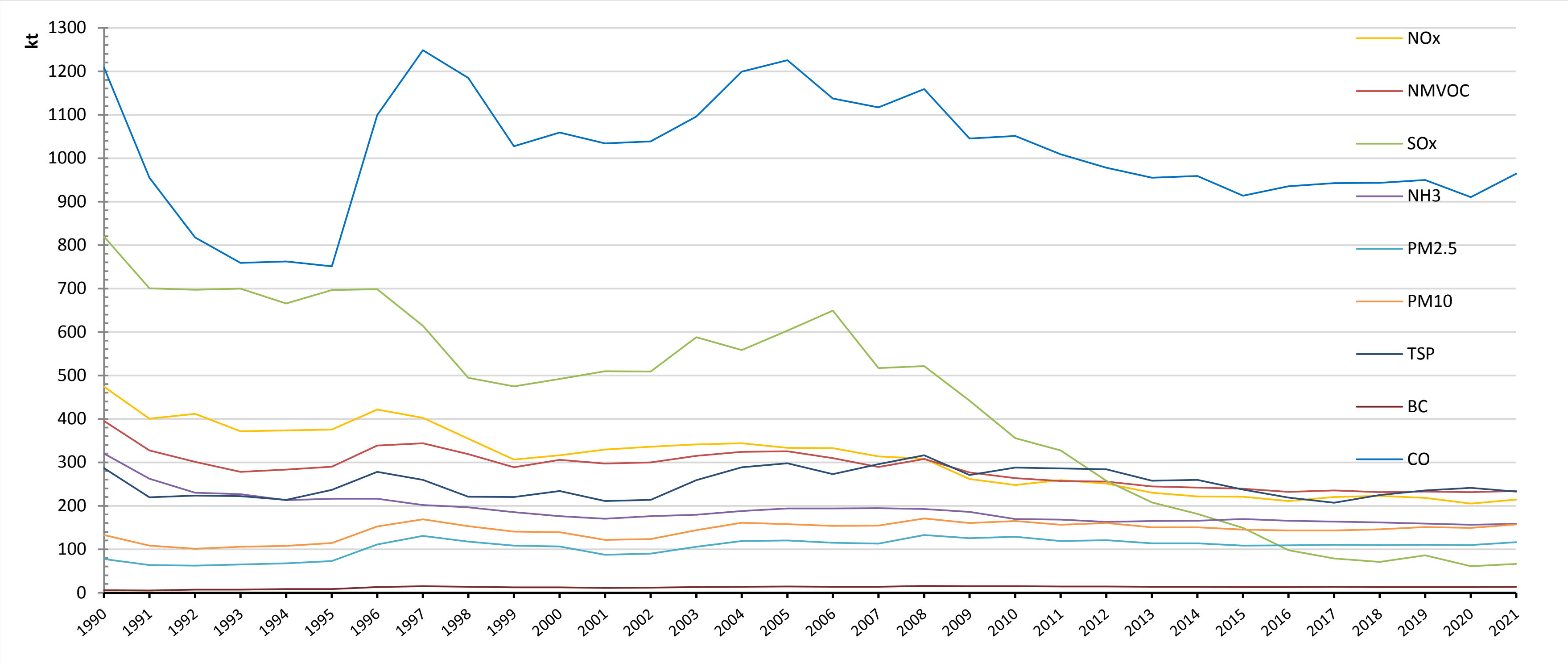


Figure 2.1.1. Total Emission trends (kt) for Main Pollutants, Particulate Matter, BC and CO

The chart shows the total emission trend for main pollutants, particulate matter, BC and CO between 1990-2021.

First of all, the most important variation can be noticed for SOx, starting from 819.3 kt/year in 1990, 603.2 kt /year in 2005 ending with 66.3 kt/year in 2021. SOx emissions decreased with 91,9% in 2021, compared to 1990 and with 89.0% in 2021, 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 473.8 kt/year in 1990, to 333.1 kt/year in 2005 and to 214.2 kt/year in 2021. NOx emissions decreased with 54.8% in 2021, compared to 1990 and with 35.7% in 2021, 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 40,7% in 2021 compared to 1990 and 28.1% in 2021 compared to 2005. NMVOC emissions were 395.3 kt in 1990, 325.6 kt in 2005 and 234.2 kt in 2021.

NH3 emissions decreased from 320.3 kt in 1990 to 193.8kt in 2005 and to 158.6kt in 2021. NH3 emissions had also an overall decrease in the given period. NH3 emissions decreased by almost 50.5% in 2021 compared to 1990 and 18.2% in 2021 compared to 2005.

The evolution of PM2.5 emissions fluctuated from 77.3 kt in 1990 to 119.9 kt in 2005, reached a maximum of 132.5 kt in 2008 and then steadily decreased to 116.1 kt in 2021. Compared to 1990, PM2.5 emissions increased in 2005 by 50.3% and compared to 2005, PM2.5 emission decreased in 2021 by 3.1%.

The residential combustion (NFR 1A4bi) is a key source for PM2,5, contributing to the 2021 national total with 84%. 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	16.698	81.219
1993	341.380	3.618	2.430	36.176	15.756	8.674	72.528	16.447	84.918
1994	359.499	3.699	2.489	37.570	16.744	8.178	63.773	15.205	88.976
1995	355.741	3.910	2.741	36.898	19.063	8.618	63.960	15.697	98.376
1996	344.193	4.618	2.608	35.977	19.656	10.272	69.594	16.004	122.859
1997	348.547	4.792	2.305	35.391	21.731	9.999	75.038	13.291	143.083
1998	265.261	4.113	2.024	26.506	20.087	8.556	54.582	10.511	125.210
1999	144.184	3.653	1.766	15.358	15.115	7.237	45.215	10.627	105.720
2000	50.075	3.377	2.554	5.814	14.735	6.899	34.522	11.731	103.229
2001	51.164	3.028	2.590	6.010	14.599	6.355	42.096	11.365	93.999
2002	57.728	3.040	2.606	6.347	16.873	6.684	33.660	11.695	98.786
2003	62.289	3.434	3.102	6.998	17.902	6.533	31.583	13.862	112.531
2004	65.749	3.551	3.227	6.747	18.399	6.793	27.095	13.131	118.755
2005	72.358	3.711	3.523	6.634	20.315	52.972	25.042	12.543	135.460
2006	71.845	3.736	3.723	7.225	20.214	54.704	23.377	14.497	133.359
2007	70.109	3.731	3.509	7.167	20.354	56.425	19.682	14.676	133.391
2008	62.383	3.917	3.373	6.809	18.696	61.608	17.518	15.154	141.001
2009	41.707	3.427	2.381	5.337	13.991	61.578	15.209	12.861	125.329
2010	48.509	3.605	2.416	5.168	14.439	59.792	14.813	11.979	132.342
2011	49.290	3.545	2.860	5.939	14.416	62.762	16.389	14.488	124.206
2012	45.339	3.482	2.187	5.435	13.858	63.659	14.596	13.277	124.925
2013	42.277	3.184	1.798	4.477	13.343	62.027	13.018	10.139	118.755
2014	43.136	3.185	1.831	4.473	13.401	62.615	11.796	10.277	119.503
2015	45.648	3.123	1.873	4.689	14.141	62.772	11.203	10.556	119.410
2016	45.070	3.168	1.804	4.323	14.072	67.535	9.775	9.376	121.352
2017	45.491	3.221	1.827	4.321	13.976	71.682	11.796	9.457	123.056
2018	46.758	3.222	1.843	4.346	14.416	74.898	11.253	9.309	123.537
2019	47.067	3.165	1.833	4.193	14.743	77.393	11.640	8.664	125.039
2020	41.578	2.902	1.588	3.295	13.606	76.040	10.465	6.190	120.590
2021	46.405	3.137	1.712	3.651	14.854	78.599	11.841	6.818	129.237

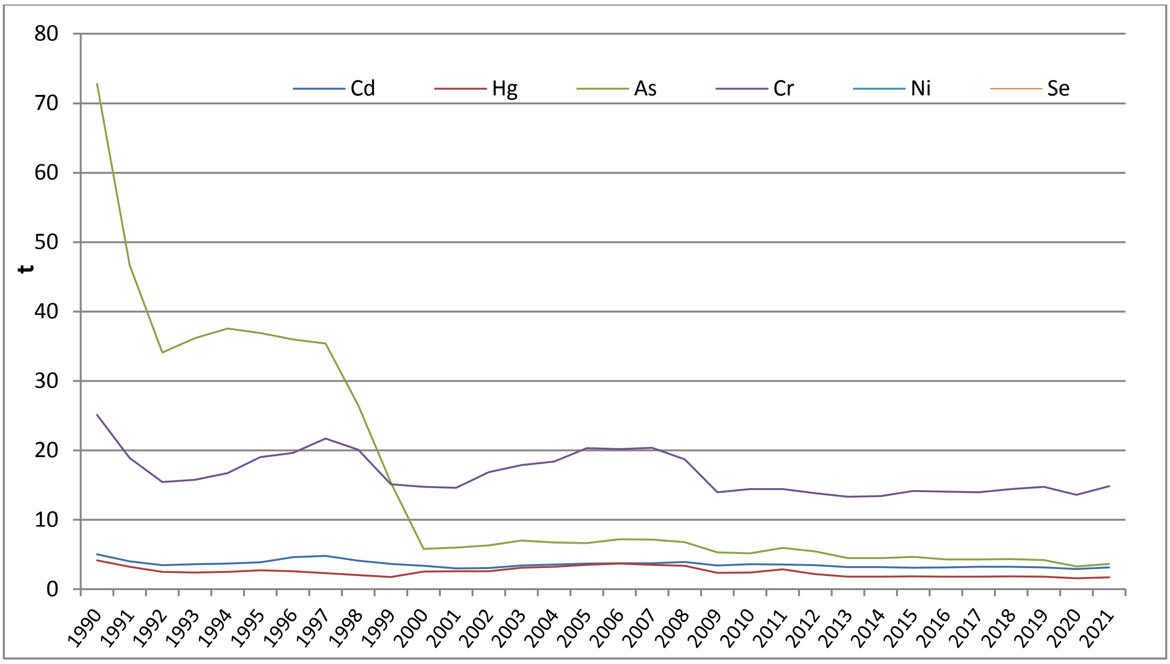


Figure 2.2.1.a Total Emission trends (t) for Cd, Hg, As, Cr, Ni and Se

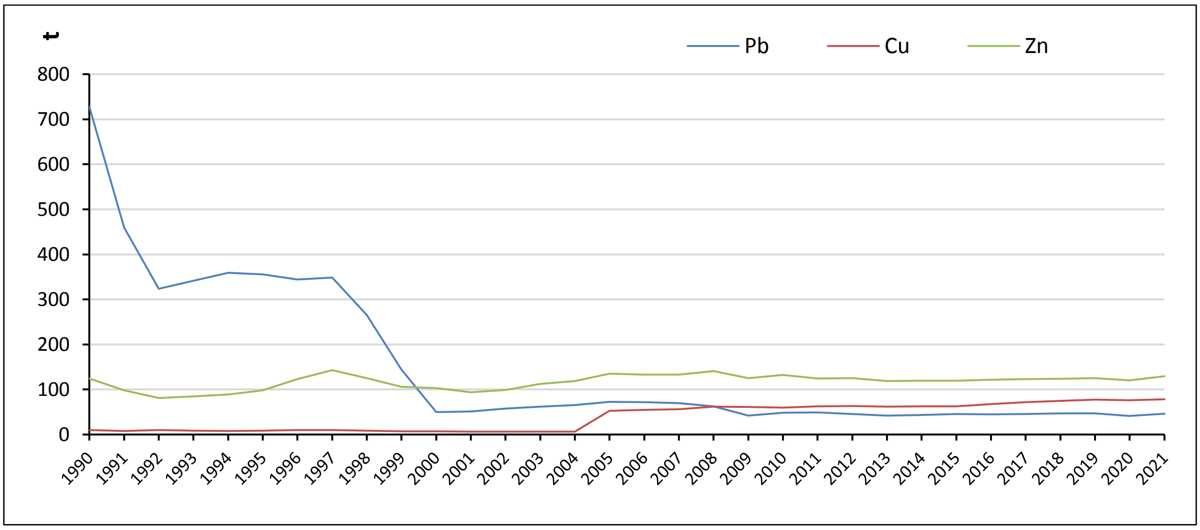


Figure 2.2.1.b Total Emission trends (t) for Pb, Cu and Zn

The graphs describe the total emission trends for heavy metals over the period 1990-2021.

At the beginning of the period analysed, Ni, As and Cr emissions had highly 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 (93.3% of the national total in 2021) due to the increase in road traffic (84% increase in 2021 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	265.605	76.481	2.843	61.689
1991	220.919	54.351	2.578	45.430
1992	201.810	43.699	2.697	34.249
1993	204.295	40.384	2.795	30.897
1994	210.909	39.196	2.790	32.143
1995	230.409	45.293	2.923	38.638
1996	268.282	62.727	3.144	35.899
1997	309.558	75.093	3.004	39.789
1998	332.546	66.510	2.699	37.546
1999	566.964	56.237	3.283	26.003
2000	762.186	55.980	3.875	28.115
2001	902.490	45.493	4.174	29.459
2002	831.266	49.691	4.086	34.175
2003	920.752	57.616	4.675	37.050
2004	874.950	65.799	4.508	38.970
2005	755.658	64.991	4.203	39.120
2006	684.939	62.225	4.230	38.381
2007	201.874	61.803	3.983	36.479
2008	207.951	69.770	3.758	30.493
2009	169.694	60.214	3.197	17.434
2010	187.337	63.385	3.203	21.141
2011	179.496	57.573	3.450	20.681
2012	182.349	58.279	3.360	18.192
2013	166.010	55.562	2.865	17.444
2014	170.318	57.164	2.929	17.982
2015	167.407	56.715	3.023	20.249
2016	169.864	56.168	2.947	19.688
2017	178.179	55.554	3.110	18.578

Year/Pollutant	PCDD/PCDF (g I-TEG)	total PAHs (t)	HCB (kg)	PCBs (Kg)
2018	180.205	55.497	3.134	19.202
2019	185.827	56.254	3.124	19.374
2020	184.711	55.374	2.993	17.018
2021	210.689	59.494	3.593	19.790

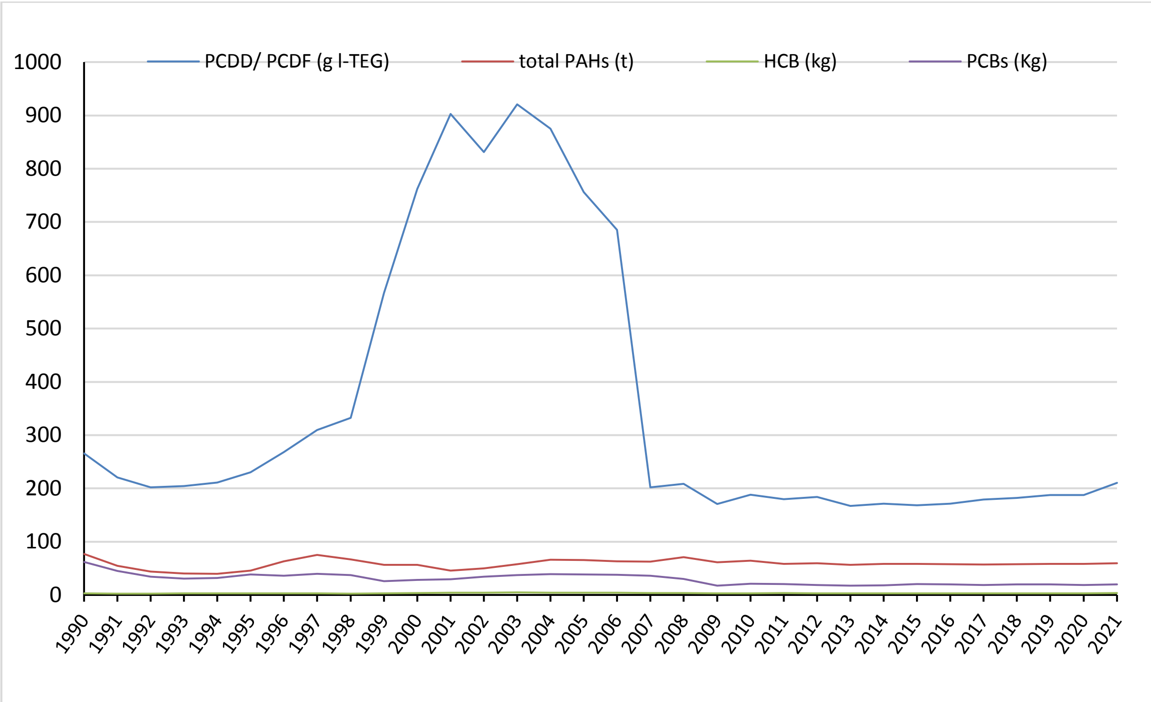


Figure 2.3.1 Total Emission trends for Dioxins (g I-TEQ), total PAHs (t), HCB and PCBs (kg)

The graph provides the total emission trend for POP's in the period 1990-2021.

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).

Following the Emission Inventory reviews in 2017-2021, all categories were recalculated and extended back to the year 1990, based on the following criteria: answer as much as possible to the specific requests of the reviews, use updated statistics, where possible, use operators measured emissions and corresponding fuel consumption, where available, assure the consistency with relevant categories from the energy statistics, and update the emission factors to those provided by the 2019 EMEP/EEA Guidebook.

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) - 2017-2021, 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* • 2017-2021, 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)* • 2016-2021: 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;* • 2017-2021: 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;* • 2017-2021: EUROSTAT ENERGY Questionnaires, National Institute of Statistics

NFR	Activity data source
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; • 2017-2021: 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;* • 2017-2021: 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;* • 2017-2021: EUROSTAT ENERGY Questionnaires, National Institute of Statistics; • 2005-2021 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; • 2017-2021: 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; • 2017-2021: 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; 2017-2021: 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; 2017-2021: 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;* 2017-2020: 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;* 2017-2021: 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; 2017-2021: 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);* 2017-2021: EUROSTAT ENERGY Questionnaires, National Institute of Statistics;
1.A.5.b Other, Mobile (including military, land	IE – included in 1.A.5a

NFR	Activity data source
based and recreational boats)	

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 (46.76%), NOx (10.24%), Cd (7.9%), Hg (23.2%), As (53.08%), Ni (19.95), Se (84.11%) and HCB (25.01%).

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 2021

Pollutant	1A1a	National Total	Unit	% 1A1a in national total
NOx	21.938	214.160	kt	10.24
NMVOC	0.600	234.216	kt	0.26
SOx	30.995	66.284	kt	46.76
PM2.5	1.317	116.136	kt	1.13
PM10	1.814	157.234	kt	1.15
TSP	2.231	232.440	kt	0.96
BC	0.040	13.733	kt	0.29
CO	7.167	964.329	kt	0.74
Pb	2.120	46.405	t	4.57
Cd	0.250	3.137	t	7.97
Hg	0.397	1.712	t	23.20
As	1.938	3.651	t	53.08
Cr	1.252	14.854	t	8.43
Cu	0.350	78.599	t	0.45
Ni	2.362	11.841	t	19.95
Se	5.735	6.818	t	84.11
Zn	3.199	129.237	t	2.47

PCDD/PCDF	1.826	210.689	g I-TEQ	0.87
Total PAH	0.021	59.494	t	0.04
HCB	0.899	3.593	kg	25.01
PCBs	0.034	19.790	kg	0.17

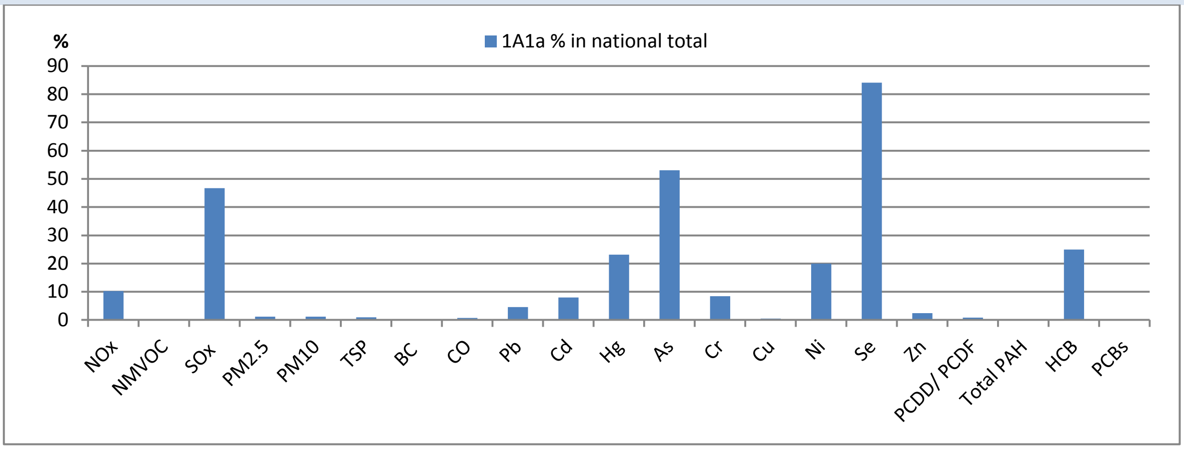


Figure 3.2.1 Share of 1A1a emissions by pollutant in the national total in 2021

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 – EMEP EEA Guidebook 2019 factors

CO, NMVOC, Heavy Metals and POPs:

The emissions were calculated for the entire time series 1990-2021 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 2005-2021 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 significant 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 (2005-2021), 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 1990-2021 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
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

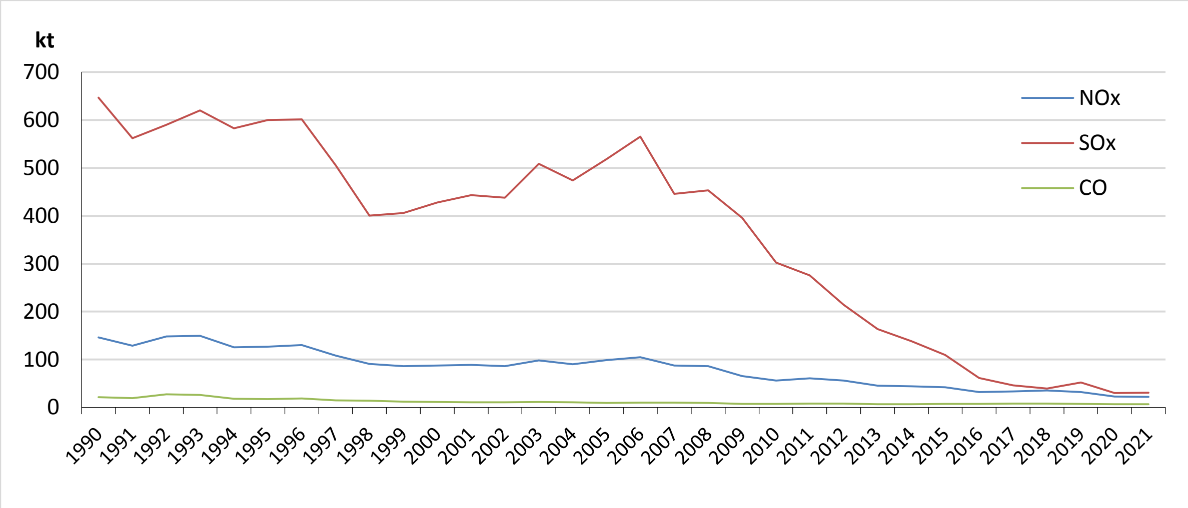


Figure 3.2.1.a Emission Trends (kt) for NFR 1.A.1.a. for NOx, SOx and CO

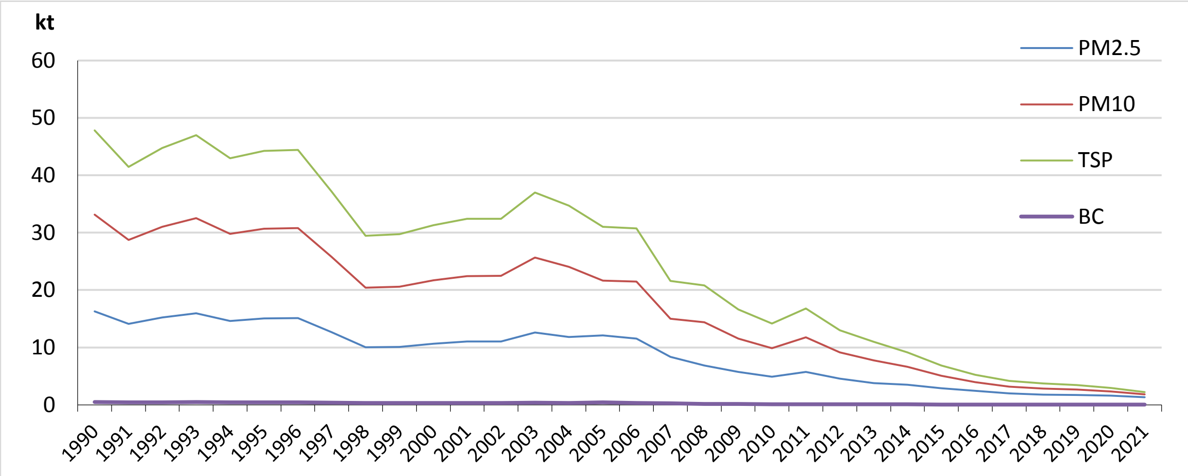


Figure 3.2.1.b. Emission Trends (kt) for NFR 1.A.1.a. for TSP, PM_{10}, $PM_{2.5}$ and BC

Compared to 1990 emissions, there was a significant decrease of emissions in the public power sector. For main pollutants, decreases are as high as 85% for NOx, 95% for SOx and 92% for $PM_{2.5}$. Compared to 2005, the emissions decreased with 77% for NOx, 94% for SOx and 87% 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 1990-2021 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
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

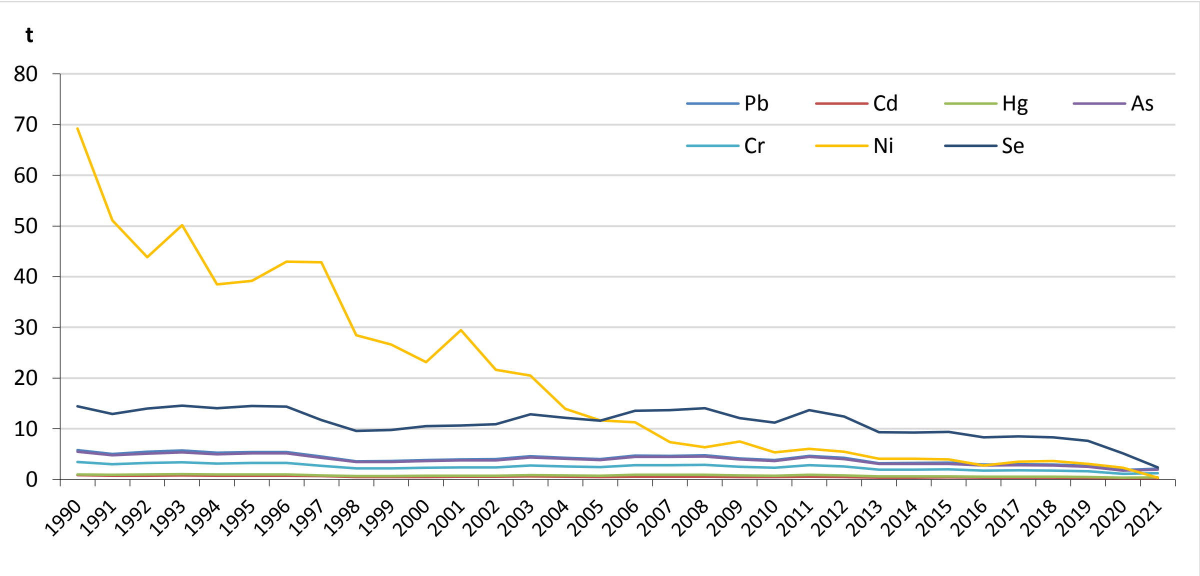


Figure 3.2.2. Emission Trends (t) for NFR 1.A.1.a. for Heavy Metals

Compared to 1990, emissions of heavy metals decreased in 2021 between 61% (Hg) and 96% (Ni). The highest decrease took place before 2007.

The table and chart below give the fuel consumption values for 1990-2021.

Table 3.2.3 Fuel consumption (TJ) 1990-2021, 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
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

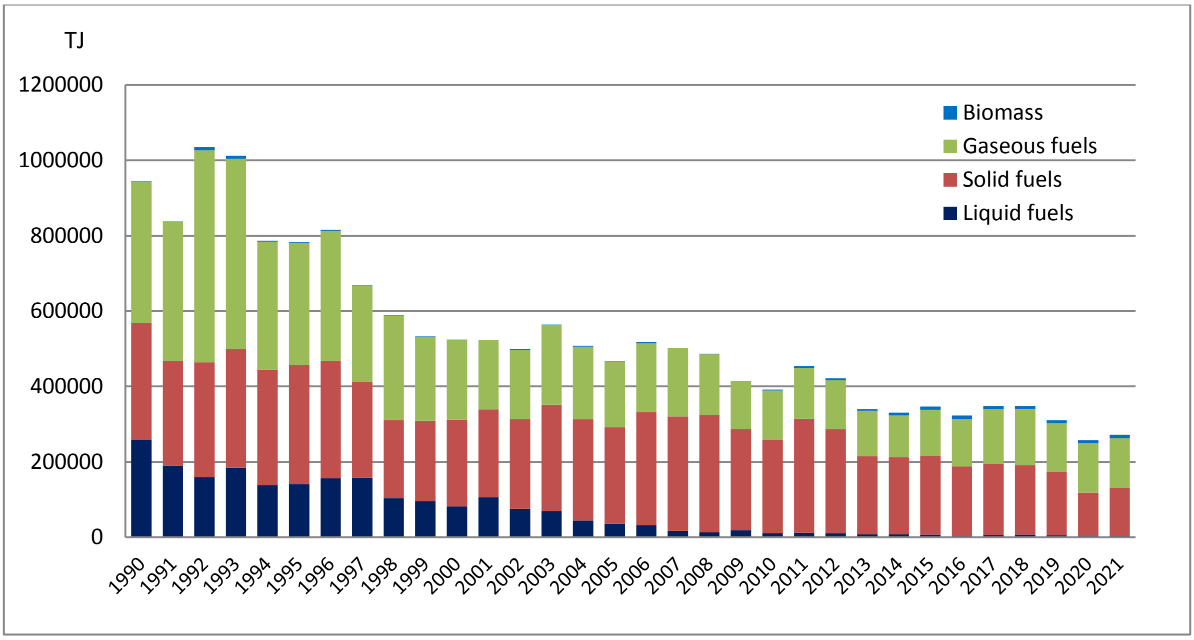


Figure 3.2.3 Fuel consumption [TJ], by fuel type, for NFR 1.A.1.a.

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 1990-2021 were calculated by applying Tier 1 emission factors (2019 EMEP/EEA Guidebook 1.A.1.a, Tables 3.3, 3.4, 3.5 and 3.7) to activity data provided by the EUROSTAT energy balances and questionnaires.

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, 1990-2021

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

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx (kt)	PM2.5 (kt)	PM_{10} (kt)	CO (kt)	Ni (t)
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

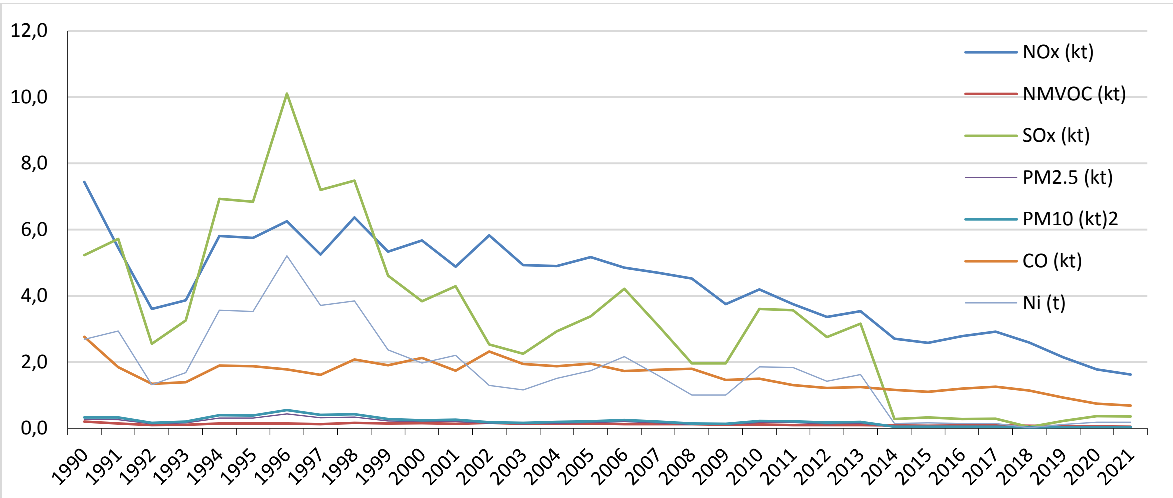


Figure 3.3.1. Emissions for NFR 1.A.1.b, 1990-2021

Emissions trends are consistent with the fuel consumption variation along the time series 1990-2021. The fuel consumption shows a strong variation in first years after 1990 followed by a steadier decrease during the last 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 to 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

Year/Fuel type (TJ)	Liquid fuels	Gaseous fuels	Biomass
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
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

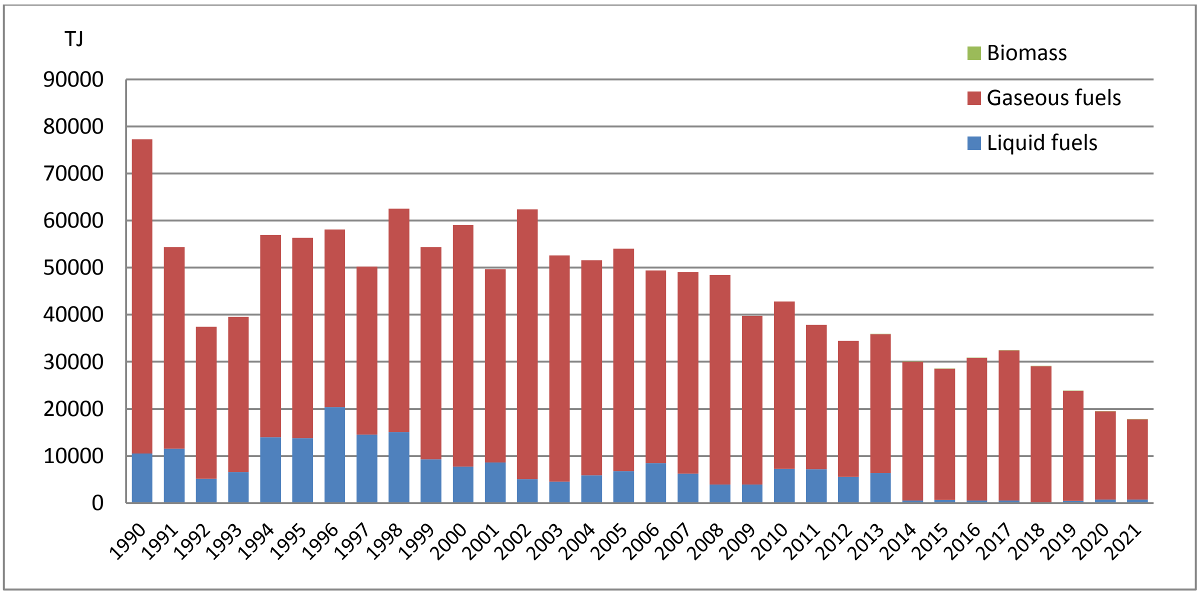


Figure 3.3.2. Fuel consumption [TJ] trends, by fuel type, for NFR 1.A.1.b

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. Tier 1 emission factors (2019 EMEP/EEA Guidebook, small combustion) have been applied to activity data provided by EUROSTAT, in the complete energy balances, annual data - nrg_110a, categories Consumption of the energy branch/Consumption in Oil and gas extraction, Consumption in Coal Mines, Consumption in Coke Ovens, Consumption in Non-specified (Energy) for 1990-2016 and in the Energy questionnaires for 2017-2021.

NFR 1.A.1.c is a key source for Ni, with a contribution of 13.6% in the national total, in 2021.

Improvements and recalculations:

- Slight correction of PM10 and TSP emissions for the entire time series 1990-2020, due to correction of emission factors for liquid fuels, from 20 la 21 g/GJ
- Correction of BC emissions, for years 1990-2020, due to a calculation error. The correction increases the BC national total with around 0.3%.

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

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx(kt)	CO (kt)	$PM_{2.5}$ (kt)	PM_{10} (kt)	TSP (kt)	Ni (t)
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

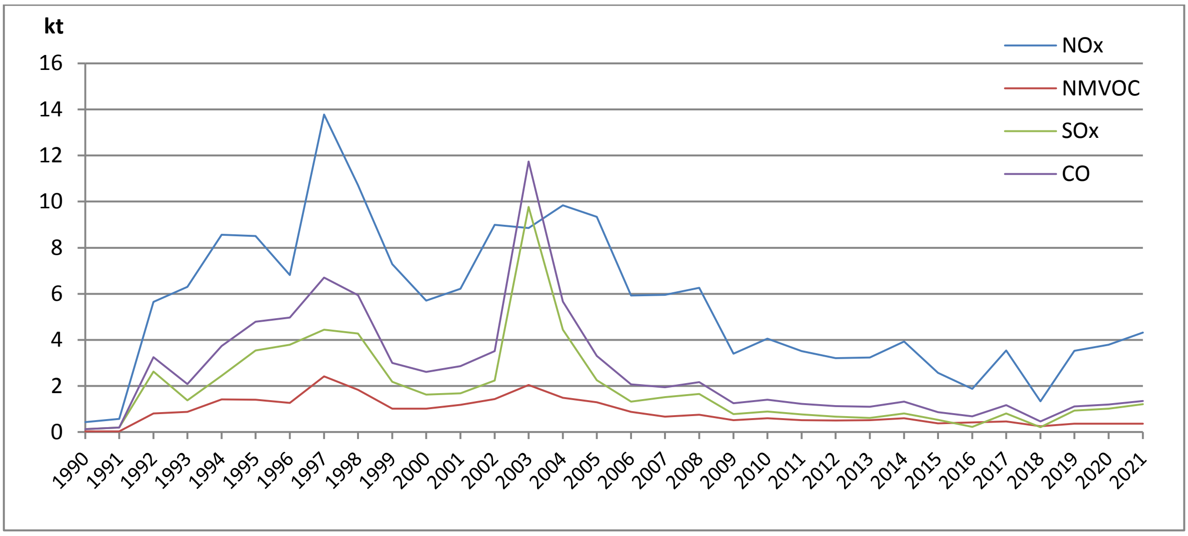


Figure 3.4.1a Emissions (kt) of NOx, NMVOC, SOx and CO for NFR 1.A.1.c.

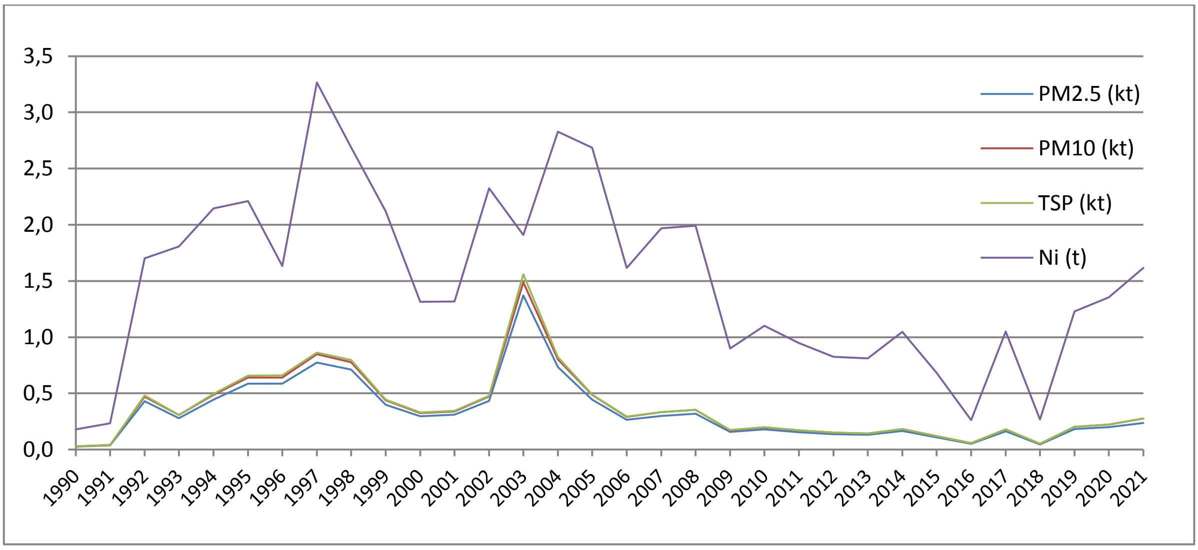


Figure 3.4.1b Emissions (kt) of TSP, PM_{10}, $PM_{2.5}$ for NFR 1.A.1.c.

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
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

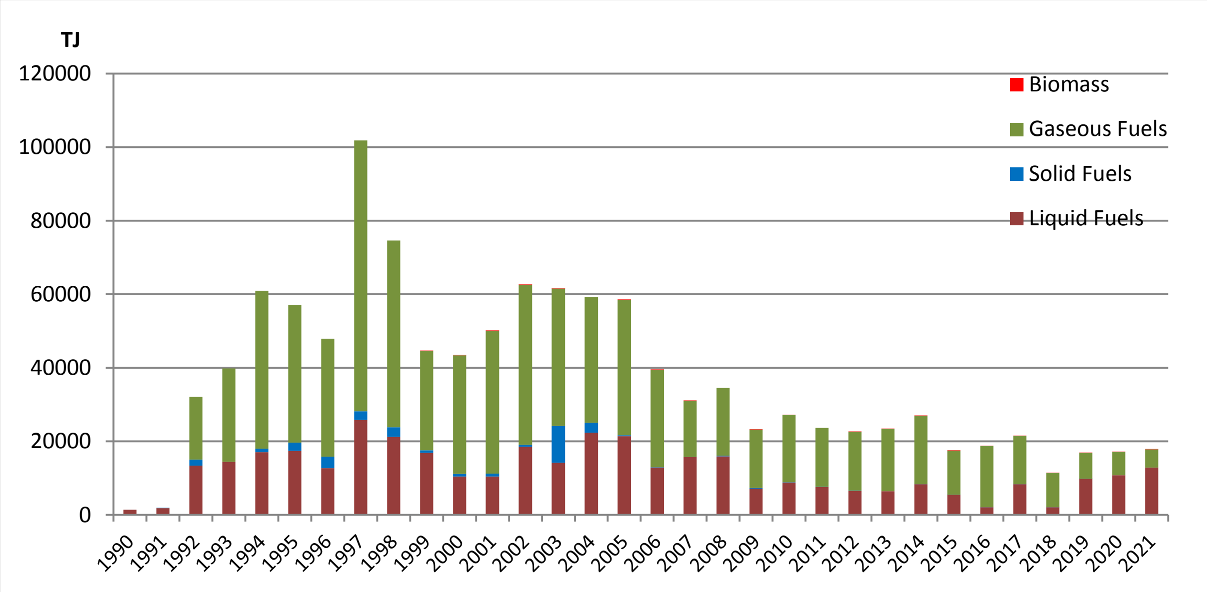


Figure 3.4.2 Fuel consumption [TJ], by fuel type, for NFR 1.A.1.c, 1990-2021

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 2021, key sources from NFR 1A2 sector, combustion in industry, are:

- NFR 1A2a – Iron and steel industry, for SOx (31%), NOx (2.7%), Pb (6.6%) and Hg (11.3%).
- NFR 1A2f – Non-metallic minerals, for NOx (5.3%), SOx (6.0%) and Hg (23.2%).

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	27.24	212.02	kt	12.85
NMVOC	10.52	225.88	kt	4.66
SOx	38.48	79.30	kt	48.52
NH_3	0.01	157.76	kt	0.01
$PM_{2.5}$	6.18	118.12	kt	5.23
PM_{10}	6.59	159.29	kt	4.14
TSP	6.94	234.32	kt	2.96
BC	0.85	13.96	kt	6.09
CO	61.74	960.99	kt	6.42
Pb	5.86	37.09	t	15.80
Cd	0.18	2.78	t	6.47
Hg	0.41	1.42	t	28.87

As	0.18	2.65	t	6.79
Cr	0.78	9.80	t	7.96
Cu	1.42	78.34	t	1.81
Ni	0.59	10.76	t	5.48
Se	0.09	6.65	t	1.35
Zn	13.46	117.93	t	11.41
PCDD/PCDF	9.45	209.98	g I-TEQ	4.50
Total PAH	6.68	62.27	t	10.73
HCB	0.06	3.57	kg	1.68
PCBs	7.14	14.33	kg	49.83

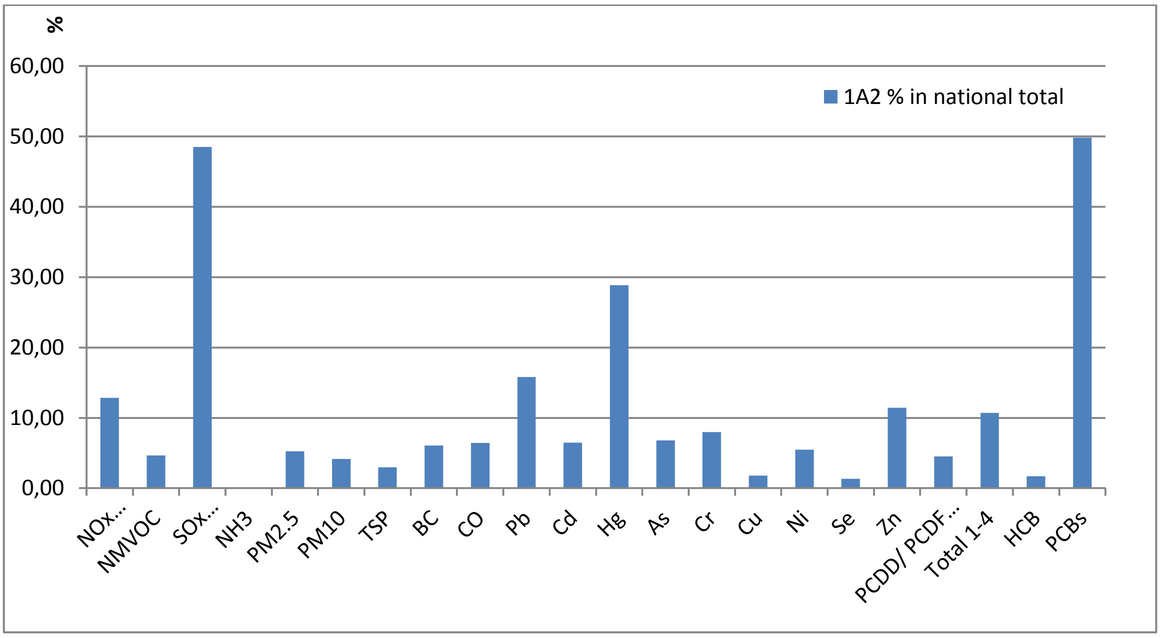


Figure 3.5.1 Share of 1A2 emissions by pollutant in the national total (%) 2021

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, 2021

NFR	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
1A2a	0	22827.444	25079.243	1.846
1A2c	41.975	64.021	55515.171	177.851
1A2d	0.00	141.109	5981.162	182.862
1A2e	7.87	369.53	14427.872	1114.426
1A2f	9913.67	18604.36	14515.45	142.89
1A2gvii	15720.82	NA	NA	NA
1A2gviii	81.923	18.40	22844.89	6764.257

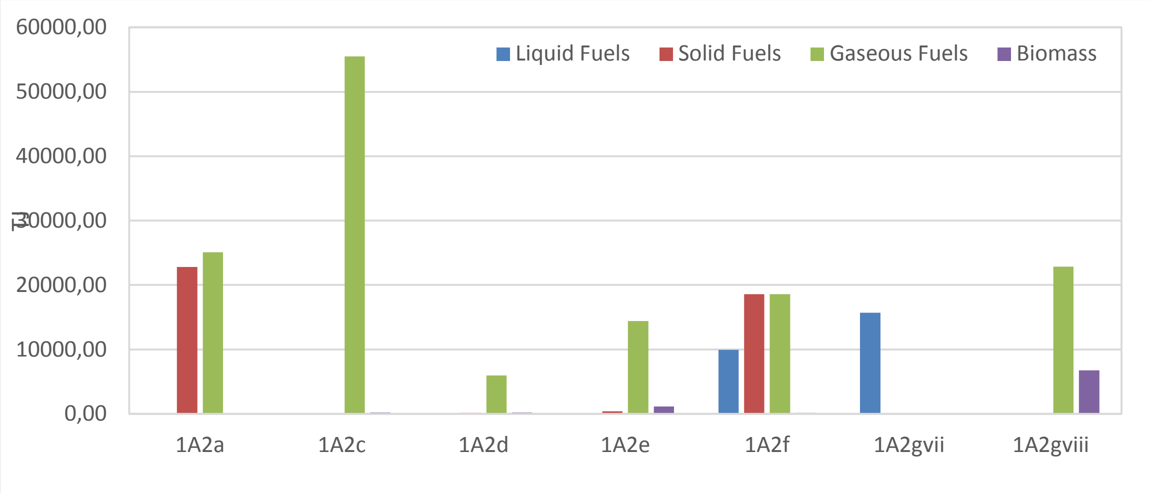


Figure 3.5.2 NFR 1A2 – Fuel consumption [TJ] by fuel type and subcategory, 2021

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

Year/Fuel type (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
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

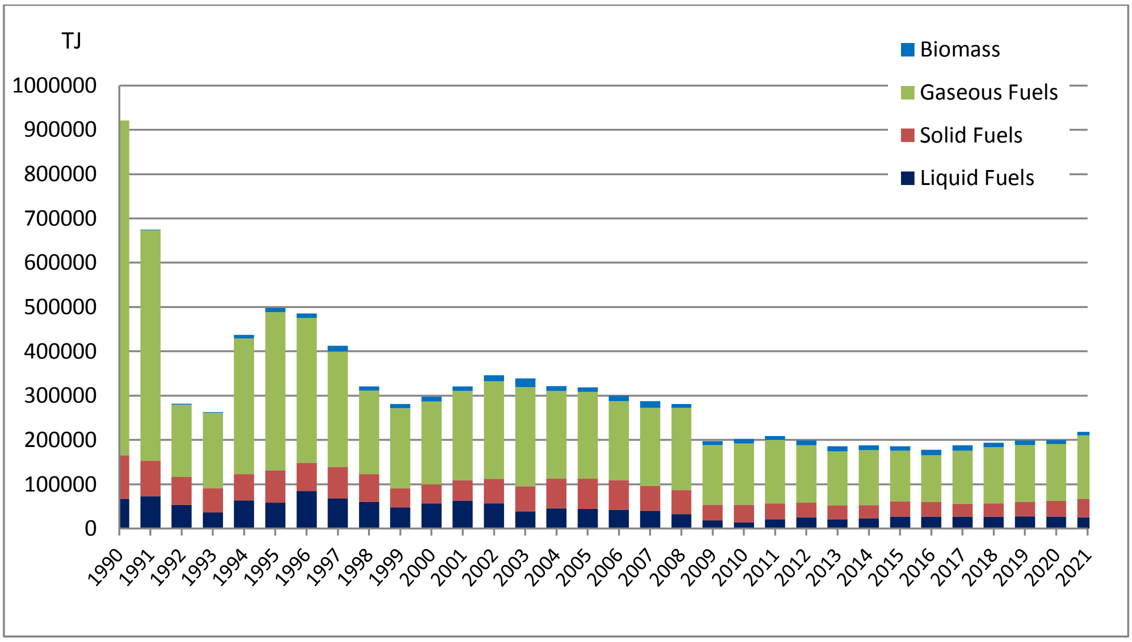


Figure 3.5.3 Fuel consumption (TJ) in industry (NFR 1A2), by fuel type 1990-2021

Total fuel consumption in industry decreased from 1990 to 2021 with about 76.3% (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 2021, 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, 1990-2021 (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

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
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	8.466	12.896	3.028
2006	18.826	6.987	0.739	1.657	6.145	12.913	4.046
2007	12.762	6.025	0.852	1.535	5.372	18.365	4.188
2008	11.116	7.024	0.238	1.445	5.900	12.124	5.211
2009	7.081	5.801	0.178	1.338	3.885	6.499	2.426
2010	7.354	5.560	0.347	1.475	2.721	5.662	2.702
2011	6.933	6.082	0.091	1.600	4.795	6.552	2.868
2012	5.542	5.256	0.127	1.787	7.265	6.882	2.596
2013	5.836	4.287	0.136	1.218	6.107	5.731	2.632
2014	5.749	4.131	0.170	1.235	7.410	5.297	2.586
2015	6.600	3.417	0.216	1.177	8.399	5.697	2.367
2016	6.470	2.670	0.239	1.294	8.590	5.012	2.472
2017	5.785	3.289	0.362	1.440	8.695	4.605	2.478
2018	5.660	3.471	0.242	1.144	9.270	4.236	2.591
2019	5.634	3.837	0.324	1.255	9.516	3.939	2.690
2020	5.240	3.750	0.307	1.206	10.215	3.690	2.474
2021	5.805	4.157	0.484	1.237	9.391	3.823	2.351

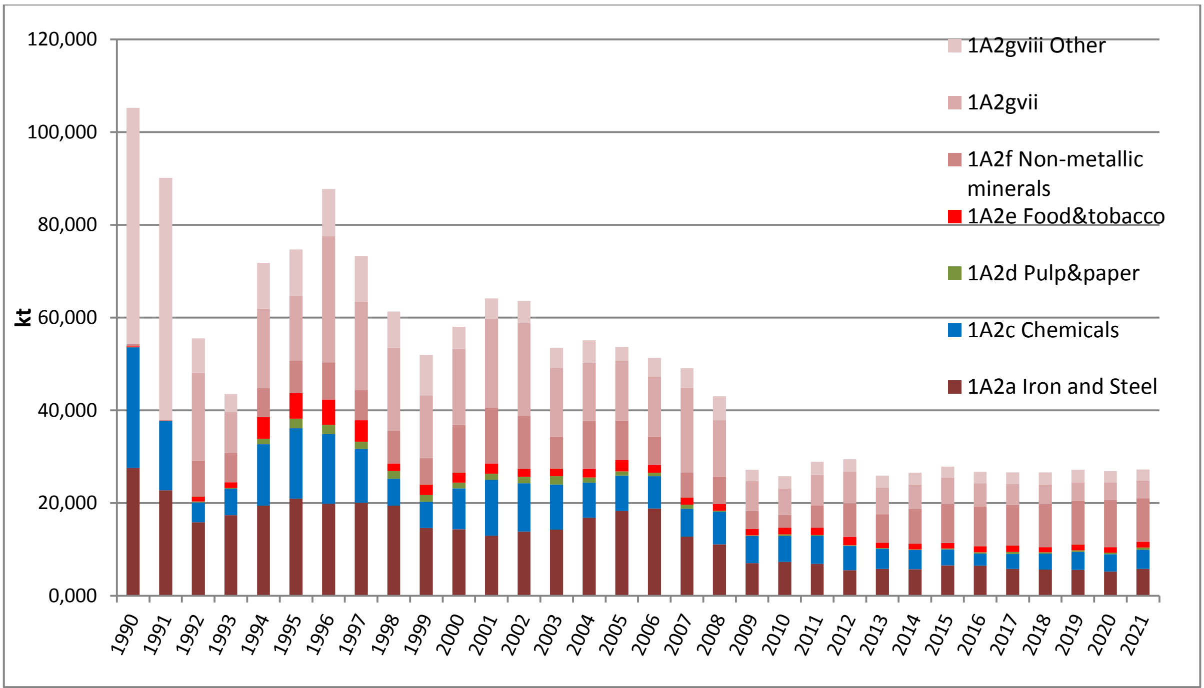


Figure 3.5.4 NOx emissions (kt) for 1A2 sector by NFR, 1990-2021

Table 3.5.5 NMVOC (kt) emissions for 1A2 sector by NFR, 1990-2021

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
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	1.113	7.913	2.190
2006	6.556	1.949	1.283	0.615	0.949	5.515	2.984
2007	5.541	1.944	1.085	0.615	0.945	4.966	3.685
2008	4.949	2.318	0.210	0.505	1.145	2.829	2.938
2009	2.882	1.943	0.161	0.676	1.145	2.041	2.274
2010	3.362	1.921	0.150	0.741	1.118	1.420	2.690
2011	3.141	2.083	0.054	0.687	1.075	1.065	2.282
2012	2.426	1.835	0.074	0.825	1.784	0.946	2.601
2013	2.531	1.540	0.065	0.698	1.744	0.933	2.665
2014	2.484	1.478	0.070	0.766	1.503	0.878	2.771
2015	2.882	1.259	0.091	0.742	1.473	0.986	2.630
2016	2.876	0.951	0.094	0.630	1.617	0.852	3.266
2017	2.497	1.106	0.157	0.794	1.683	0.825	3.027
2018	2.461	1.167	0.102	0.667	1.501	0.694	3.130
2019	2.496	1.232	0.129	0.719	1.461	0.744	3.082
2020	2.316	1.179	0.152	0.648	1.990	0.732	2.612
2021	2.604	1.337	0.205	0.699	2.277	0.844	2.558

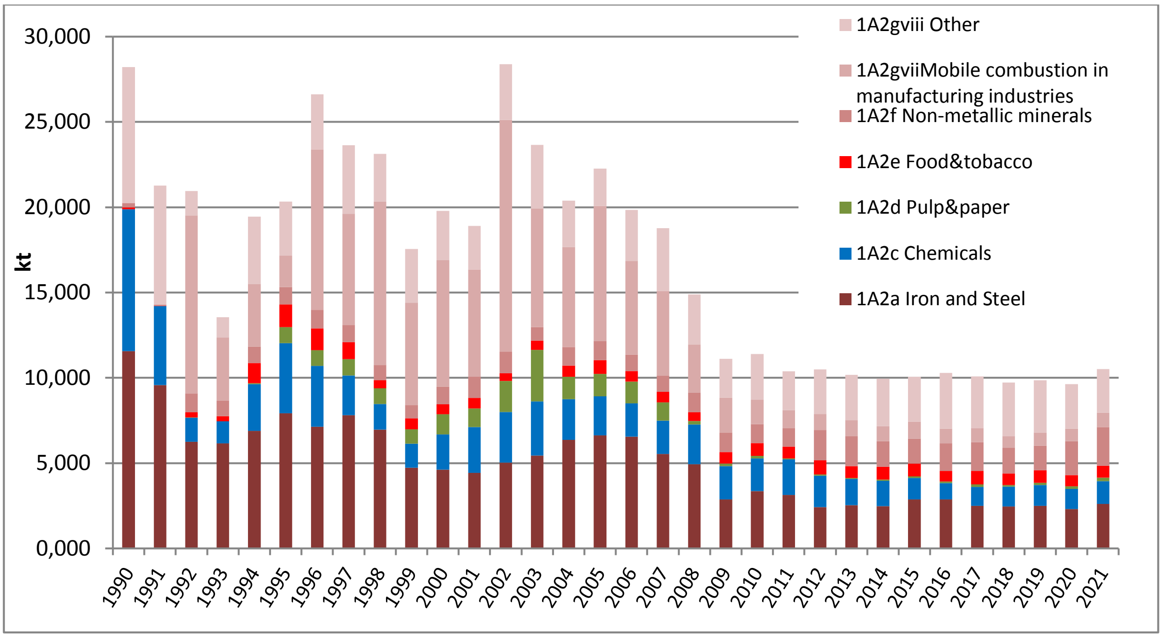


Figure 3.5.5 NMVOC emissions (kt) for 1A2 sector by NFR, 1990-2021

Table 3.5.6 $PM_{2.5}$ (kt) emissions for 1A2 sector by NFR, 1990-2021

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	0.500	0.965	0.765
2006	6.523	0.860	0.563	0.178	0.393	0.891	1.047
2007	5.327	0.688	0.472	0.152	0.462	1.150	1.450
2008	4.847	0.747	0.072	0.101	0.757	0.726	1.010
2009	2.796	0.722	0.056	0.198	0.724	0.395	0.813
2010	3.354	0.727	0.025	0.248	0.599	0.346	1.014
2011	3.076	0.735	0.014	0.205	0.486	0.399	0.831
2012	2.219	0.724	0.019	0.317	1.231	0.414	0.999
2013	2.267	0.593	0.013	0.276	1.075	0.336	1.018
2014	2.174	0.532	0.011	0.289	0.987	0.300	1.063
2015	2.657	0.515	0.015	0.271	1.013	0.320	1.014
2016	2.761	0.268	0.015	0.217	1.112	0.277	1.324

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
2017	2.249	0.275	0.034	0.278	1.117	0.246	1.190
2018	2.195	0.305	0.026	0.198	1.210	0.219	1.227
2019	2.316	0.251	0.031	0.207	1.236	0.195	1.189
2020	2.137	0.069	0.050	0.182	1.897	0.170	0.983
2021	2.485	0.076	0.045	0.207	2.239	0.168	0.968

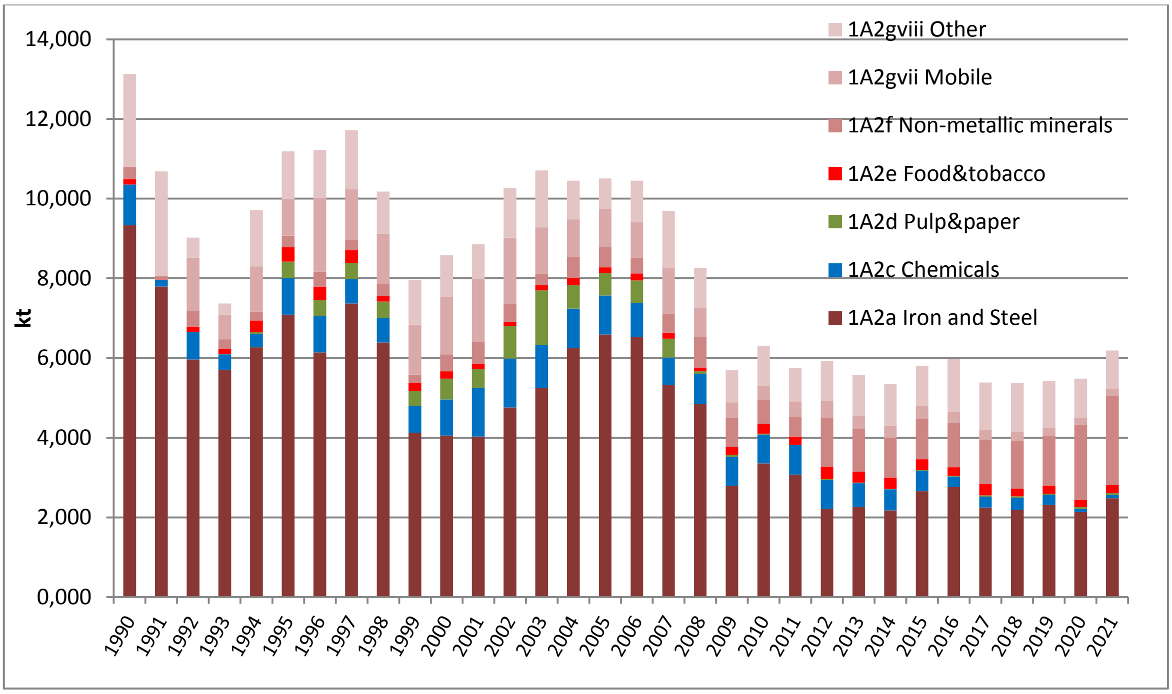


Figure 3.5.6 $PM_{2.5}$ emissions (kt) for 1A2 sector by NFR, 1990-2021

Table 3.5.7 SOx emissions for 1A2 sector by NFR, 1990-2021

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	1.918	0.833	0.177
2006	52.869	6.432	0.056	0.129	1.737	0.839	0.354

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gvii	1A2gviii
2007	43.961	5.232	0.063	0.104	1.962	1.280	0.283
2008	40.085	5.695	0.007	0.047	3.846	0.894	0.314
2009	22.968	5.585	0.006	0.085	3.560	0.527	0.100
2010	27.788	5.556	0.005	0.466	2.303	0.476	0.125
2011	25.467	5.559	0.002	0.280	0.952	0.567	0.142
2012	18.325	5.577	0.005	0.823	6.147	0.627	0.155
2013	18.706	4.473	0.004	0.878	4.353	0.559	0.129
2014	17.934	3.968	0.004	0.741	4.532	0.551	0.132
2015	21.934	3.848	0.012	0.664	4.956	0.647	0.132
2016	22.833	1.832	0.028	0.647	5.477	0.619	0.152
2017	18.50	1.828	0.079	0.646	5.344	0.624	0.129
2018	18.117	2.100	0.101	0.282	8.358	0.006	0.141
2019	19.143	1.601	0.132	0.273	8.474	0.006	0.146
2020	17.665	0.056	0.179	0.314	14.050	0.007	0.117
2021	20.561	0.098	0.133	0.354	17.221	0.007	0.110

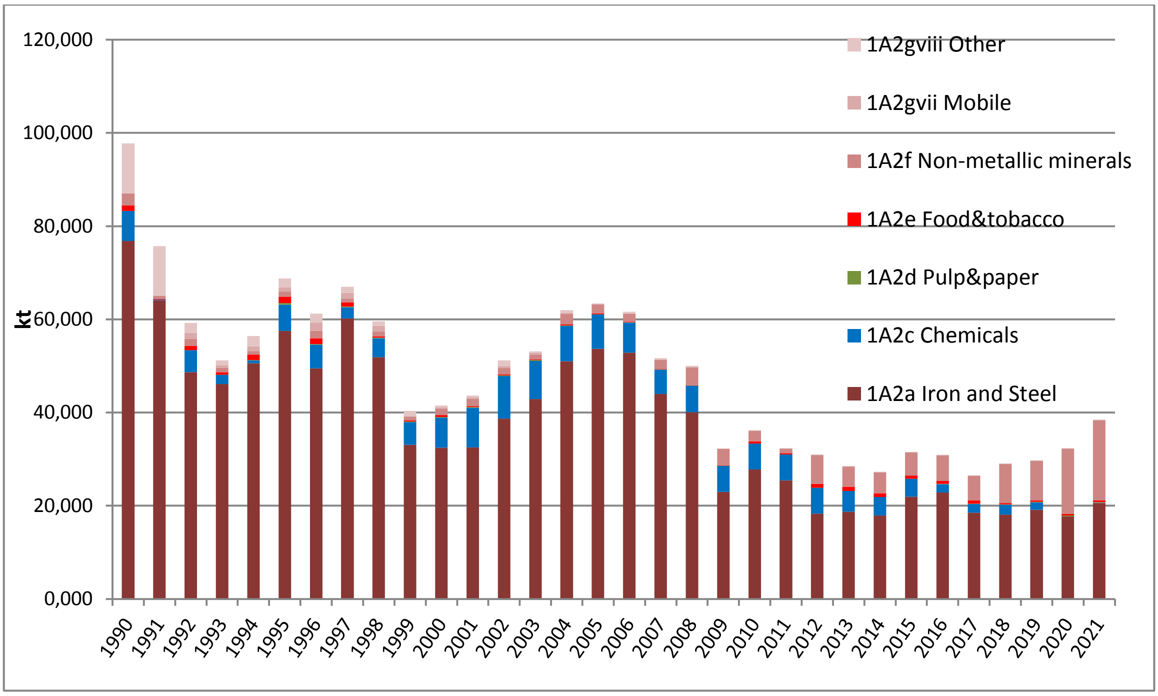


Figure 3.5.7 SOx emissions (kt) for 1A2 sector by NFR, 1990-2021

Table 3.5.8 Pb (t) emissions for 1A2 sector by NFR, 1990-2021

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

year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gviii
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	0.209	7.924
2006	7.799	0.929	0.107	0.034	0.209	7.799
2007	6.534	0.767	0.089	0.031	0.259	6.534
2008	5.961	0.837	0.014	0.015	0.543	5.961
2009	3.407	0.822	0.010	0.039	0.538	3.407
2010	4.135	0.822	0.004	0.096	0.374	4.135
2011	3.789	0.822	0.003	0.062	0.140	3.789
2012	2.726	0.826	0.004	0.150	0.907	2.726
2013	2.782	0.666	0.003	0.158	0.666	2.782
2014	2.667	0.591	0.002	0.143	0.647	2.667
2015	3.262	0.574	0.004	0.131	0.688	3.262
2016	3.396	0.275	0.006	0.116	0.772	3.396
2017	2.758	0.272	0.015	0.127	0.756	2.758
2018	2.695	0.311	0.017	0.069	1.157	0.236
2019	2.848	0.235	0.021	0.069	1.169	0.230
2020	2.628	0.007	0.031	0.070	2.004	0.188
2021	3.059	0.013	0.024	0.079	2.497	0.185

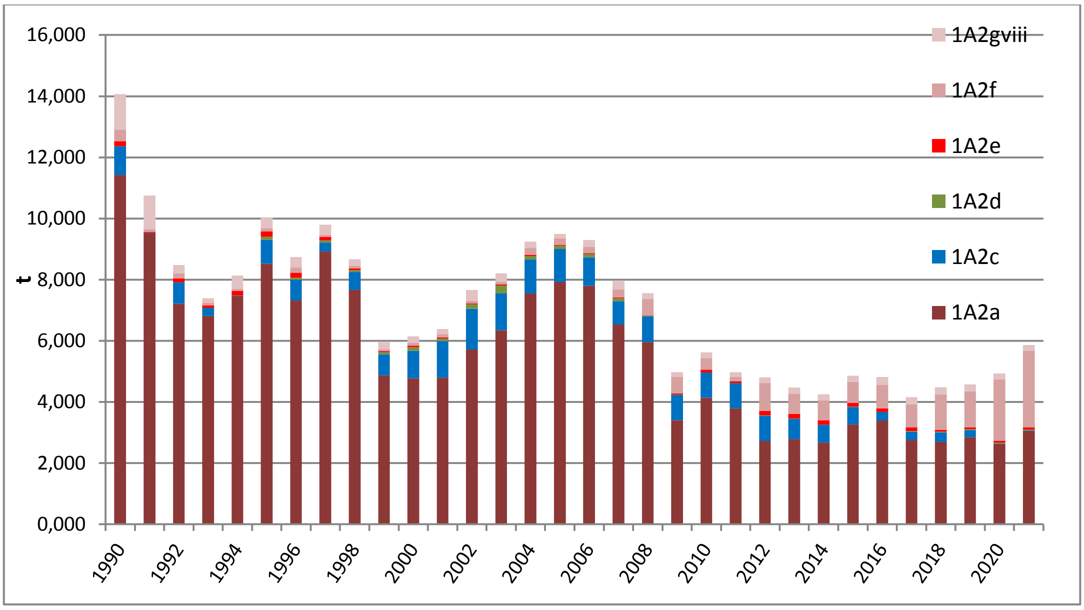


Figure 3.5.8 Pb emissions (t) for 1A2 sector by NFR, 1990-2021

Table 3.5.9 Hg (t) emissions for 1A2 sector by NFR, 1990-2021

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

Year	1A2a	1A2c	1A2d	1A2e	1A2f	1A2gviii
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
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	0.025	0.495
2006	0.488	0.084	0.004	0.008	0.025	0.488
2007	0.413	0.078	0.004	0.009	0.024	0.413
2008	0.375	0.090	0.002	0.008	0.037	0.375
2009	0.215	0.081	0.001	0.008	0.036	0.215
2010	0.258	0.080	0.003	0.012	0.026	0.258
2011	0.238	0.083	0.001	0.010	0.014	0.238
2012	0.175	0.078	0.001	0.015	0.058	0.175
2013	0.180	0.064	0.001	0.014	0.042	0.180
2014	0.174	0.059	0.001	0.014	0.043	0.174
2015	0.209	0.053	0.002	0.013	0.046	0.209
2016	0.215	0.033	0.002	0.013	0.051	0.215
2017	0.178	0.036	0.003	0.014	0.051	0.178
2018	0.175	0.040	0.002	0.010	0.079	0.018
2019	0.182	0.038	0.003	0.011	0.078	0.019
2020	0.168	0.026	0.004	0.011	0.127	0.017
2021	0.193	0.030	0.004	0.011	0.156	0.185

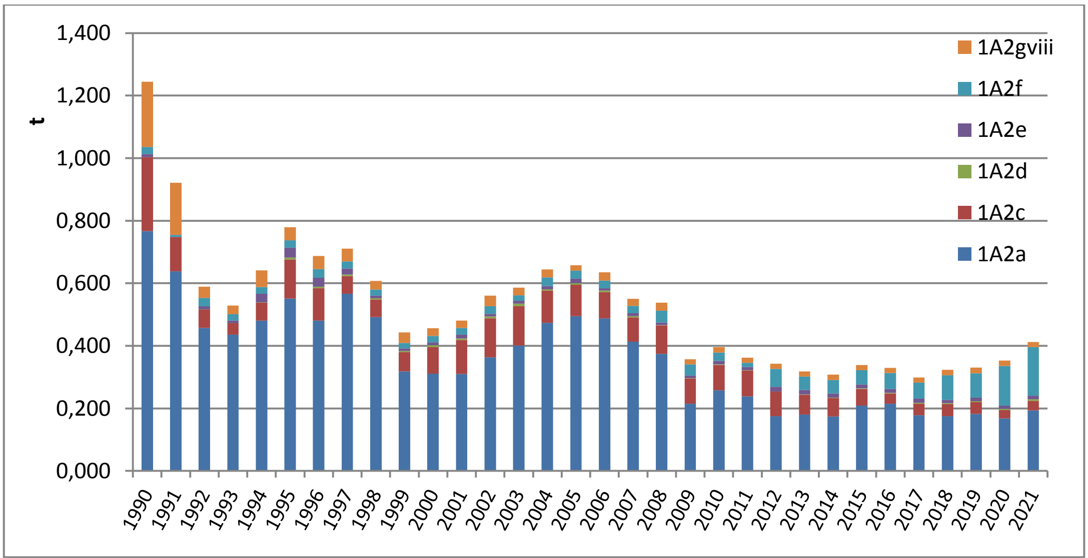


Figure 3.5.9 Hg emissions (t) for 1A2 sector by NFR, 1990-2021

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
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	0.027	0.474
2005	0.495	0.100	0.005	0.015	0.025	0.495
2006	0.488	0.084	0.004	0.008	0.025	0.488
2007	0.413	0.078	0.004	0.009	0.024	0.413
2008	0.375	0.090	0.002	0.008	0.037	0.375
2009	0.215	0.081	0.001	0.008	0.036	0.215
2010	0.258	0.080	0.003	0.012	0.026	0.258
2011	0.238	0.083	0.001	0.010	0.014	0.238
2012	0.175	0.078	0.001	0.015	0.058	0.175
2013	0.180	0.064	0.001	0.014	0.042	0.180
2014	0.174	0.059	0.001	0.014	0.043	0.174
2015	0.209	0.053	0.002	0.013	0.046	0.209
2016	0.215	0.033	0.002	0.013	0.051	0.215
2017	0.178	0.036	0.003	0.014	0.051	0.178
2018	3.418	0.389	0.019	0.049	1.464	0.005
2019	3.613	0.292	0.024	0.047	1.478	0.007
2020	3.333	0.001	0.033	0.055	2.537	0.004
2021	3.880	0.010	0.024	0.062	3.162	0.003

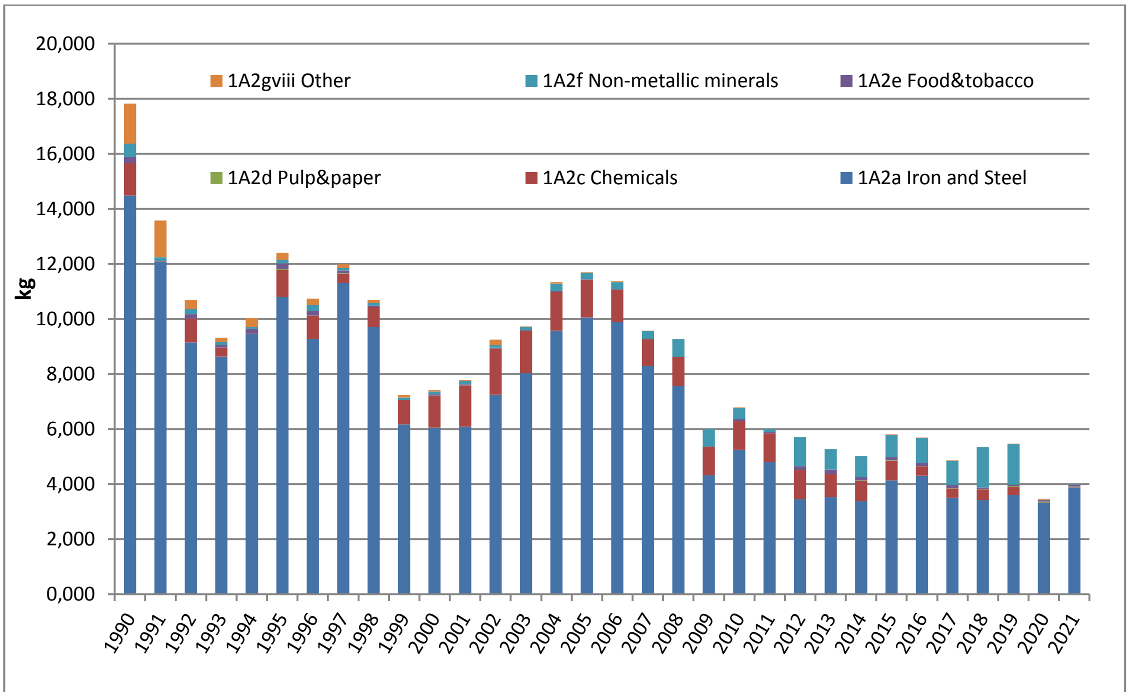


Figure 3.5.10 PCBs emissions (kg) for 1A2 sector by NFR, 1990 -2021

The next subchapters give details on NFR categories which are key sources in 2021.

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 (31,0%), NO_X(2.7%), Pb (6.6%) and Hg (11.3%) in 2021.
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, 1990-2021

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

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx (kt)	TSP (kt)	BC (kt)	CO (kt)	PCDD (g)	PAH (t)	PCBs (kg)
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
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

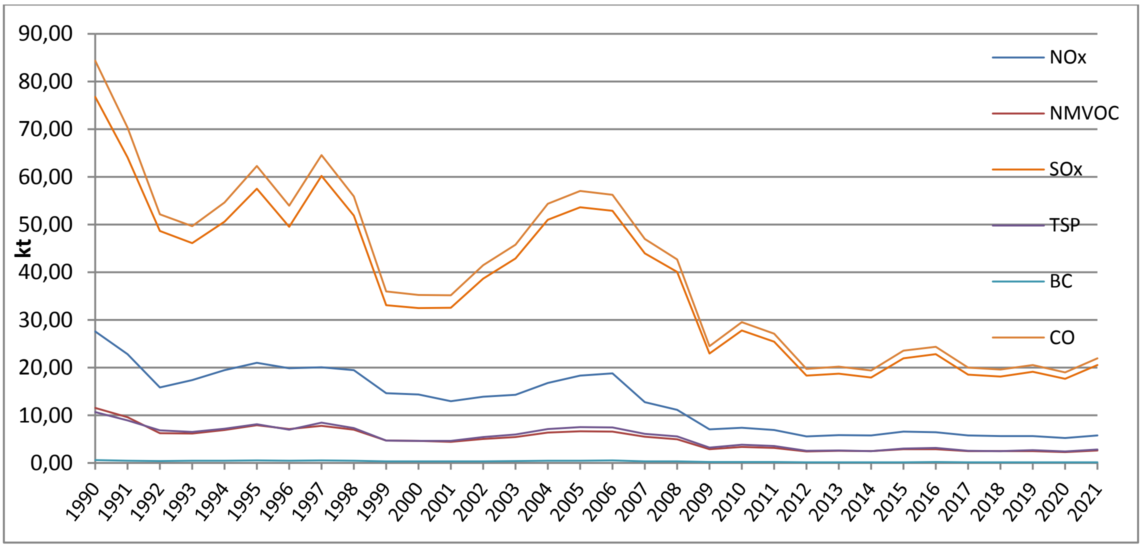


Figure 3.5.1.1 Emissions of NOx, SOx, NMVOC, NH_3, TSP, BC and CO (kt) for NFR 1A2a, 1990-2021

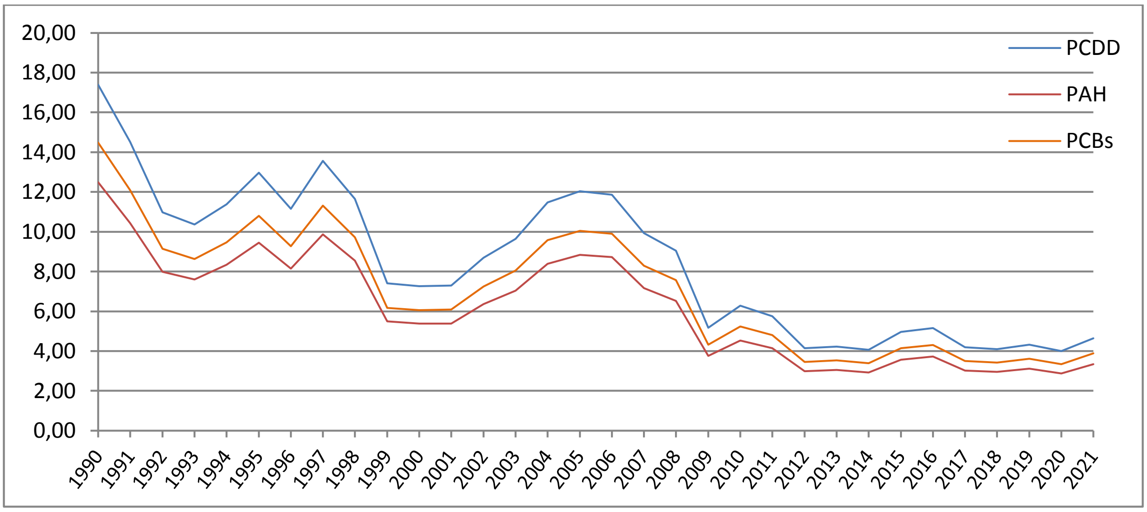


Figure 3.5.1.2 Emissions of PCDD/PCDF (g), PAH (t) and PCBs (kg) for NFR 1A2a, 1990-2021

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

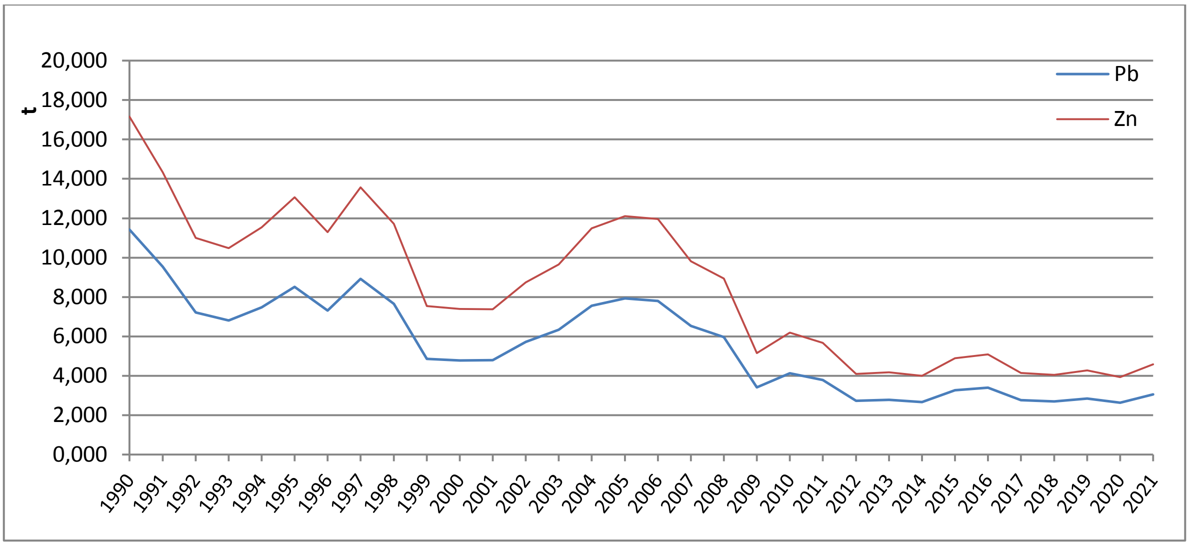


Figure 3.5.1.2.a Emissions of Pb and Zn (t) for NFR 1.A.2.a, 1990-2021

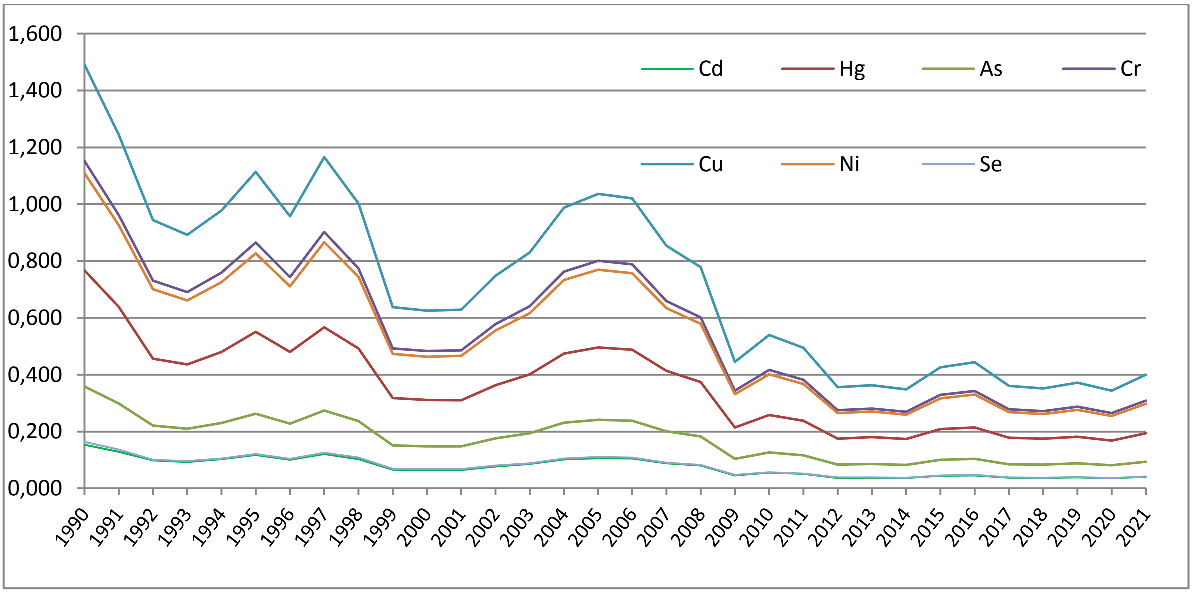


Figure 3.5.1.2.b Emissions of As, Cd, Cr, Cu, Hg, Ni and Se (t) for NFR 1.A.2.a, 1990-2021

All heavy metals emissions showed important decreases in 2021 compared to 1990 emissions, around 75% 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

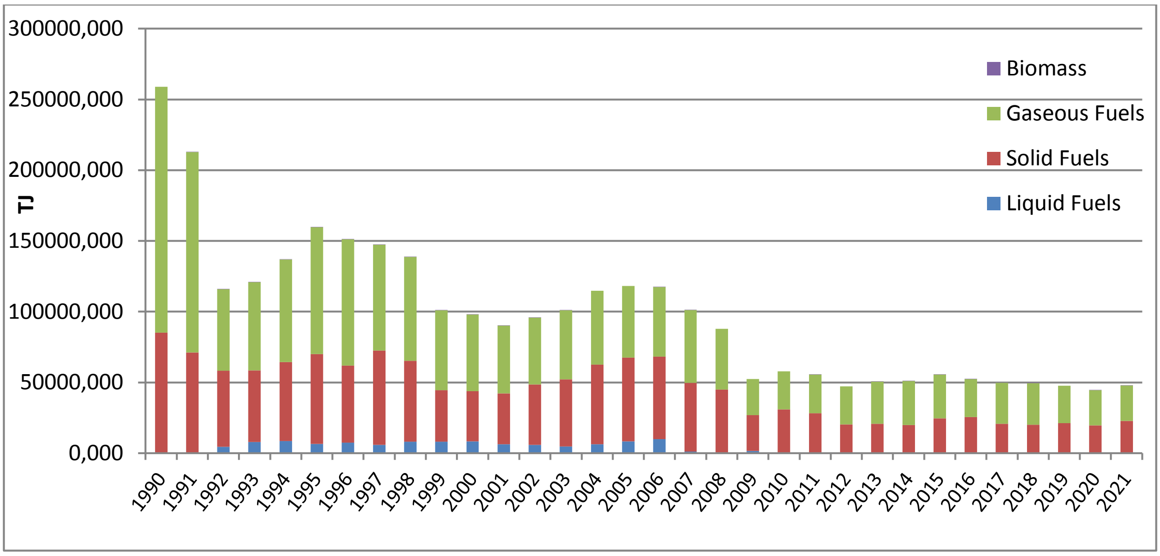


Figure 3.5.1.3 Fuel consumption (TJ), by fuel type, for NFR 1.A.2.a, 1990-2021

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 (5.3%), SOx (6.0%) and Hg (23.2%) pollutants in 2021.

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 2005-2021 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, 1990-2021

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

Year/Fuel (TJ)	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
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

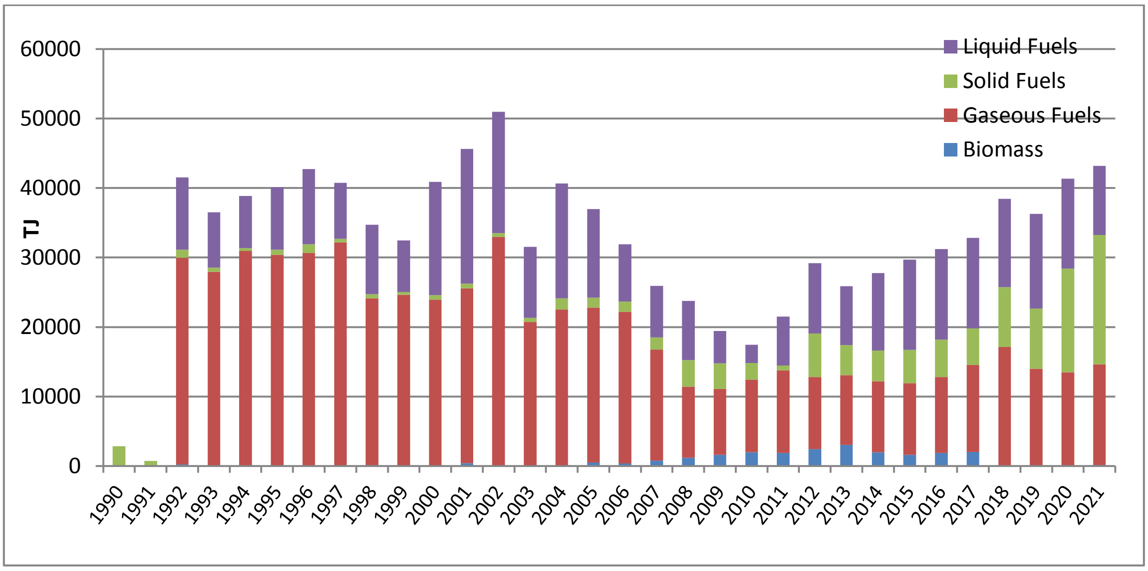


Figure 3.5.2.1 Fuel consumption (TJ), by fuel type, for NFR 1.A.2.f, 1990-2021

Table 3.5.2.2 Clinker production 2005-2021 (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	7765.02

Table 3.5.2.3 Emission for NOx, SOx, CO, PCBs, cement production - 2005-2021

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

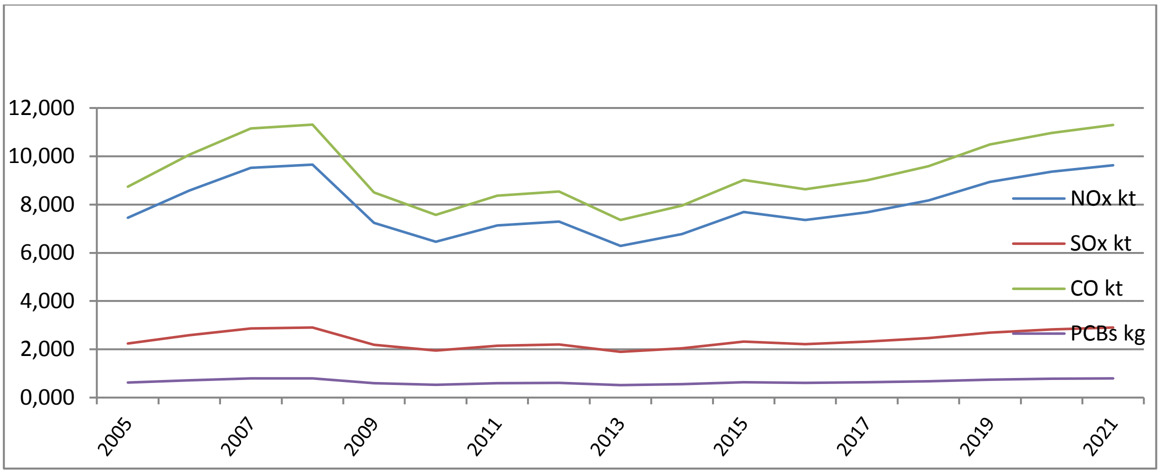


Figure 3.5.2.2 NOx, SOx, CO and PCBs emissions from cement production, 2005-2021

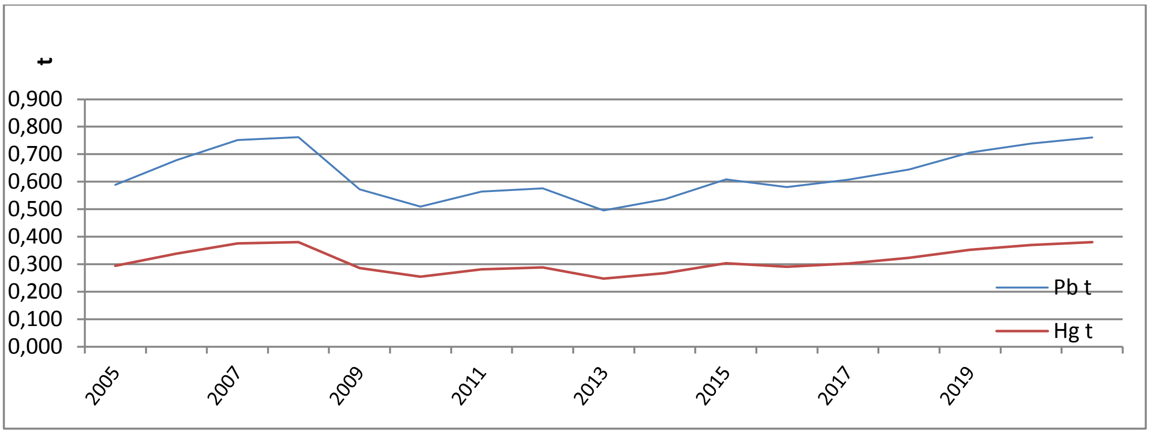


Figure 3.5.2.3 Hg and Pb emissions trend (t) from cement production, 2005-2021

Table 3.5.2.4 Fuel consumption, by fuel type, for 1A2 sector without consumption for cement production, 2005-2021

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
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

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 2005-2021

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

Table 3.5.2.6 Emissions for NOx, SOx, PM2.5, CO, Pb, Hg and PCBs from 1A2f sector, 1990-2021

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
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

Year/Pollutant	NOx kt	SOx kt	PM2.5 kt	CO kt	Pb t	Hg t	PCBs kg
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

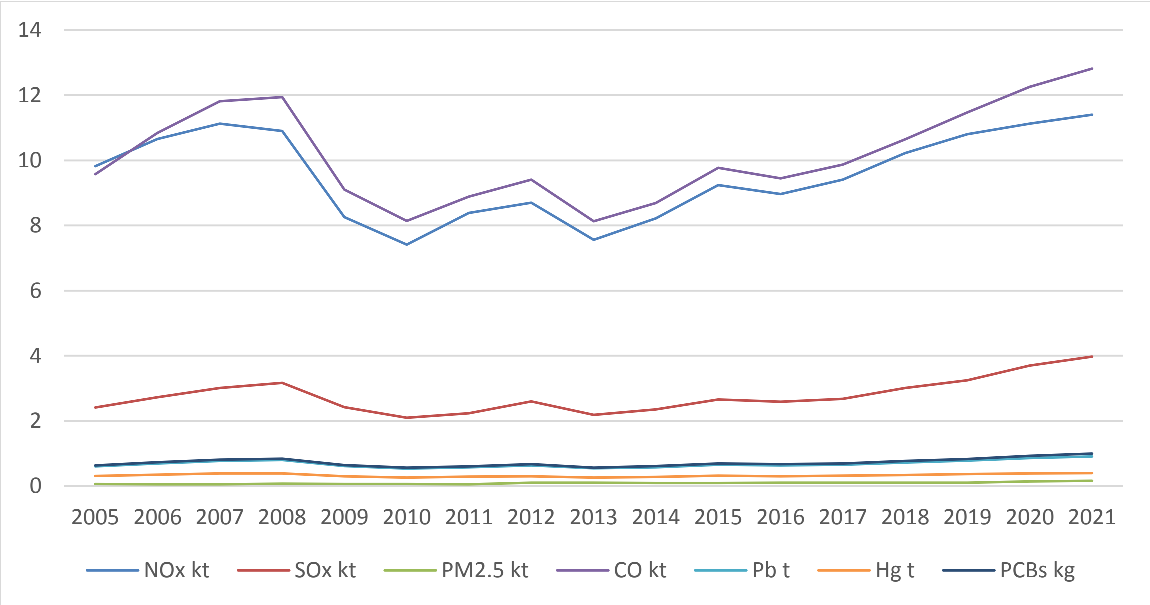


Figure 3.5.2.4 NOx, SOx, PM2.5, CO, PB, Hg, PCBs emissions trend for 1A2f sector

Recalculations and improvements:

- Recalculated 2005-2020 series applied Tier 2 and Tier 1 emissions factors (RO-1A2f-2022-0001)

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 2021 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, 1990-2021

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

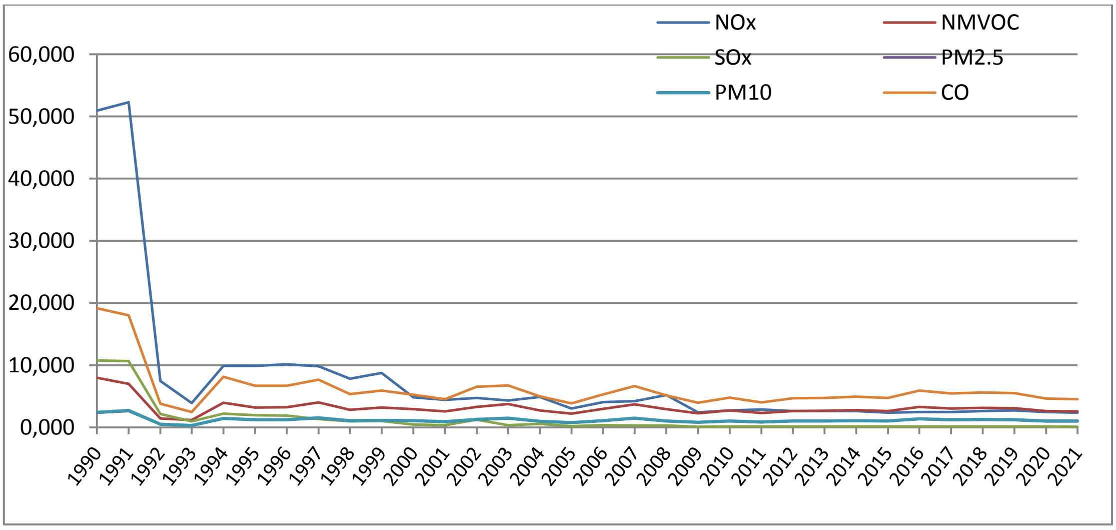


Figure 3.5.3.1 Emission trends (kt) for NFR 1.A.2.g.viii, Other industries, 1990-2021

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, 1990-2021

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
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

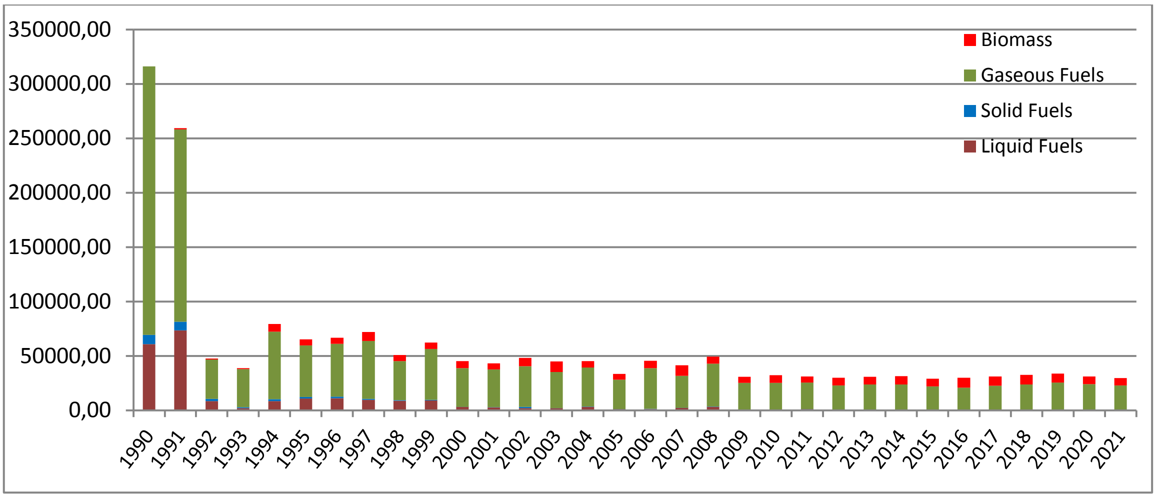


Figure 3.5.3.2 Fuel consumption [TJ], by fuel type, for NFR 1.A.2.g.viii, Other industries, 1990-2021

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 – 2021. 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 2021.

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.

No recalculation was performed on the 1990-2020 time series compared to 2022 submission.

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 2021 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
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

Year/Pollutant (kt)	NOx	NMVOC	CO
2019	3.939	0.744	10.669
2020	3.690	0.732	10.857
2021	3.823	0.845	13.162

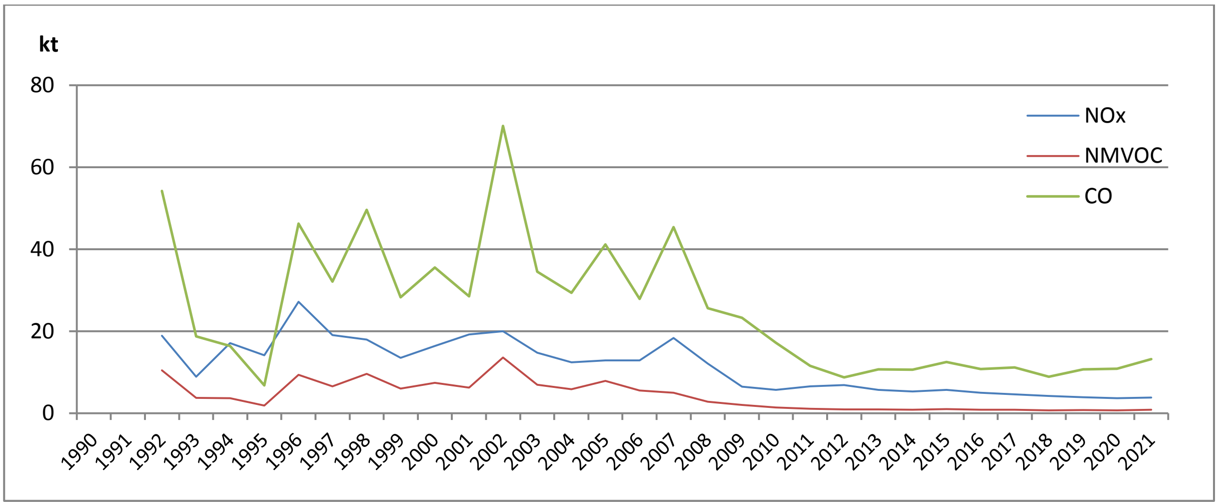


Figure 3.6.1 Emissions of NOx, NMVOC and CO for NFR 1.A.2.gvii

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
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

Year/Fuel (TJ)	Diesel fuel	Gasoline	Total liquid fuel
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

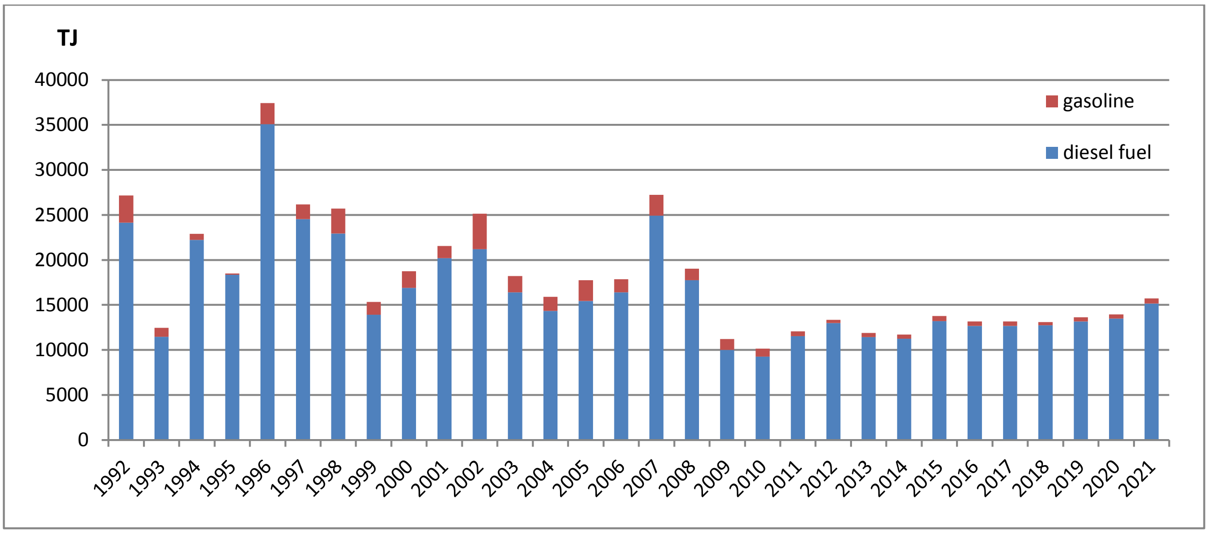


Figure 3.6.2 Fuel consumption (TJ) for NFR 1.A.2.gvii

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 and 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.
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.

NFR	NFR name	Source description
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

Source of emission factors:

NFR	Reported pollutants	Emission Factor 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 - 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)
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 1999-2021, T1 for 1992-1998 T1 for 1992-2021 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 - EMEP EEA guidebook (2019) factors for liquid fuels (average of Tier 2 tables 3.17-3.18) T2 - EMEP EEA guidebook (2019) factors for gaseous fuels (average of Tier 2 tables 3.13-3.16) T2 – factors for biomass and wood combustion (tables 3.40, 3.43, 3.44)
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 1999-2021, T1 for 1992-1998 T1 for 1992-2021 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 the table 3.7.2 and figure 3.7.1:

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	26.94	214.16	kt	12.58
NMVOC	83.09	234.22	kt	35.48
SOx	5.85	66.28	kt	8.82
NH_3	9.57	158.60	kt	6.03
$PM_{2.5}$	98.30	116.14	kt	84.64
PM_{10}	100.96	157.23	kt	64.21
TSP	106.21	232.44	kt	45.70
BC	10.32	13.73	kt	75.16
CO	593.15	964.33	kt	61.51
Pb	4.30	46.41	t	9.27
Cd	1.84	3.14	t	58.51
Hg	0.12	1.71	t	6.98
As	0.07	3.65	t	1.84
Cr	3.46	14.85	t	23.31
Cu	1.55	78.60	t	1.97
Ni	2.62	11.84	t	22.10
Se	0.31	6.82	t	4.61
Zn	73.17	129.24	t	56.62
PCDD	107.16	210.69	g I-TEQ	50.86
Total PAH	47.99	59.49	t	80.66
HCB	0.71	3.59	t	19.69
PCBs	0.48	19.79	t	2.44

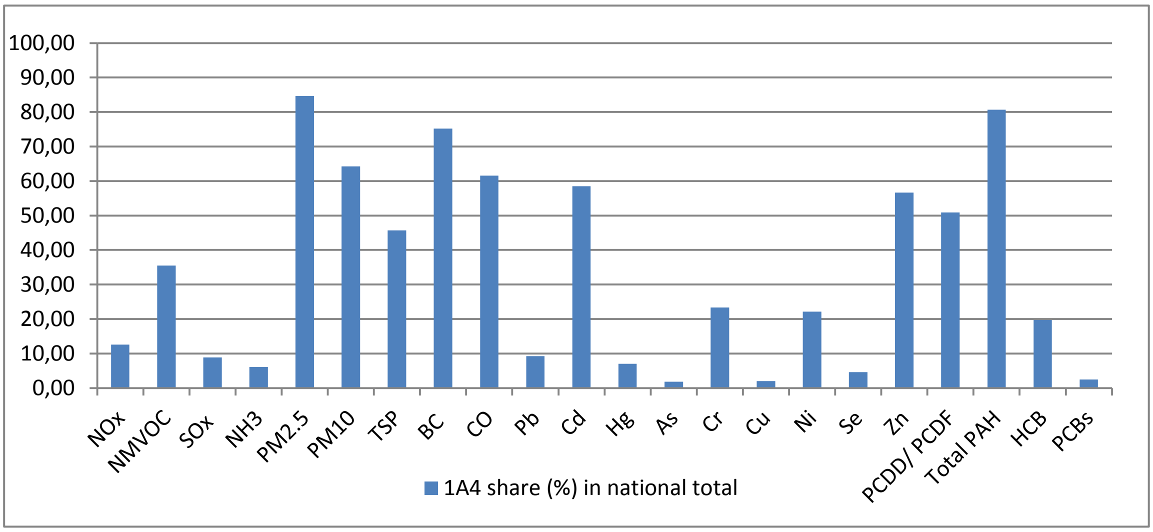


Figure 3.7.1 Share of small combustion emissions, including non-road, in the 2021 national total

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

Emissions were estimated by applying emission factors from Guidebook 2019 to activity data from EUROSTAT energy balances, category *Final energy consumption/Other Sectors/Service.* For biomass, years 1991-2017, the consumption in the EUROSTAT category *Final energy consumption/Other Sectors/Non-specified (Other)* is also included in NFR 1.A.4.a.i. Since 2018, NIS reallocated the Solid Biofuel in the EUROSTAT ENERGY Questionnaires from 'Other sectors/Not elsewhere specified' (corresponding to 1A5a) to 'Other sectors/Commercial and public services' (corresponding to 1A4a).

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 (2019 EMEP/EEA Guidebook, NFR 1.A.4 Small combustion, Tables 3.7 – 3.9) for liquid, gaseous and solid fuels and Tier 2 for biomass - Table 3-46, *Tier 2 emission factors for non-residential sources, medium sized (>50KWth to ≤ 1 MWth) boilers wood (in the absence of information on manual/automatic feed).* The Tier1 emission factors are average of Tier 2 EFs for commercial/institutional for all technologies (ref: Guidebook notes to Tables 3.8, 3.9) for gaseous and liquid fuels.

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 for NFR 1A4ai, stationary combustion in commercial/institutional sector.

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	0.690	0.180	3.051
1992	1.107	0.462	0.019	0.101	0.024	0.803
1993	0.871	0.495	0.026	0.180	0.045	1.043
1994	1.048	0.546	0.027	0.179	0.045	1.100
1995	1.194	0.578	0.027	0.691	0.042	1.114
1996	1.419	0.845	0.045	0.102	0.082	1.820
1997	1.042	0.606	0.032	0.181	0.057	1.290
1998	1.738	0.647	0.090	0.179	0.039	1.157
1999	1.439	0.722	0.151	0.170	0.060	1.546
2000	0.910	0.372	0.149	0.324	0.020	0.764
2001	2.194	1.393	0.334	0.226	0.143	3.317
2002	0.944	1.107	0.235	0.149	0.165	3.069
2003	2.143	1.452	0.198	0.246	0.160	3.412
2004	2.850	1.521	0.145	0.095	0.134	3.190
2005	3.414	2.055	0.123	0.591	0.200	4.458
2006	6.114	2.736	0.343	0.652	0.201	5.356
2007	4.271	2.095	0.156	0.639	0.157	4.133
2008	3.104	1.674	0.102	0.535	0.144	3.455
2009	3.630	1.698	0.167	0.796	0.137	3.384
2010	3.505	1.738	0.122	0.801	0.136	3.461
2011	2.976	1.222	0.178	0.641	0.087	2.335
2012	2.743	1.179	0.089	0.579	0.073	2.159
2013	2.834	1.154	0.109	0.534	0.066	2.068
2014	2.776	1.116	0.283	0.549	0.057	2.121
2015	2.901	1.474	0.292	0.336	0.118	3.135
2016	2.992	1.609	0.298	0.297	0.138	3.496
2017	3.329	1.598	0.210	0.270	0.115	3.193

Year/Pollutant (kt)	NOx	NMVOC	SOx	PM2.5	BC	CO
2018	3.338	1.573	0.207	0.259	0.110	3.111
2019	3.306	1.565	0.194	0.494	0.110	3.088
2020	3.073	1.399	0.158	0.573	0.092	2.686
2021	3.091	1.449	0.175	0.481	0.103	2.858

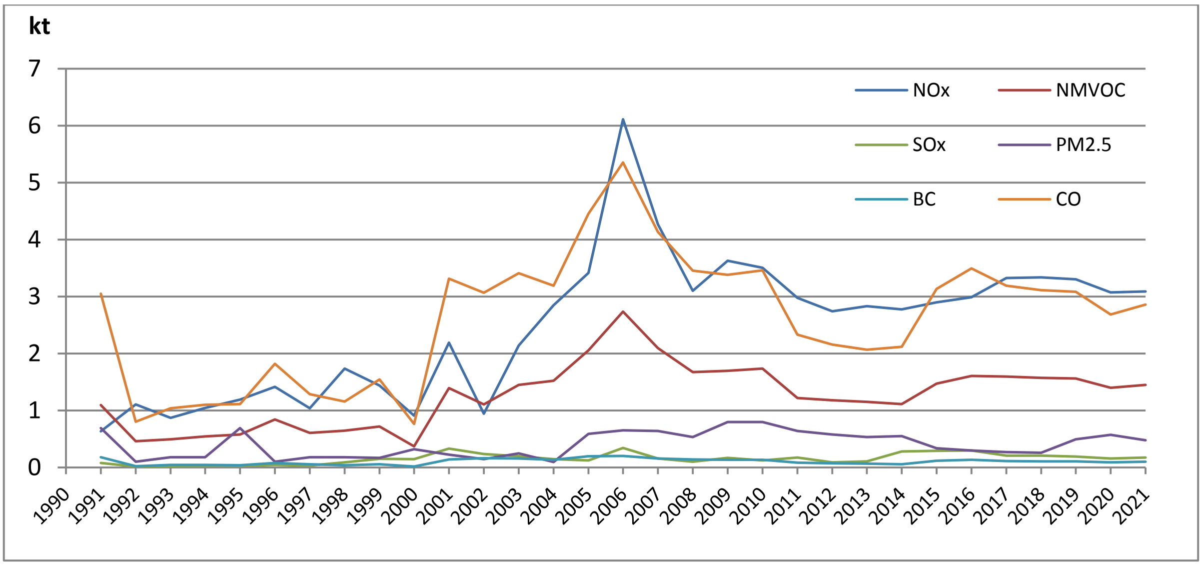


Figure 3.8.1 Emissions (kt) of NOx, NMVOC, SOx, PM_{10}, BC and CO for NFR 1.A.4.a.i

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.

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

Year/Fuel type	Liquid Fuels	Solid Fuels	Gaseous Fuels	Biomass
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

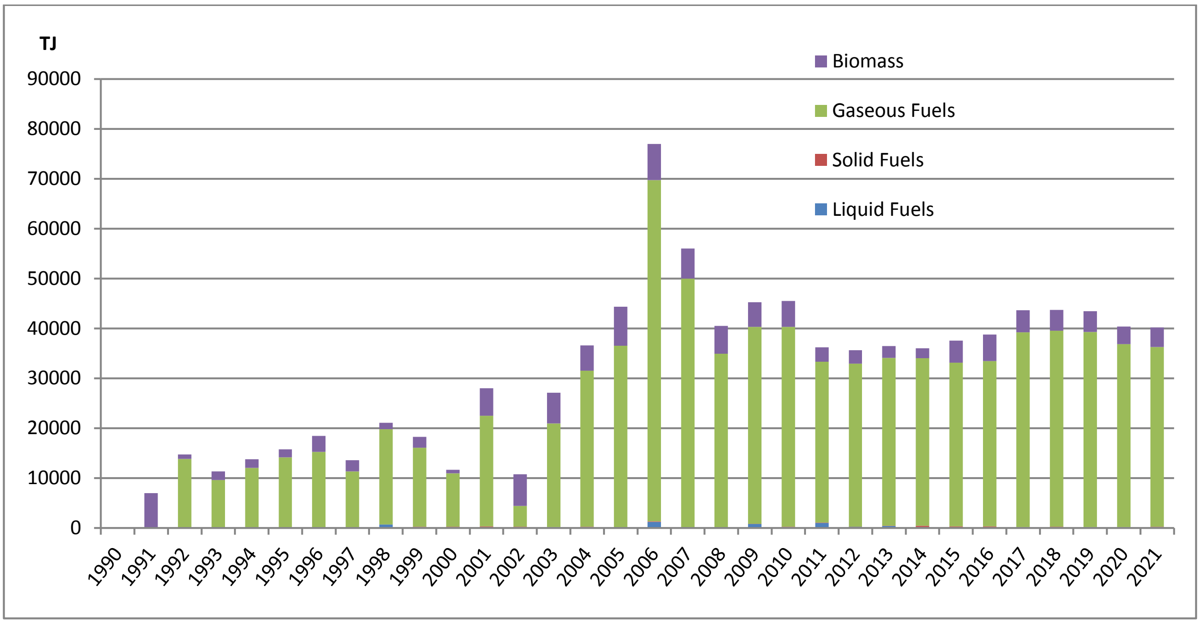


Figure 3.8.2 Fuel consumption (TJ), by fuel type, for NFR 1.A.4.a.i

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 (2017-2021). Data for 1991-1992 are included in NFRs 1A3b.

The estimation for 2021 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 key category in 2021 for CO, accounting for 3.57% in the national total.

No recalculation was performed compared to 2021 submission for this NFR, except one correction (SOx emission in 2019).

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 2021 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

Year/Pollutant (kt)	NOx	NMVOC	CO
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
2021	0.372	1.544	34.474

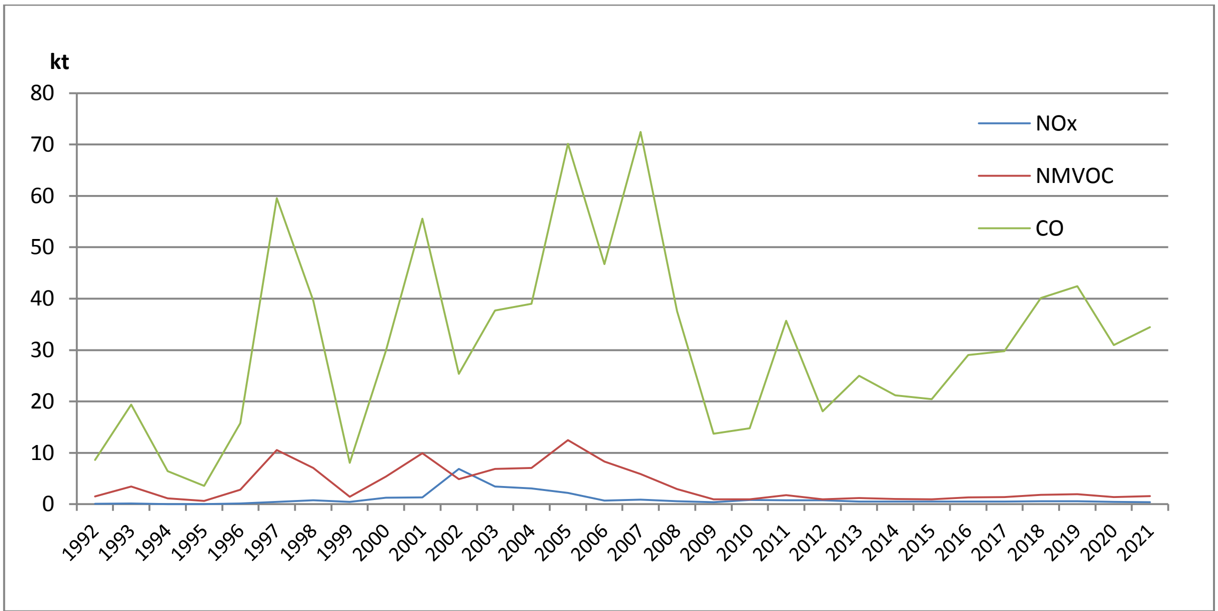


Figure 3.8.1.1 Emissions of NOx, NMVOC and CO (kt) for NFR 1.A.4.a.ii

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

Year/Fuel (TJ)	Diesel fuel	Gasoline	Total liquid fuel
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
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

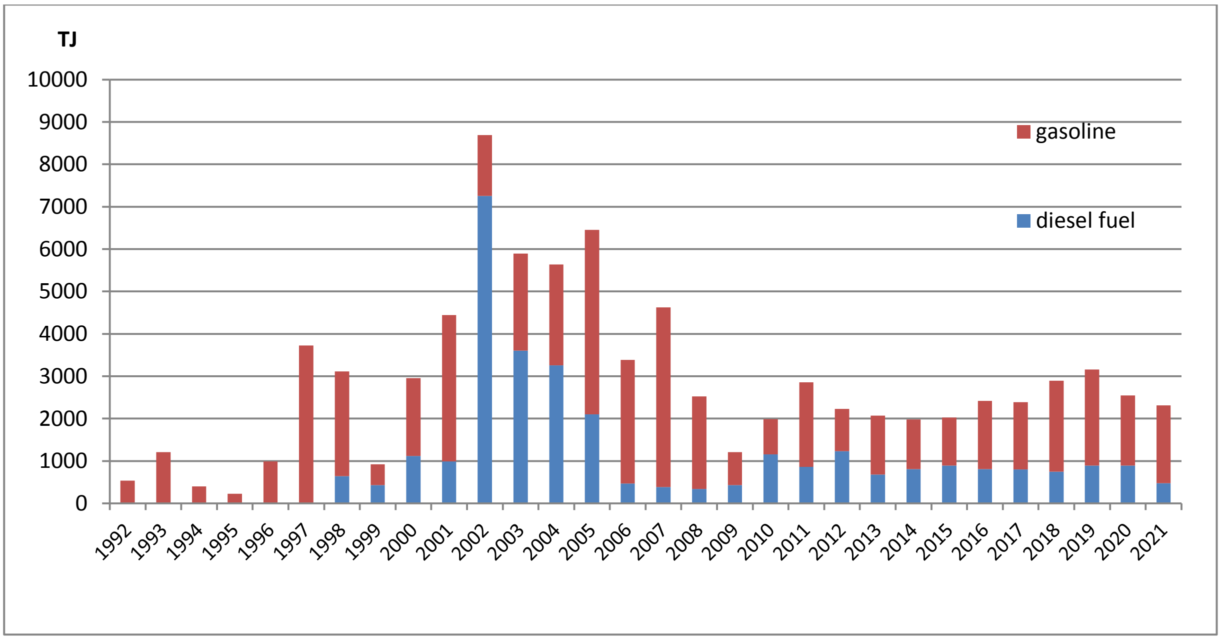
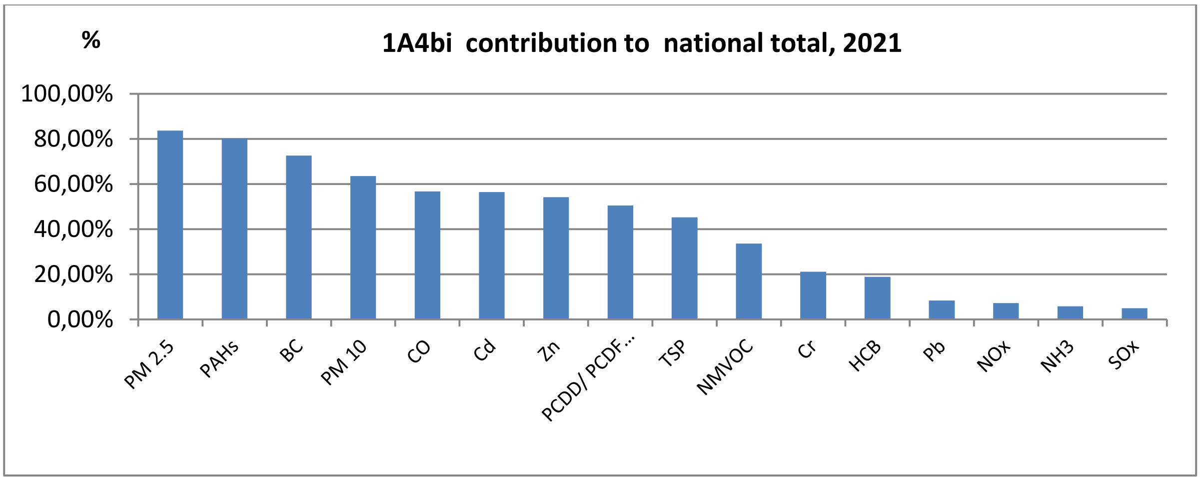


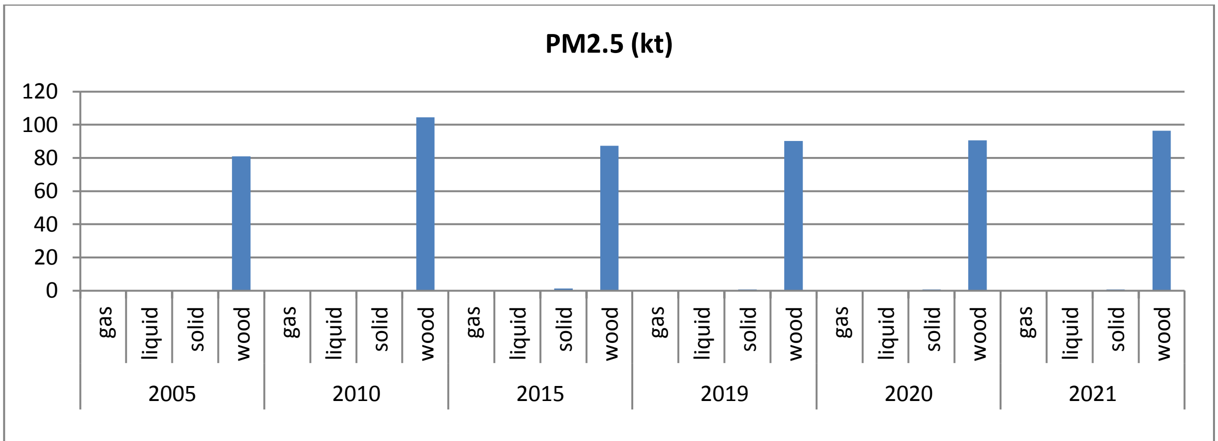
Figure 3.8.1.2 Fuel consumption (TJ) for NFR 1.A.4.a.ii

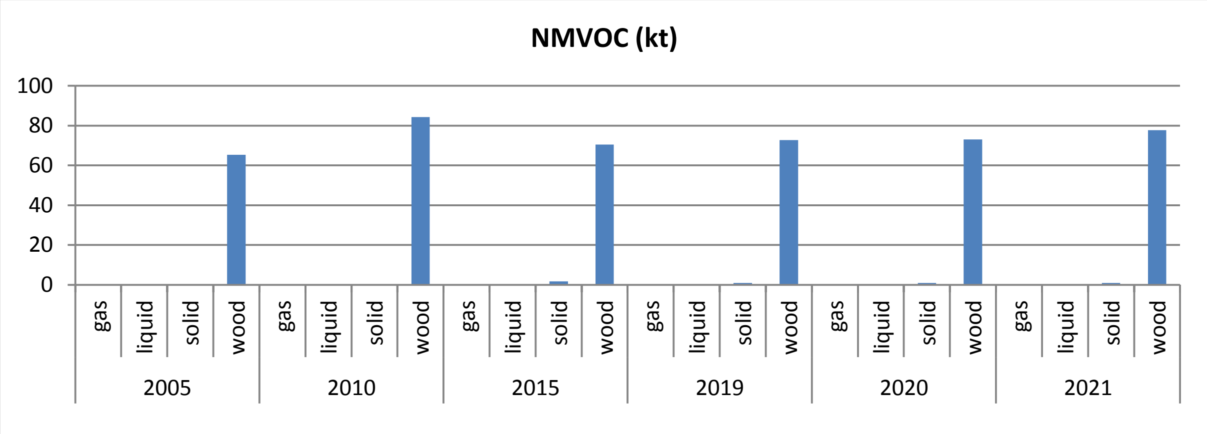
3.9 NFR 1.A.4.b.i Residential

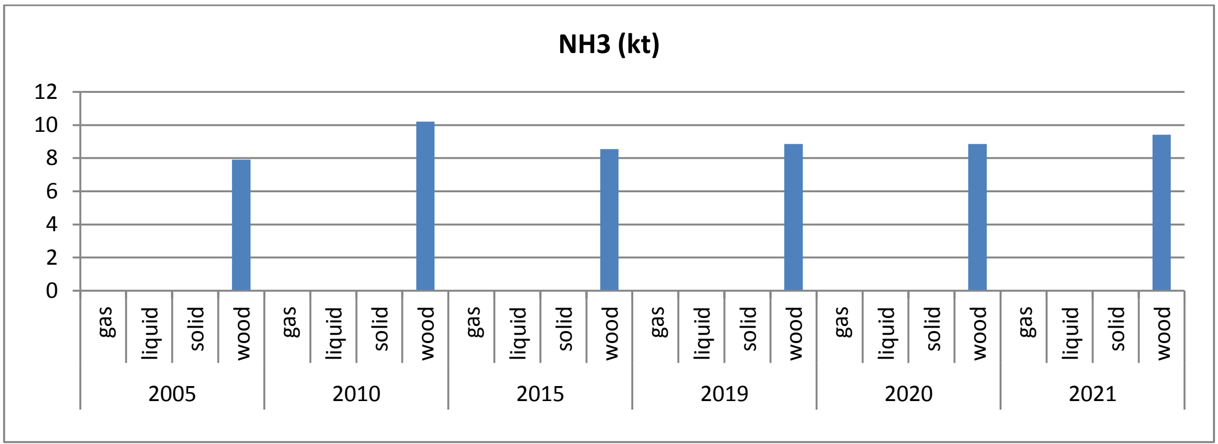
Residential heating is, as for 2021, key category for many pollutants, accounting for the following contributions to the national total: PM2.5 (83.8%), PAH (80.16%), BC (72.6%), PM10 (63.5%), Zn (54.3%), Cd (56.5%), CO (56.8%), PCDD/PCDF (50.5%), TSP (45.22%), NMVOC (33.7%), Cr (21.2%), HCB (19%), Pb (8.5%), NOx (7,3%), NH3 (5.9%).

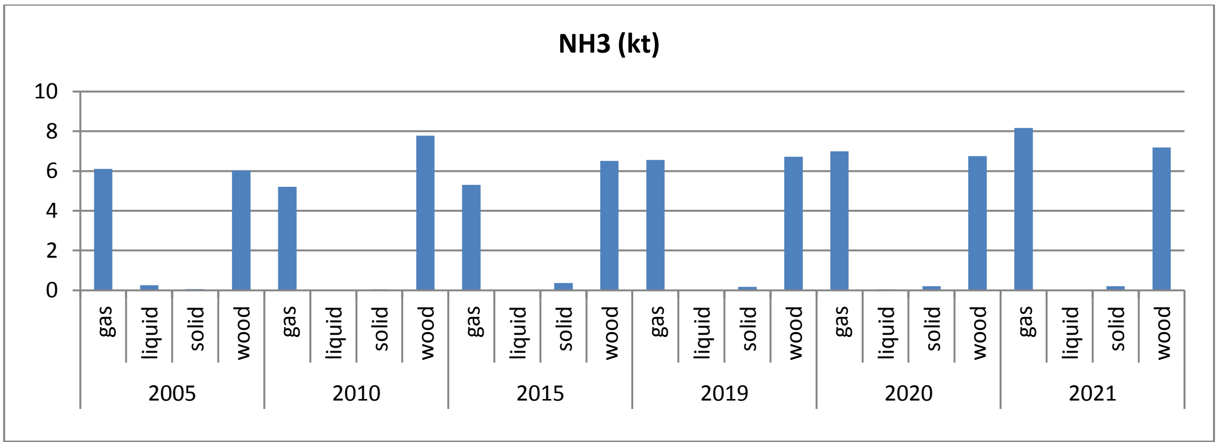


The activity data consist of fuel consumption provided, for the years 1990-2016, by EUROSTAT (energy balances, annual data – nrg_110a, *Final energy consumption/Other Sectors/Residential)* and for 2017-2021 by the N.I.S, in the forms of the EUROSTAT ENERGY questionnaires. The diesel and gasoline consumption for this category are not included in 1A4bi but allocated to 1A4bii – Mobile machineries.
The emission factors are given by the 2019 EMEP/EEA Guidebook.
For NFR category 1A4bi, relevant fuels are solid biomass (wood) and natural gas (see Figure 3.9.1). The emissions on type of fuels for the pollutants $PM_{2.5}$, NOx, NH_3 and NMVOC is shown in charts below, in kt.









Tier 2 methodology was applied for wood combustion, with following percentages of technologies in 2021: conventional stoves burning wood and similar wood waste 91% (*Small combustion, Table 3.40 Tier 2 emission factors for NFR category 1.A.4.b.i*), conventional boilers < 50 kW 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 2% (*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).

The tables and charts below provide the main emissions and the fuel consumption 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	10.350	30.253	29.997	30.726	31.394	33.648	2.625	249.812
1991	9.638	21.163	17.979	22.114	22.613	24.156	1.947	170.957
1992	6.865	20.122	14.389	21.759	22.270	23.716	1.979	157.729
1993	6.800	23.367	9.414	26.834	27.507	29.126	2.574	172.527
1994	6.150	23.323	3.104	28.151	28.891	30.454	2.810	163.024
1995	6.741	25.967	2.789	31.527	32.357	34.089	3.183	181.916
1996	9.394	55.950	6.318	67.966	69.758	73.505	6.861	391.150
1997	11.893	73.852	5.908	90.272	92.666	97.591	9.156	512.686
1998	11.355	66.170	2.067	81.610	83.791	88.172	8.334	454.844
1999	10.692	62.610	3.036	76.961	79.011	83.167	7.839	431.960
2000	10.948	60.285	2.805	74.206	76.179	80.176	7.594	417.985
2001	8.795	42.594	1.125	52.596	53.998	56.812	5.396	294.393
2002	9.711	43.568	1.749	53.644	55.071	57.952	5.492	302.154
2003	11.187	53.498	1.704	66.000	67.758	71.294	6.767	370.172
2004	12.356	65.202	2.905	80.329	82.466	86.784	8.226	451.844
2005	12.443	65.791	2.147	81.313	83.479	87.830	8.348	455.117
2006	12.124	61.865	1.986	76.476	78.513	82.603	7.852	427.960
2007	11.667	64.481	2.142	79.734	81.858	86.124	8.188	445.857
2008	13.089	82.944	3.643	102.317	105.038	110.540	10.487	574.591
2009	12.820	81.586	2.152	100.908	103.597	108.999	10.364	563.347
2010	13.041	84.652	2.039	104.741	107.534	113.137	10.761	584.200
2011	12.510	75.783	2.224	93.661	96.156	101.173	9.615	523.756
2012	13.220	79.243	2.599	97.870	100.476	105.725	10.042	548.100
2013	12.634	75.012	2.420	92.650	95.117	100.085	9.507	518.808
2014	12.314	76.131	4.129	93.675	96.160	101.219	9.584	528.750
2015	12.215	72.332	4.458	88.873	91.228	96.037	9.083	503.232
2016	12.244	72.423	3.551	89.184	91.553	96.360	9.130	502.607
2017	13.235	73.821	2.763	91.083	93.505	98.396	9.339	511.281
2018	13.419	73.194	2.746	90.307	92.709	97.557	9.259	507.009
2019	13.517	73.778	3.059	90.972	93.390	98.279	9.323	511.429
2020	13.993	74.304	3.209	91.578	94.011	98.935	9.382	515.364
2021	15.579	78.954	3.344	97.303	99.888	105.118	9.969	547.720

The following charts show the variation of the pollutants for which 1A4bi is a key source.

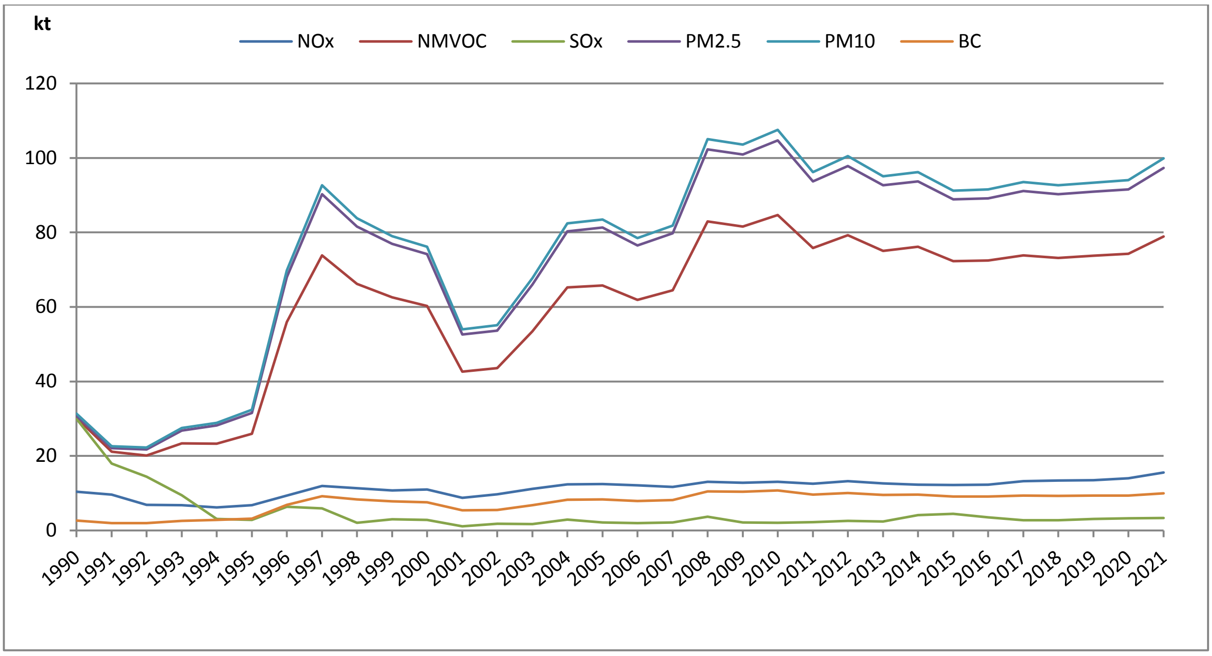


Figure 3.9.1 Emissions (kt) of NOx, NMVOC, SOx, PM_{10}/$PM_{2.5}$ for NFR 1.A.4.b.i

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

Year/Pollutant	Pb (t)	Cd (t)	Cr (t)	Zn (t)	HCB (kg)
2018	3.602	1.648	2.929	65.145	0.634
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

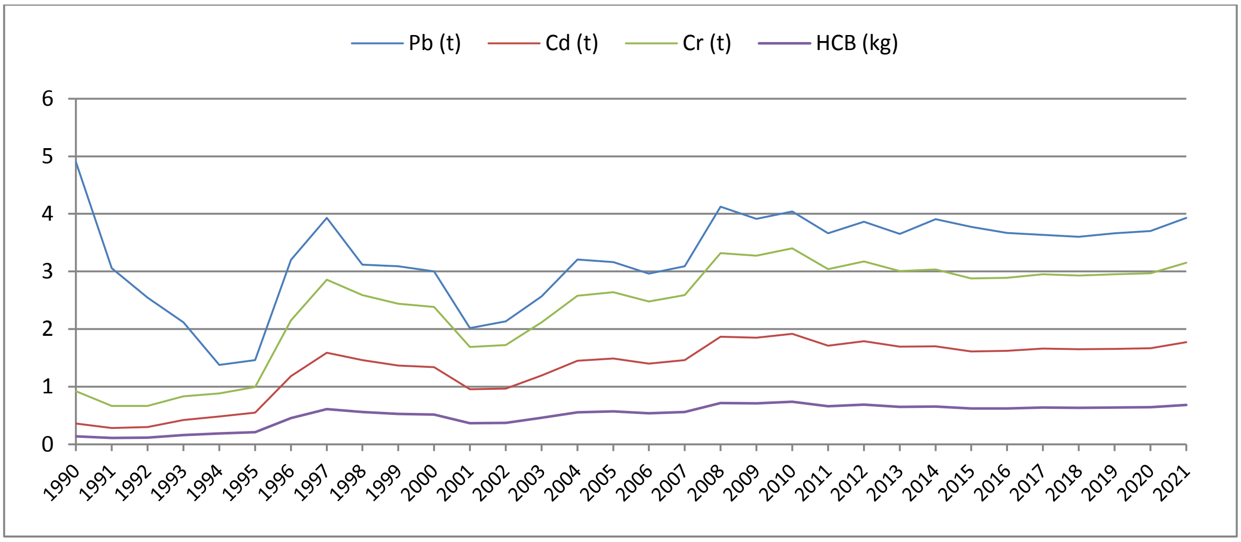


Figure 3.9.2 Emissions of Pb, Cd, Cr and HCB for NFR 1.A.4.bi

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	45.389	34.488	5.563
1991	31.182	22.313	3.314
1992	29.203	19.517	2.577
1993	32.712	18.641	1.667
1994	31.597	15.069	0.501
1995	35.139	16.516	0.431
1996	75.877	35.905	0.995
1997	99.749	45.986	0.847
1998	88.800	39.269	0.127
1999	84.213	37.822	0.339
2000	81.237	36.535	0.306
2001	57.232	25.301	0.055
2002	58.626	26.215	0.172
2003	71.926	31.923	0.118
2004	87.813	39.311	0.267
2005	88.575	39.214	0.103
2006	83.269	36.806	0.078
2007	86.818	38.387	0.082
2008	111.896	50.135	0.343
2009	109.843	48.616	0.107
2010	113.946	50.353	0.080
2011	102.056	45.284	0.145
2012	106.760	47.512	0.206
2013	101.050	44.950	0.188
2014	102.847	46.581	0.504

Year/Pollutant	PCDD/F (g I-TEQ)	Total 4 PAHs (t)	PCBs (kg)
2015	97.792	44.543	0.578
2016	97.764	44.086	0.409
2017	99.490	44.421	0.252
2018	98.639	44.029	0.247
2019	99.472	44.528	0.297
2020	100.195	44.920	0.327
2021	106.441	47.689	0.339

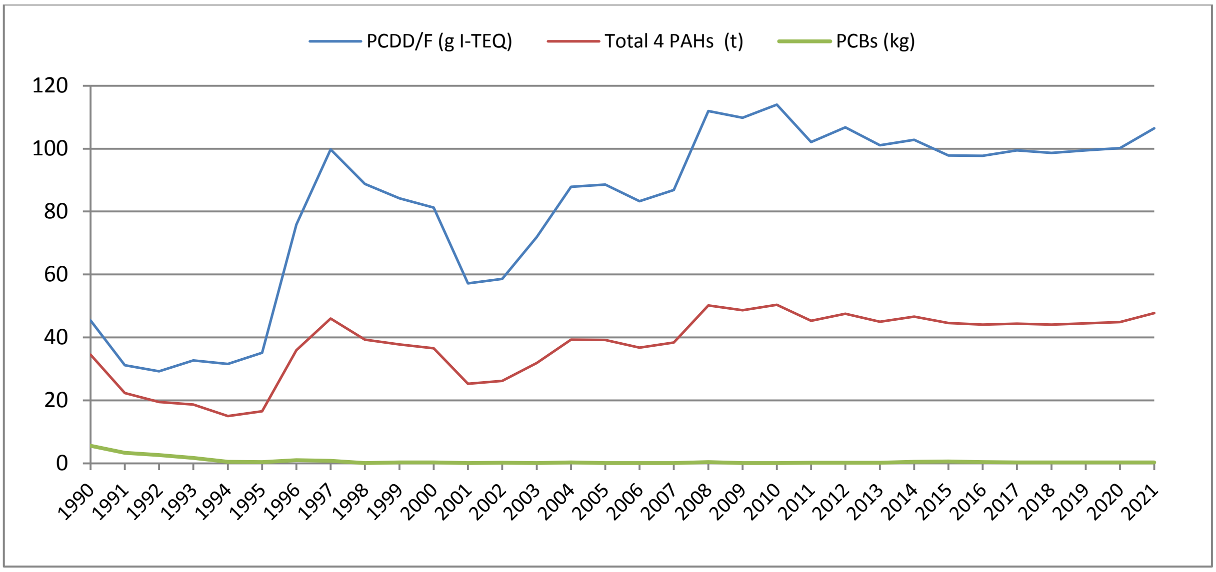


Figure 3.9.3 Emissions of PCDD/F (g I-TEQ) and Total PAHs (t) for NFR 1.A.4.b.i

Most of pollutants 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.

Compared to 2005, the emissions in 2021 increased with 3.14 kt for NOx, 1.2 kt for SOx, 13.16 kt for NMVOC and 15.99 kt for $PM_{2.5}$.

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
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

Year/Fuel (TJ)	Liquid fuels	Solid fuels	Gaseous fuels	Biomass
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

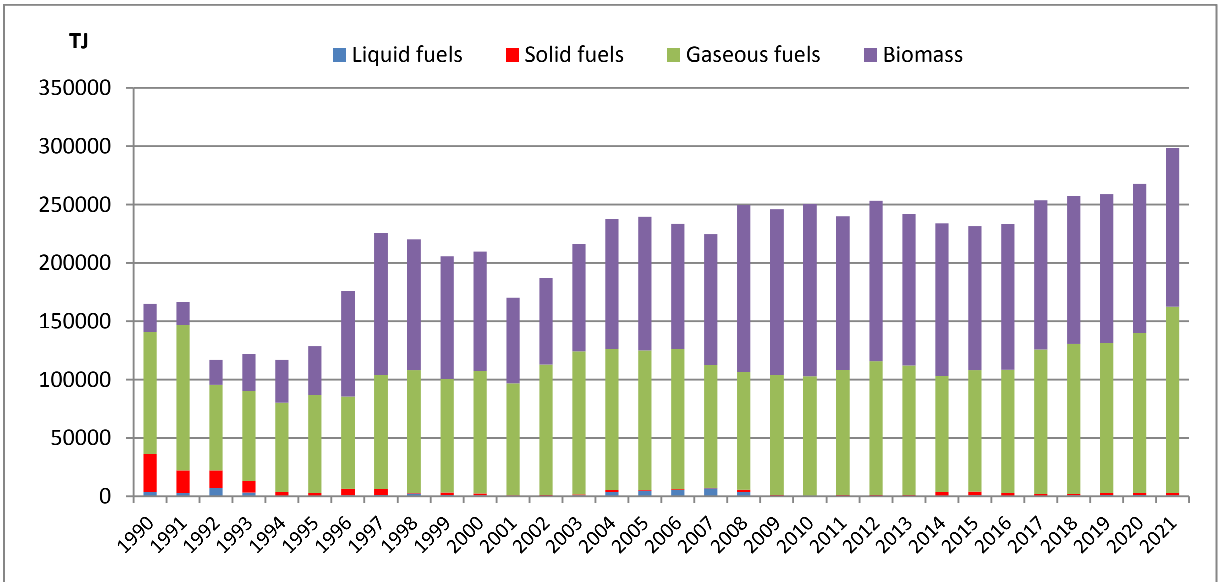


Figure 3.9.4 Fuel consumptions trend (TJ) for Residential heating (NFR 1.A.4.bi)

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.

Estimation of emissions for 1A4bii was performed only for those years for which there are non-zero values in the EUROSTAT energy database for the mentioned fuel category. Where data are not available separately, the estimation is considered as included in NFRs 1A3b (same for 2021).

No recalculation was performed compared to 2021 submission for this NFR.

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

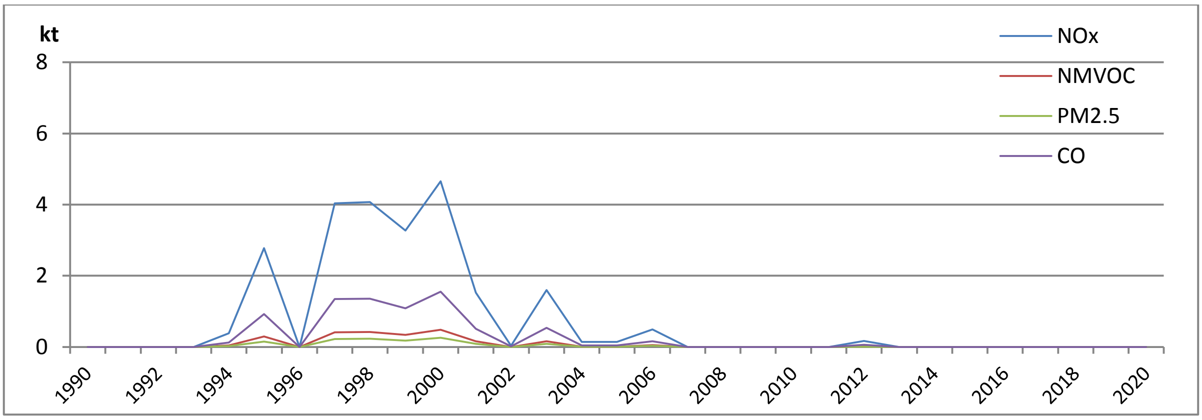


Figure 3.9.1.1 Emissions of main pollutants (kt) from NFR 1A4bii

The fuel consumption for the time-series 1990-2021 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

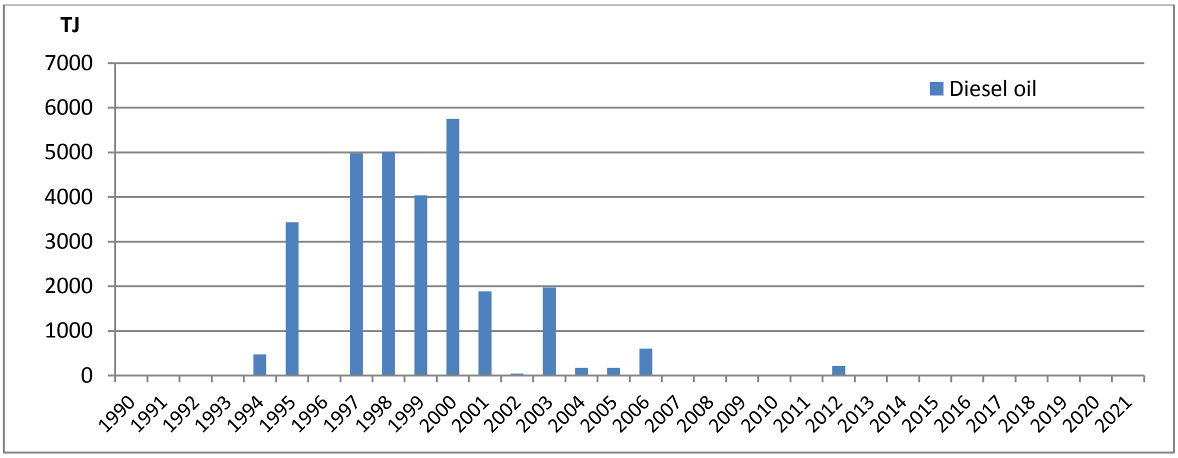


Figure 3.9.1.2 Fuel consumption (TJ) for NFR 1A4bii

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

The emissions for 1990-2021 are 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).

No recalculation was performed for this NFR compared to 2021 submission.

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
2002	0.525	0.118	0.218	0.063	0.021	0.361	0.161

Year/Pollutant	NOx (kt)	NMVOC (kt)	SOx (kt)	$PM_{2.5}$ (kt)	BC (kt)	CO (kt)	Ni (t)
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

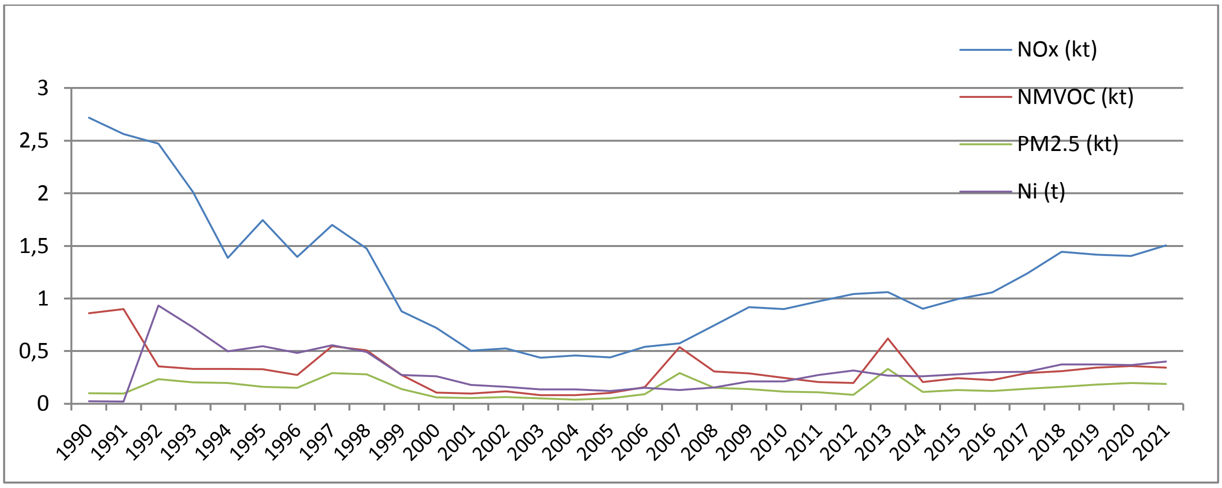


Figure 3.10.1 Emission of main pollutants for NFR 1.A.4.c.i

The fuel consumption for the time-series 1990-2021 for this category is provided in the table and chart below.

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
1997	4433.00	23.00	2992.00	1291.00

Year/Fuel (TJ)	Liquid fuels	Solid fuels	Gaseous fuels	Biomass
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

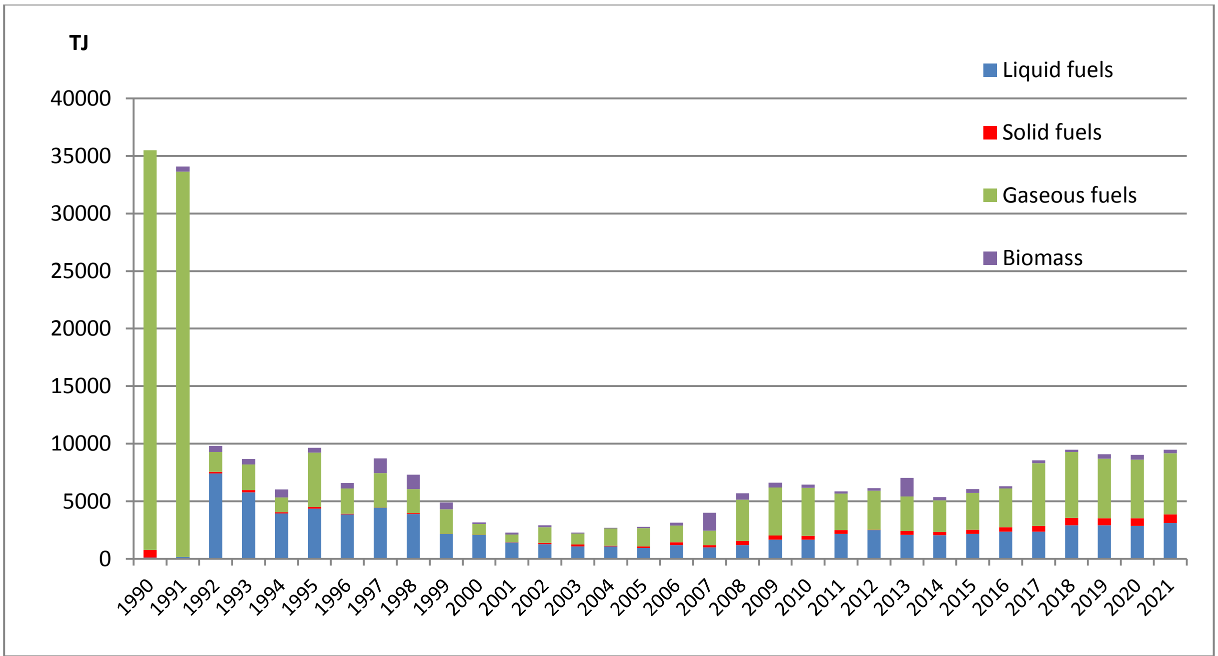


Figure 3.10.2 Fuel consumptions (TJ) for NFR 1.A.4.c.i: Agriculture/Forestry/Fishing, stationary

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*. Data for 2017 - 2019 are provided by N.I.S. in the Eurostat Energy questionnaires.
The activity data considered in the actual estimation 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. The emission factors used for Tier 2 calculation are given in the Table 3-2 - Tier 2 emission factors for non-road machinery, Diesel, 1A4cii Agriculture and Forestry, Guidebook 2019. The emission factors for diesel are different than those for agriculture for the gaseous pollutants and particulate matter and they are the same, for heavy metals and PAHs.

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 in 2021 between two-stroke and four-stroke machinery, the percentage split (20/80) is used (expert judgement). There this no difference between emission factors for forestry and agriculture for gasoline, but there are differences between two strokes and four stroke technologies, for gaseous pollutants and particulate matter.
SOx emissions are estimated based on sulphur content in the fuel.
During 2021, the project 'Capacity building for Member States regarding the development of national emission inventories' commissioned by the DG Environment of the European

Commission, supported the Romanian national inventory team on several issues, including the assessment and improvement of calculations for non-road mobile machineries. Within this project, a tool was developed for the NFR 1A4cii calculations, which simplifies the previous calculation method. The tool was used for the actual submission, for 2020 and all previous years in the time series.

Improvements and recalculations:

Slight correction of SOx emissions from gasoline for 1992-2020 period.

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

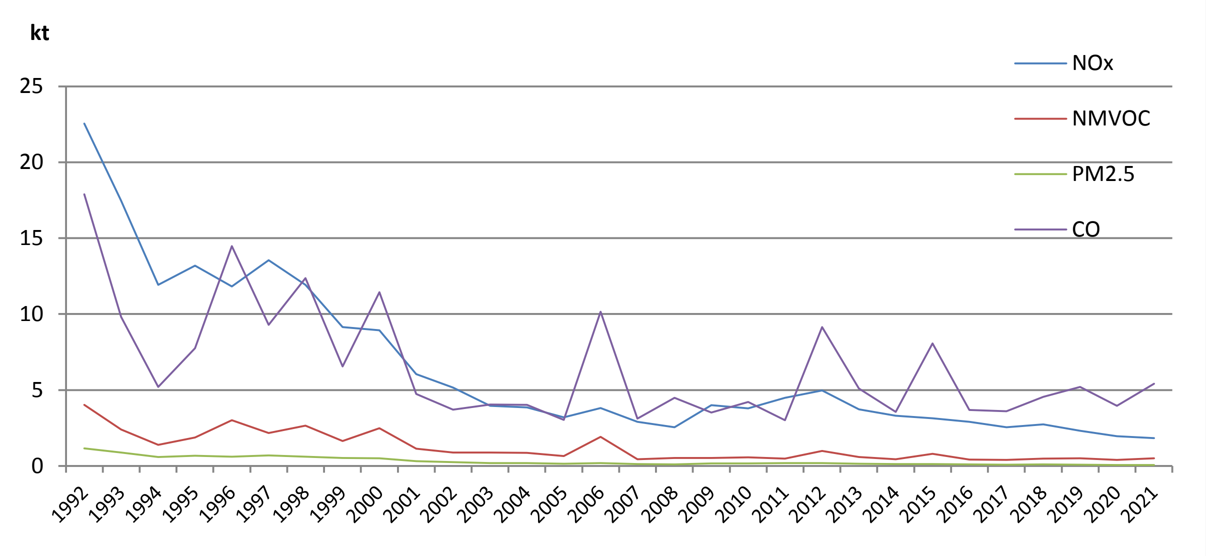


Figure 3.10.1.1 Emissions (kt) of NOx, NMVOC, PM_{10} and CO for NFR 1.A.4.c.ii, 1992-2021

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

Year/Fuel (TJ)	Gasoline	Diesel fuel	Total liquid fuel
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

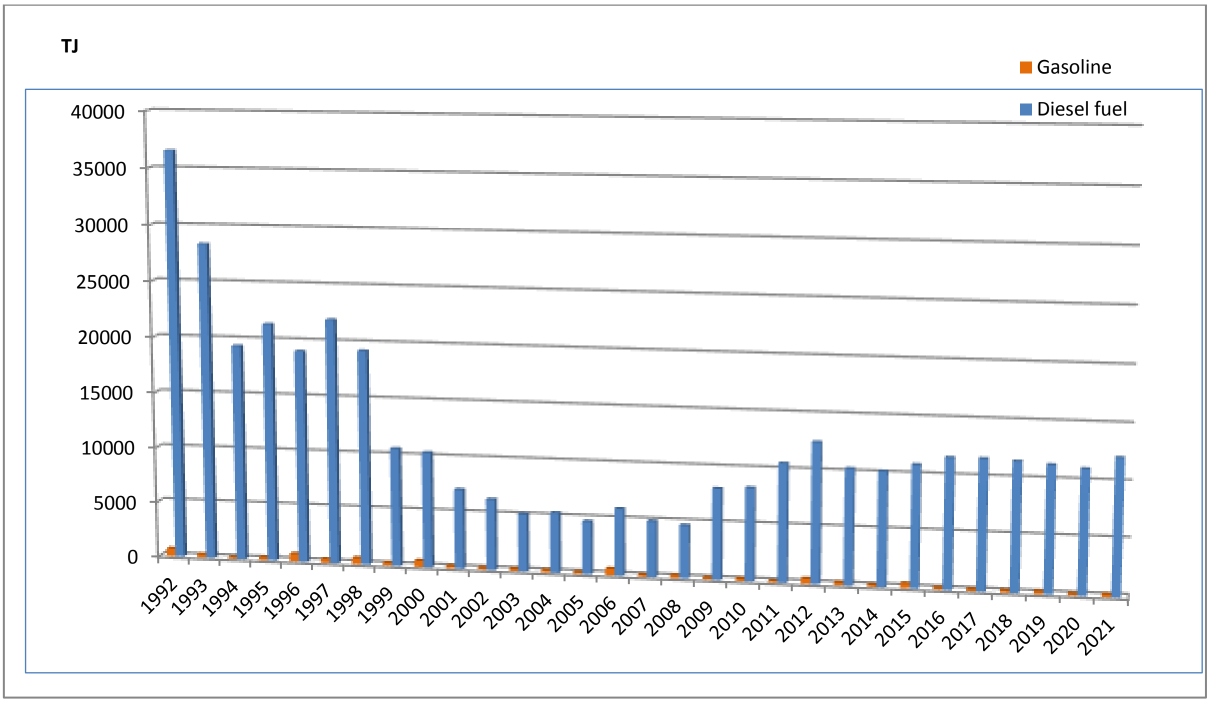


Figure 3.10.1.2 Fuel consumption (TJ) for NFR 1.A.4.c.ii, off road Agriculture/Forestry/Fishing

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 2017-2021 are provided by the National Institute of Statistics in the forms of the Eurostat Energy questionnaires. Tier 1 emission factors were applied (2019 EMEP/EEA Guidebook, NFR 1.A.4 Small combustion, Tables 3.7–3.10 *Tier 1 emission factors for NFR category 1.A.4.a/c, 1.A.5.a*). NFR 1A5b Other, Mobile (including military, land based and recreational boats) is also included in NFR 1A5a.

NFR 1A5a is a key source for Ni in 2021, accounting for 15.74 % in the national total. Most of Ni emission arises from liquid fuel, due to high emission factor. 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).

The Review question RO-1A5a-2021-0001 noted that “with reference to the IIR categories 1A5a, pollutant BC for year 2005 that a Tier 1 method is used for a key category”. Nearly 70% of 1A5a emissions for year 2005 in the 2021 submission arise from biomass burning (solid biofuel). In order to answer to another Review recommendation (RO-1A4ai-2020-0001) regarding an inconsistency of biomass values along the time series, the solid biofuel was reallocated from 1A5a to 1A4ai for all years previous to 2018. Therefore, all emissions for 1990-2017 have been recalculated and BC is not anymore a key source for NFR 1A5a in 2005.

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, 1990-2021

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
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

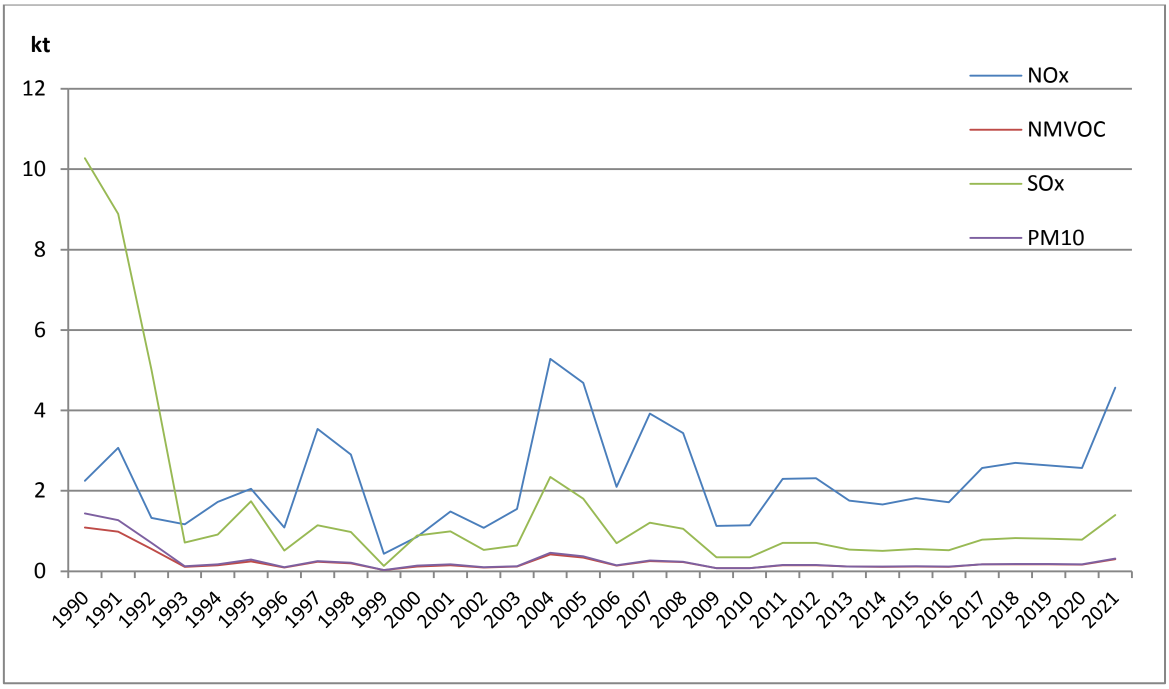


Figure 3.11.1 Emissions for NFR 1A5, 1990-2021

The emissions are consistent with the variation of the fuel consumption in the Energy statistics. The fuel consumption for the time-series 1990-2021 for this category is given in the table and chart below.

Table 3.11.2 Fuel consumption (TJ), 1A5, 1990-2021

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

Year/Fuel (TJ)	Liquid fuels	Solid fuels	Gaseous fuels
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

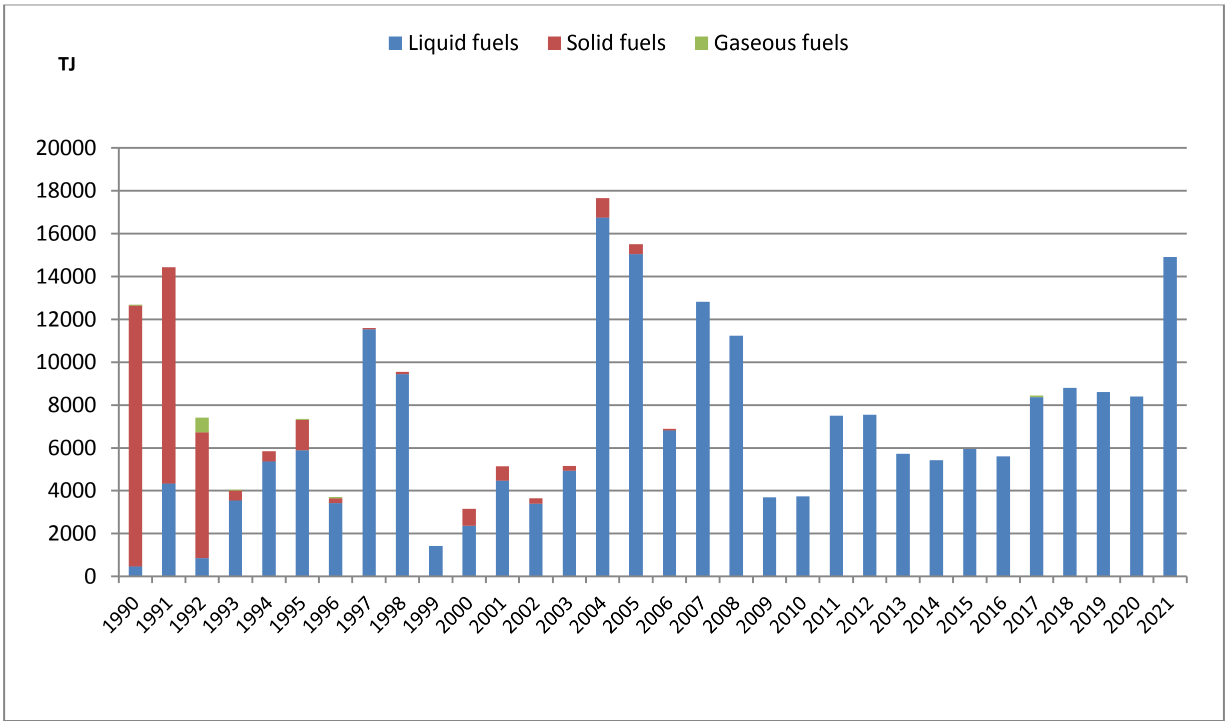


Figure 3.11.2 Fuel consumption (TJ), 1A5, 1990-2021

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 to 2021).
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 to 2021).

The values of pollutants due to the aviation activities for the period 2005-2021 were taken from EUROCONTROL, D2G.1 European Aviation Fuel Burn and Emissions Inventory System for the European Environment Agency (for data from 2005 to 2021).

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 2017-2021.

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
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

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

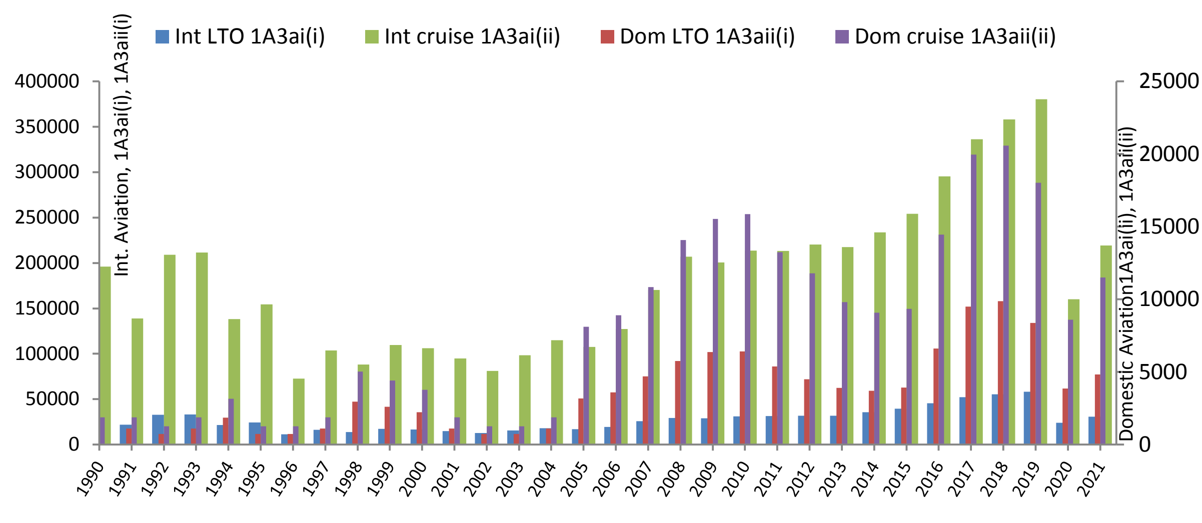


Figure 3.12.1. Fuel burnt (tonnes), for Aviation transport

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
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

** Included emissions of new category – UNDETERMINED.*

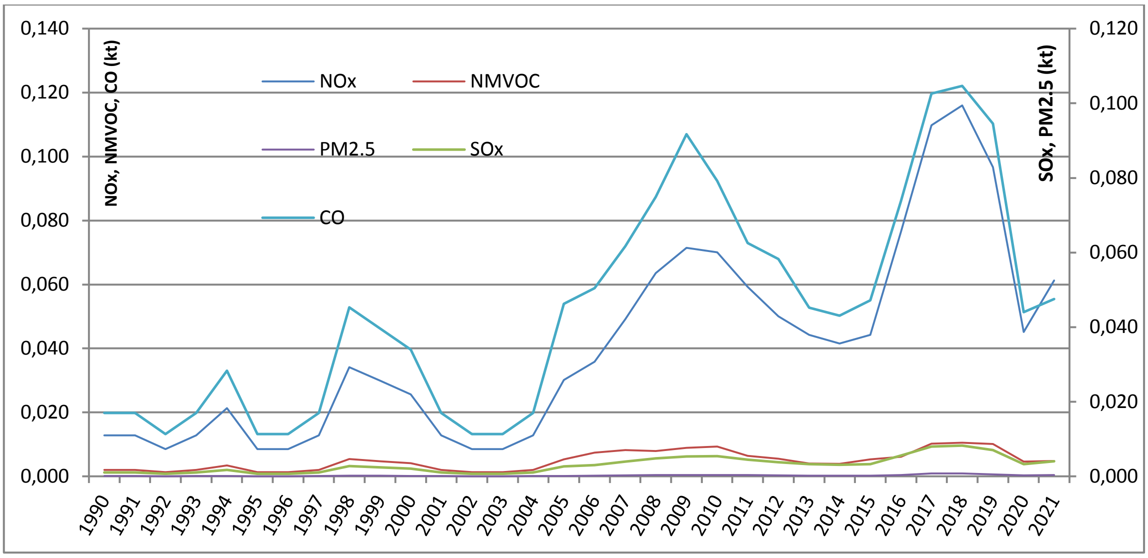


Figure 3.12.2. Emissions trends (kt), NFR 1.A.3.a.ii(i) - Domestic aviation LTO (civil)

There is an oscillating trend in emissions with a peak in 2018, trend directly correlated with fuel consumption. In 2021, compared to 2020, emissions from aviation increased by an average of 25%, after the sharp decline due to the COVID-19 pandemic.

Recalculations and improvements:

- Updated with changes for 2017-2020 calculations by EUROCONTROL.

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 for period 2005-2021	Linear regression between T1 - EMEP EEA guidebook (2019) factors and T3 – COPERT version 5.6.1 factors T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.6.1 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 for period 2005-2021	Linear regression between T1 - EMEP EEA guidebook (2019) factors and T3 – COPERT version 5.6.1 factors T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.6.1 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 for period 2005-2021	Linear regression between T1 - EMEP EEA guidebook (2019) factors and T3 – COPERT version 5.6.1 factors T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.6.1 factors

NFR	Pollutants Reported	Emission Factor tier and source
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 for period 2005-2021	Linear regression between T1 - EMEP EEA guidebook (2019) factors and T3 – COPERT version 5.6.1 factors T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.6.1 factors
1A3bv Road transport: Gasoline evaporation	NMVOC for period 1990-2004 NMVOC for period 2005-2021	T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.6.1 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 for period 2005-2021	T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.6.1 factors
1A3bvii Road transport: Automobile road abrasion	PM2.5, PM10, TSP for period 1990-2004 PM2.5, PM10, TSP, BC for period 2005-2021	T1 - EMEP EEA guidebook (2019) factors T3 – COPERT version 5.6.1 factors

The road transport sector contributed to the total national emissions in 2021, for NOx with 39.38% of the total, NMVOC with 8.25% of total, BC with 16.03% of the total, CO with 13.31% of the total, Pb with 19.24% of total, Cr with 22.81% of total, Cu with 93.35% of the total and Zn with 17.58% of the total.

Table 3.13.1. Share of emissions (%) from 1A3b in the national total in 2021

Pollutant	1A3bi	1A3bii	1A3biii	1A3biv	1A3bv	1A3bvi	1A3bvii	1A3b
NOx	14.49%	5.57%	19.28%	0.03%				39.38%
NMVOC	4.76%	0.84%	1.07%	0.27%	1.31%			8.25%
SOx	0.09%	0.02%	0.06%	0.00%				0.18%
NH_3	0.51%	0.03%	0.04%	0.00%				0.59%
$PM_{2.5}$	1.00%	0.49%	0.89%	0.01%		0.98%	0.43%	3.79%
PM_{10}	0.74%	0.36%	0.66%	0.01%		1.41%	0.58%	3.76%
TSP	0.50%	0.24%	0.44%	0.01%		1.20%	0.79%	3.18%
BC	6.63%	3.08%	4.37%	0.01%		1.80%	0.14%	16.03%
CO	9.82%	1.96%	1.19%	0.34%				13.31%
Pb	0.01%	0.00%	0.00%	0.00%		19.23%		19.24%
Cd	0.01%	0.00%	0.00%	0.00%		1.23%		1.24%
Hg	1.30%	0.28%	0.66%	0.01%				2.25%
As	0.02%	0.00%	0.01%	0.00%		2.79%		2.81%
Cr	0.17%	0.05%	0.12%	0.00%		22.47%		22.81%
Cu	0.02%	0.01%	0.02%	0.00%		93.31%		93.35%
Ni	0.03%	0.00%	0.00%	0.00%		4.30%		4.33%
Se	0.01%	0.00%	0.00%	0.00%		0.82%		0.83%
Zn	0.06%	0.01%	0.03%	0.00%		17.48%		17.58%
PCDD/PCDF	0.78%	0.18%	0.18%	0.00%				1.14%
Total PAH	0.46%	0.12%	0.24%	0.00%				0.82%
HCB	0.05%	0.01%	0.01%	0.00%				0.06%
PCBs	0.00%	0.00%	0.00%	0.00%				0.00%

Note – Only two decimals are displayed in the table.

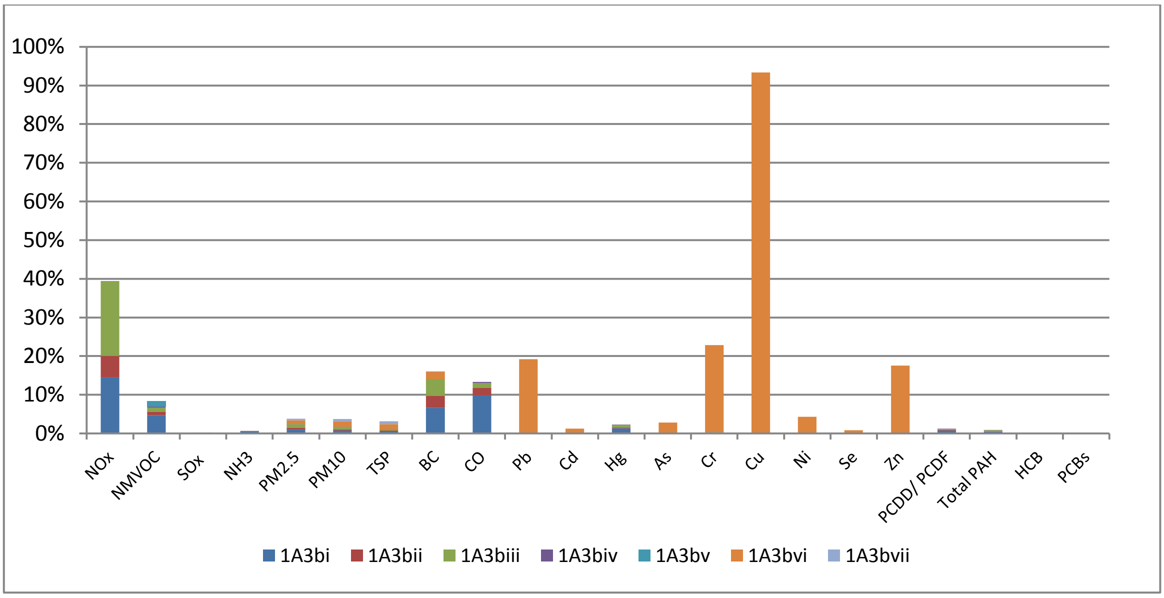


Figure 3.13.1 Share of emissions (%) from 1A3b in the national total in 2021

In 2021, key sources from 1A3b sector, road transport, are:

- NFR 1.A.3.b.i - Road transport: Passenger cars, for NOx, NMVOC, BC and CO;
- NFR 1.A.3.b.ii - Road transport: Light duty vehicles, for NOx;
- NFR 1.A.3.b.iii - Road transport: Heavy duty vehicles and buses, for NOx and BC;
- NFR 1.A.3.b.vi - 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 2021 (%)

NFR/Pollutant	NOX	NMVOC	BC	CO	Pb	Cr	Cu	Ni	Zn
1A3bi Road transport: Passenger cars	14.49%	4.76%	6.63%	9.82%					
1A3bii Road transport: Light duty vehicles	5.57%								
1A3biii Road transport: Heavy duty vehicles and buses	19.28%		4.37%						
1A3bvi Road transport: Automobile tyre and brake wear					19.23%	22.47%	93.31%	4.30%	17.48%
Total	39.34%	4.76%	11.00%	9.82%	19.23%		93.31%	4.30%	17.48%

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 SO2, 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 5.6.1 (Tier 3) for year 2005 (recommendation RO-1A3b-2021-0001).
The emissions of SO2 per fuel-type are estimated by assuming that all sulphur in the fuel is transformed completely into SO2, using the formula from 2019 EMEP/EEA Guidebook, chapter 1.A.3.b.i-iv, page 22.

To estimate the SO2 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 2005-2021:

For the period 2005-2021 the emissions were estimated with COPERT version 5.6.1.

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 SO2 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 and buses - 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	291475	142075

Year/ number of vehicles	Passenger Cars – Gasoline+ LPG	Passenger Cars – Diesel	Light duty vehicles - Gasoline	Light duty vehicles - Diesel	Heavy duty vehicles and buses - Gasoline	Heavy duty vehicles and buses - Diesel	Mopeds & motorcycles - Gasoline
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

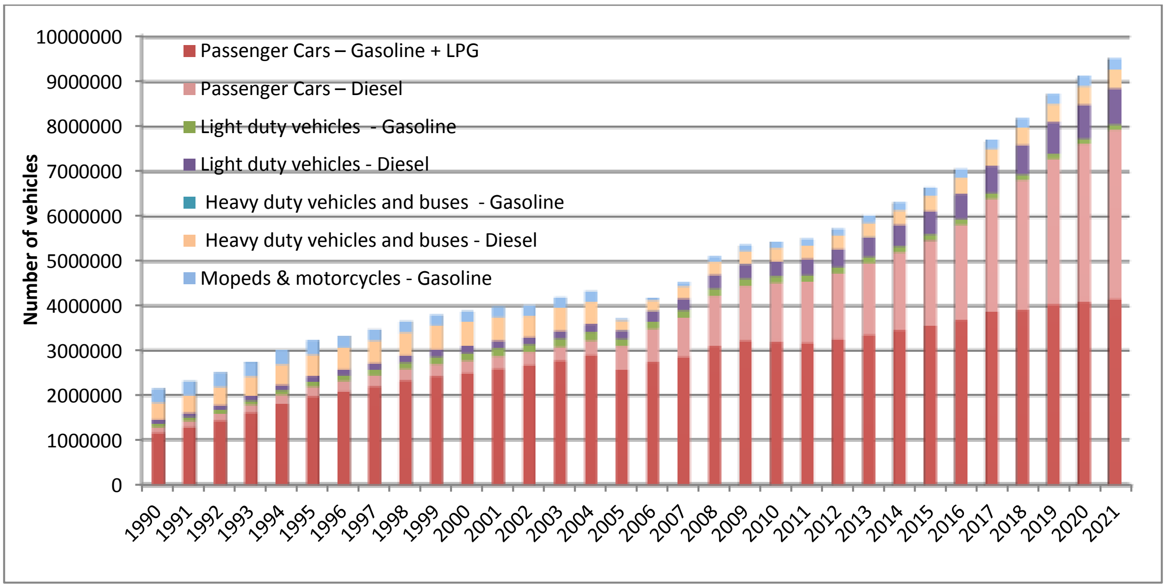


Figure 3.13.2. Fleet evolution (number of vehicles)

Compared to 2005 data, in 2021 the number of vehicles increased by 609% for diesel cars, 491% for gasoline mopeds and motorcycles, 325% for light diesel vehicles and 94% 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		-

Year/fuel consumption	Gasoline	Diesel	LPG	Biomass
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
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

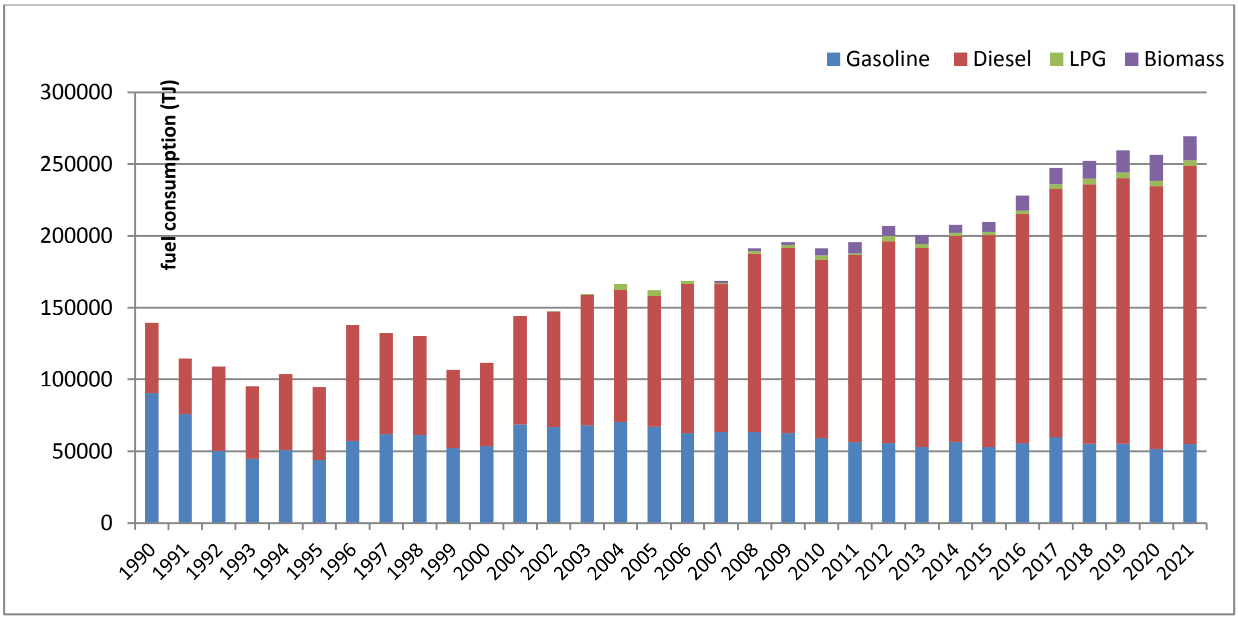


Figure 3.13.3. Fuel consumption (TJ), for Road Transport 1.A.3.b.

NFR 1.A.3.b.i., 1.A.3.b.ii, 1.A.3.b.ii are key source for emissions of NOx in 2021.

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	34.139	6.367	56.626	0.092
2003	33.945	6.949	64.580	0.083
2004	35.592	6.358	68.695	0.076
2005	34.719	9.060	52.448	0.017
2006	31.903	9.227	54.536	0.023
2007	29.174	8.395	50.650	0.040
2008	28.829	8.904	55.566	0.048
2009	28.819	8.891	54.618	0.052
2010	25.838	8.366	51.488	0.053
2011	25.914	8.893	53.345	0.054
2012	25.797	9.701	54.718	0.047
2013	24.530	9.630	51.328	0.057
2014	25.261	10.092	50.012	0.061
2015	24.696	10.244	48.663	0.059
2016	26.244	11.213	49.973	0.062
2017	28.275	11.725	49.780	0.076
2018	29.112	12.003	48.147	0.089
2019	28.796	12.201	44.120	0.083
2020	29.597	11.172	42.726	0.072
2021	31.035	11.927	41.292	0.075

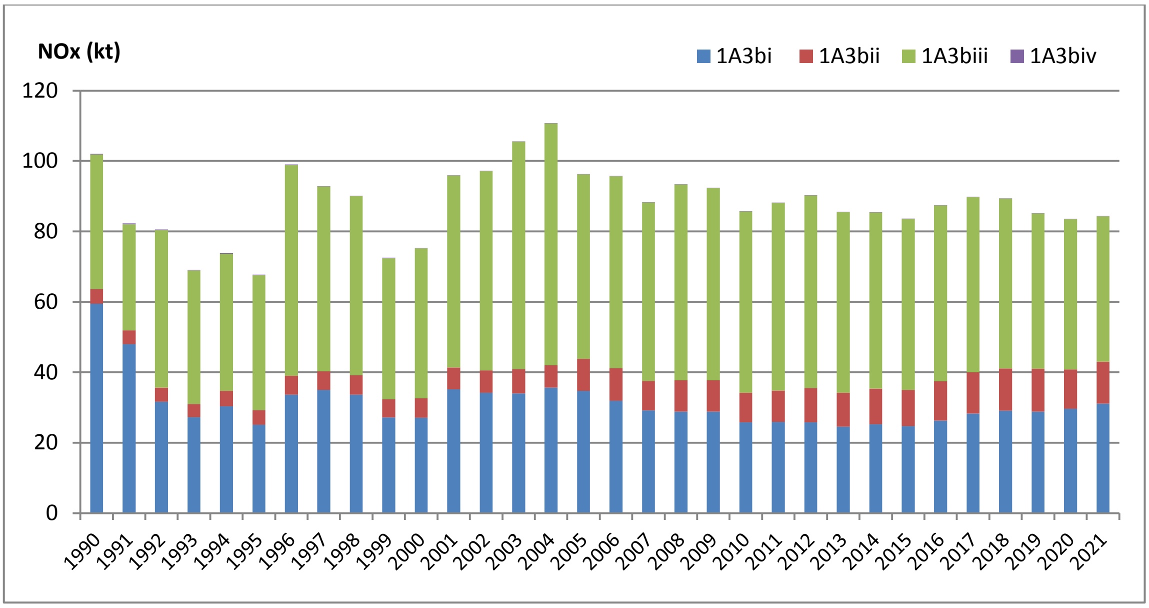


Figure 3.13.4. NOx emissions trend (kt) for Road Transport 1.A.3.b. by NFR

NFR 1.A.3.b.i. is key source for emissions of NMVOC in 2021.

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	54.286	2.957	2.973	7.799	4.270
1992	34.674	2.483	4.432	7.707	4.694
1993	29.690	2.450	3.766	7.504	5.207
1994	33.102	2.646	3.882	7.215	5.785
1995	27.105	2.784	3.833	6.995	6.267
1996	35.696	3.092	6.016	5.213	6.505
1997	37.627	3.210	5.287	4.916	6.829
1998	35.949	3.461	5.141	4.613	7.241
1999	29.156	3.278	4.065	4.343	7.562
2000	28.742	3.626	4.336	4.080	7.764
2001	37.015	3.759	5.553	3.856	8.033
2002	35.167	3.665	5.798	3.669	8.237
2003	34.699	3.799	6.634	3.425	8.561
2004	36.318	3.676	7.080	3.208	8.949
2005	32.209	4.491	5.520	0.760	8.279
2006	27.319	4.045	5.473	0.721	8.389
2007	22.744	3.347	5.111	0.581	8.908
2008	20.099	3.100	5.092	0.642	7.648
2009	18.217	2.792	4.729	0.657	7.898
2010	15.092	2.491	4.290	0.655	6.498
2011	14.107	2.386	4.213	0.649	6.572
2012	12.743	2.314	4.083	0.545	7.117
2013	11.345	2.113	3.689	0.534	5.868
2014	11.188	2.098	3.469	0.607	5.607
2015	10.110	1.947	3.270	0.576	5.909
2016	10.415	2.035	3.284	0.591	5.667

Year/NMVOC (kt)	1A3bi	1A3bii	1A3biii	1A3biv	1A3bv
2017	10.303	2.024	3.203	0.715	5.709
2018	9.630	1.925	3.040	0.730	5.789
2019	9.299	1.747	2.653	0.769	5.671
2020	9.391	1.689	2.571	0.574	5.534
2021	11.145	1.970	2.504	0.637	3.071

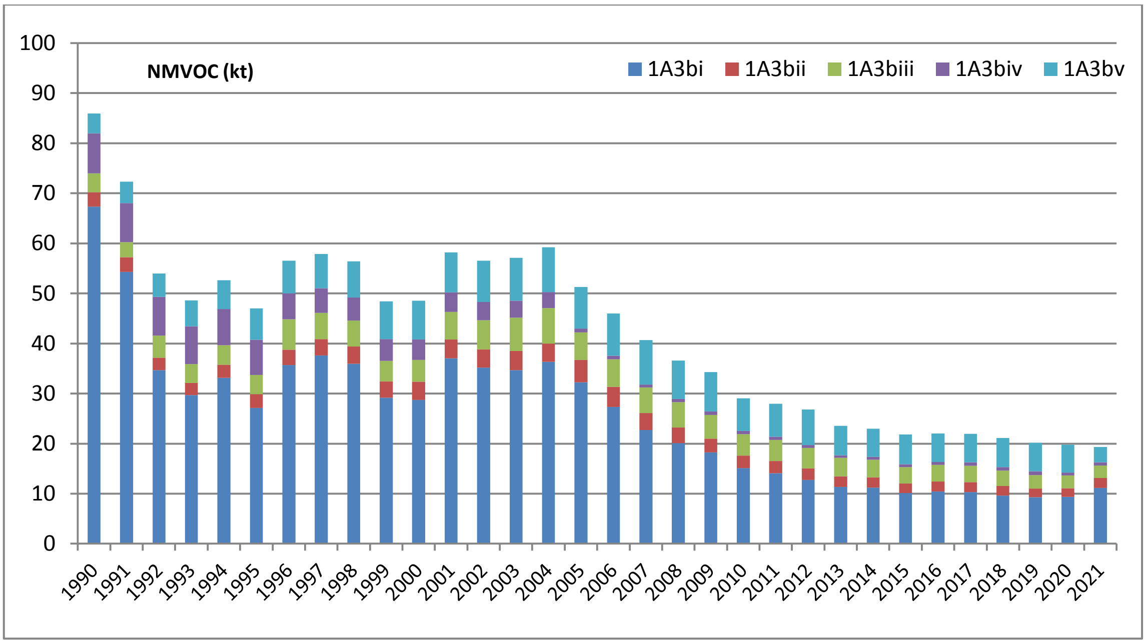


Figure 3.13.5. NMVOC emissions trend (kt) for Road Transport 1.A.3.b. by NFR

NFR 1.A.3.b.i. and 1.A.3.b.iii are key source for emissions of BC in 2021.

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	0.1391	0.0108
2006	0.6529	0.4474	1.0985	0.0021	0.1461	0.0113
2007	0.5485	0.3769	0.9986	0.0019	0.1521	0.0119
2008	0.6818	0.4226	1.0356	0.0020	0.1708	0.0135
2009	0.7143	0.4241	0.9865	0.0021	0.1775	0.0140
2010	0.6988	0.4010	0.9122	0.0022	0.1722	0.0136
2011	0.7281	0.4369	0.9200	0.0022	0.1814	0.0143

Year/BC (kt)	1A3bi	1A3bii	1A3biii	1A3biv	1A3bvi	1A3bvii
2012	0.7615	0.4772	0.9177	0.0017	0.1886	0.0151
2013	0.7268	0.4642	0.8428	0.0014	0.1846	0.0147
2014	0.7247	0.4785	0.8061	0.0019	0.1903	0.0152
2015	0.7150	0.4795	0.7699	0.0018	0.1919	0.0154
2016	0.7691	0.5184	0.7785	0.0019	0.2091	0.0167
2017	0.8674	0.5371	0.7649	0.0023	0.2230	0.0177
2018	0.8941	0.5267	0.7307	0.0023	0.2324	0.0182
2019	0.8442	0.4587	0.6367	0.0024	0.2409	0.0189
2020	0.8152	0.3773	0.6185	0.0018	0.2376	0.0187
2021	0.9102	0.4231	0.6000	0.0020	0.2468	0.0194

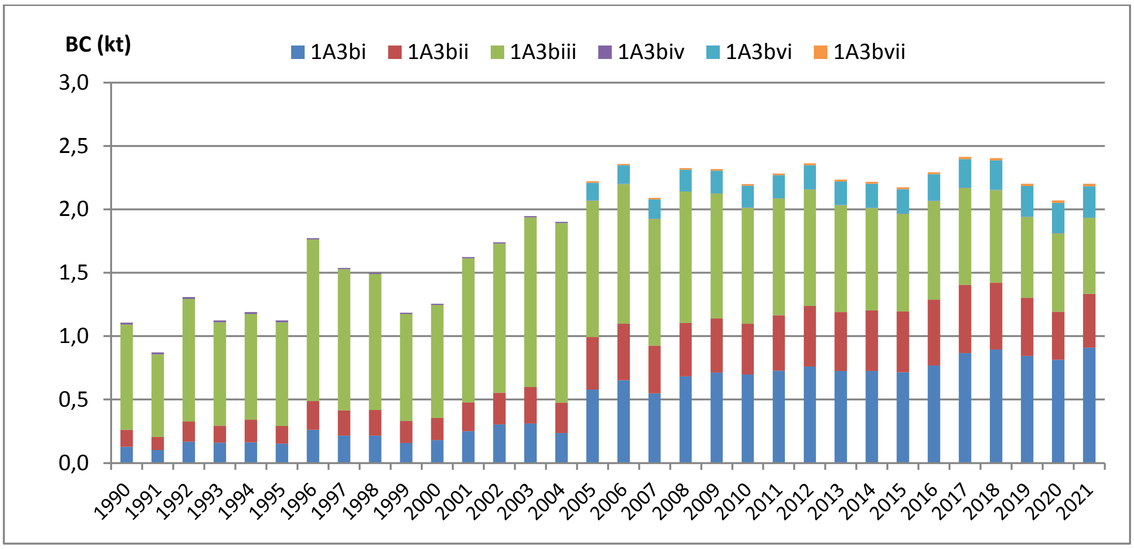


Figure 3.13.6. BC emissions trend (kt) for Road Transport 1.A.3.b. by NFR

NFR 1.A.3.b.i. is key source for emissions of CO in 2021.

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	427.744	26.924	8.333	14.524
1992	274.832	22.562	12.420	14.690
1993	237.095	22.617	10.550	14.655
1994	266.582	24.548	10.874	14.454
1995	220.047	26.370	10.734	14.395
1996	292.052	29.292	16.841	11.036
1997	310.964	30.983	14.797	10.721
1998	299.879	33.935	14.386	10.383
1999	245.713	32.682	11.372	10.108
2000	244.605	36.811	12.126	9.838
2001	318.325	38.410	15.528	9.655
2002	305.230	37.838	16.208	9.568
2003	304.317	39.630	18.540	9.324
2004	316.478	39.276	19.781	9.148
2005	284.349	47.831	15.227	2.280
2006	243.532	42.606	15.705	2.300
2007	197.022	35.242	14.675	2.315
2008	174.022	32.347	15.630	2.570
2009	156.818	28.649	15.072	2.695
2010	133.908	25.189	14.081	2.744

Year/CO (kt)	1A3bi	1A3bii	1A3biii	1A3biv
2011	122.623	23.487	14.453	2.735
2012	113.185	22.371	14.809	2.088
2013	101.523	19.977	13.899	2.526
2014	101.355	19.893	13.567	2.829
2015	91.604	18.061	13.234	2.703
2016	93.712	18.679	13.621	2.817
2017	91.840	18.356	13.579	3.336
2018	85.321	17.144	13.150	3.635
2019	80.624	15.577	12.365	3.858
2020	78.815	15.885	12.028	3.121
2021	94.659	18.930	11.501	3.267

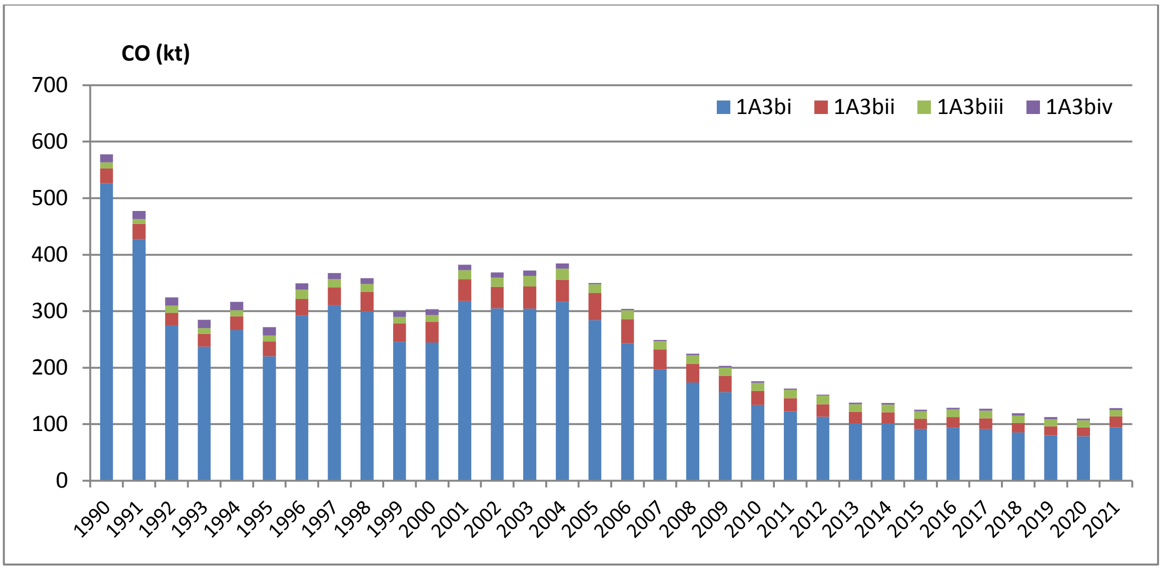


Figure 3.13.7. CO emissions trend (kt) for Road Transport 1.A.3.b. by NFR

NFR 1.A.3.b.vi. is key source for emissions of Pb, Cr, Cu, Ni and Zn in 2021. These emissions are estimate for the 2005-2021 period. For the other NFRs of road transport, these emissions are not significant.

Due to the calculation with COPERT version 5.6.1, the emissions of heavy metal for NFR 1.A.3.b.vi. have increased approximately 3 times compared to the previous version of COPERT.

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	5.594	2.096	46.101	0.317	13.419
2006	5.844	2.190	48.150	0.331	14.058
2007	6.075	2.276	50.051	0.344	14.622
2008	6.747	2.528	55.574	0.382	16.332
2009	6.947	2.602	57.212	0.394	16.892
2010	6.688	2.505	55.069	0.379	16.325
2011	7.016	2.627	57.755	0.398	17.161
2012	7.150	2.676	58.827	0.406	17.664
2013	6.982	2.613	57.444	0.397	17.271
2014	7.066	2.644	58.106	0.402	17.640
2015	7.056	2.640	58.009	0.402	17.706

Year/A.3.b.vi	Pb (t)	Cr (t)	Cu (t)	Ni (t)	Zn (t)
2016	7.664	2.867	63.000	0.436	19.262
2017	8.154	3.050	67.022	0.464	20.517
2018	8.518	3.186	70.017	0.485	21.407
2019	8.768	3.280	72.065	0.499	22.117
2020	8.639	3.231	71.002	0.492	21.804
2021	8.925	3.338	73.341	0.509	22.587

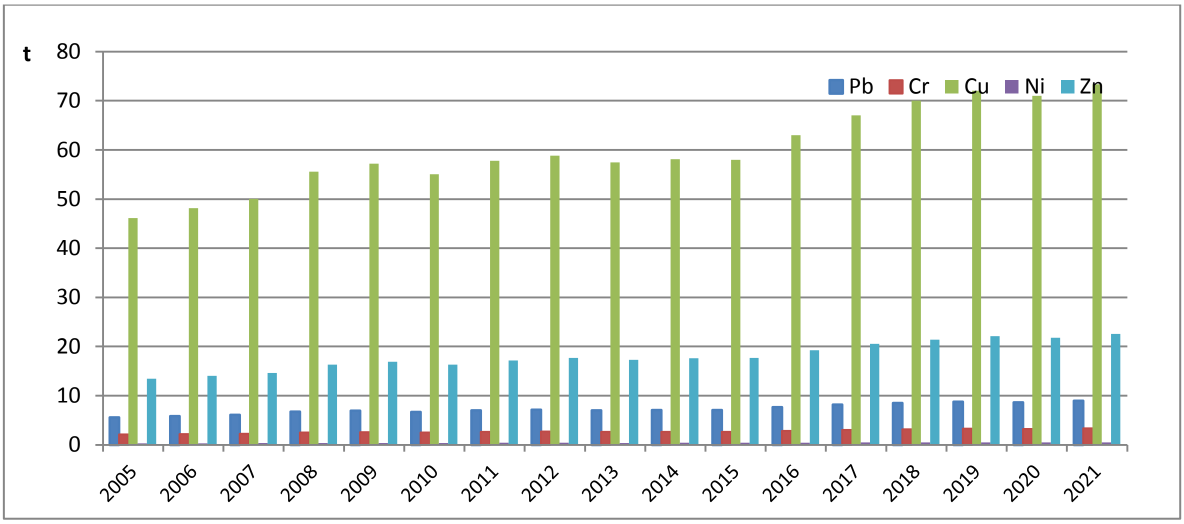


Figure 3.13.8. Pb, Cr, Cu, Ni and Zn (t) emissions for NFR 1.A.3.b.vi Road transport: Automobile tyre and brake wear

The trend of SO_2 emissions for 1990-2021 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
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

Year/SOx (kt)	1A3bi	1A3bii	1A3biii	1A3biv
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	0.0393	0.0002
2020	0.0567	0.0143	0.0385	0.0002
2021	0.0606	0.0157	0.0400	0.0002

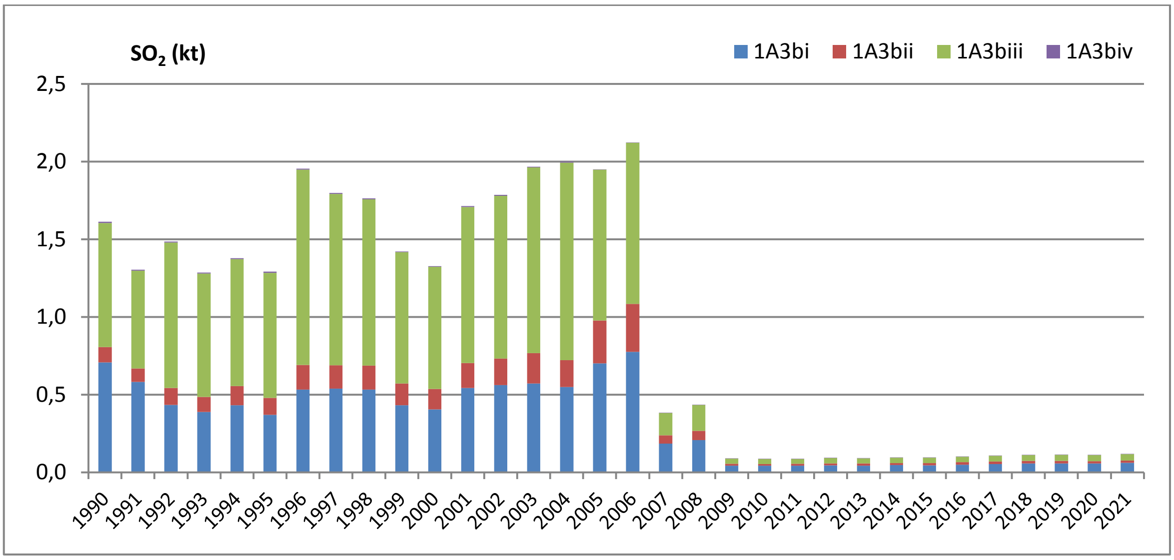


Figure 3.13.9. SO_2 (kt) emissions for NFR 1.A.3.b Road transport

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 2005-2020, recalculated using the new version of COPERT (5.6.1) and national NCV; correction of fuel consumption for 2009-2011 and 2013;
- Changed EFs (excepted SO_2) for 1990-2004 applying a linear regression between maxim Tier 1 EFs (the year 1990) and the COPERT 5.6.1 EFs (the year 2005);
- Correction of error in SO2 emission estimation based on sulphur content in fuels, for 2000-2004 period.

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.

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

NFR	Pollutants Reported	Emission Factor tier and source
1A3c Railways	All CLRTAP pollutants (except Pb, Hg, As, POPs)	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
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

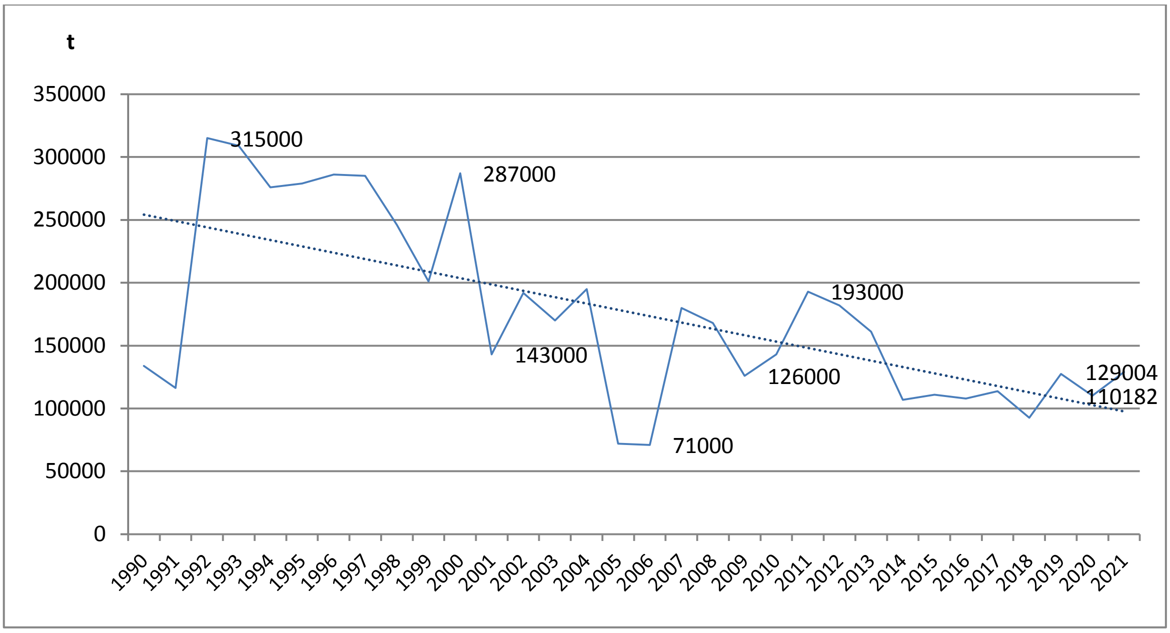


Figure 3.14.1. Fuel consumption (t) for NFR 1.A.3.c – Railway

Diesel consumption for rail transport in the period 1990-2009 shows large fluctuations (maximum 315000 t in 1992, minimum 71000 t in 2006), and in the period 2011-2021 it has a decreasing trend (from 193000 t in year 2011 to 129004 t in year 2020, almost 33 %).

In 2021 NFR 1.A.3.c is a key source for NOx pollutant with 3.16% 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

Year/Pollutant	NOx	NMVOC	SOx	NH_3	$PM_{2.5}$	CO
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

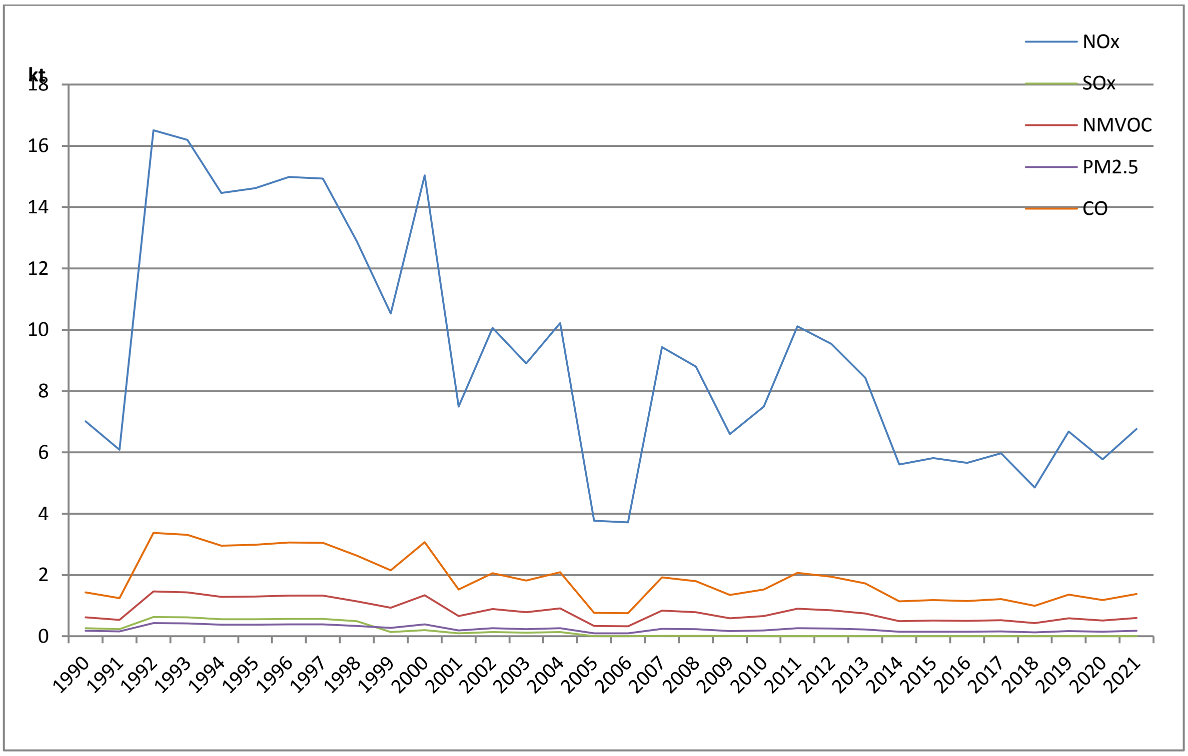


Figure 3.14.2. Emissions trend (kt) of NOx, NMVOC, SOx, $PM_{2.5}$
and CO for NFR 1.A.3.c – Railway

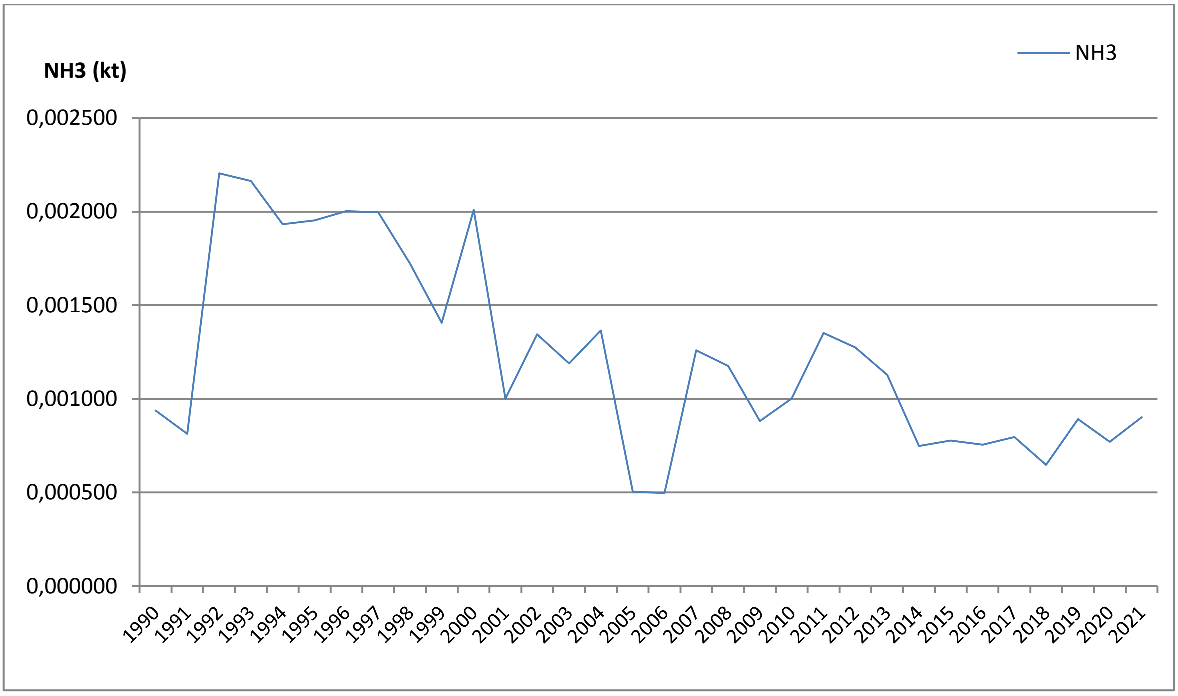


Figure 3.14.3. Emissions trend (kt) of NH_3 for NFR 1.A.3.c – Railway

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

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 (is included in NFR 1.A.3.d.i(i));
- 1.A.3.d.ii - National navigation (shipping);
- Memo item 1.A.3.d.i(i) - International maritime navigation.

The contribution of navigation to total national emissions is not significant.

NFR 1.A.3.d.ii is not a key source for any pollutant.

Table 3.15 Pollutants and Emission factors for 1A3d

NFR	Pollutants Reported	Emission Factor tier and source
1A3di(ii) International inland waterways	-	-
1A3dii National navigation (shipping)	All CLRTAP pollutants (except NH3, PAHs)	T1 - EMEP EEA guidebook (2019) factors

Emissions from navigation activities were estimated using the default Tier 1 emission factors from 2019 EMEP/EEA Guidebook updated in December 2021, chapter 1.A.3.d, Table 0-1 and

Table 0-2 and fuel consumption (fuel oil and marine diesel oil) from Energy Balance provided by the N.I.S.

There are no emission factors for $PM_{2.5}$ and TSP in this version of this chapter.
In the previous version of the chapter, 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 updated emission factors.

For the period 1990-2006, category 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 - National navigation (shipping):

Table 3.15.1. 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
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

Year	Fuel oil (t)	Marine diesel oil (t)
2020	-	41271
2021	-	50879

Table 3.15.2. Emissions trend (kt) of Main Pollutants, $PM_{2.5}$ and CO for NFR 1.A.3.d.ii - National navigation

Year/Pollutant	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
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

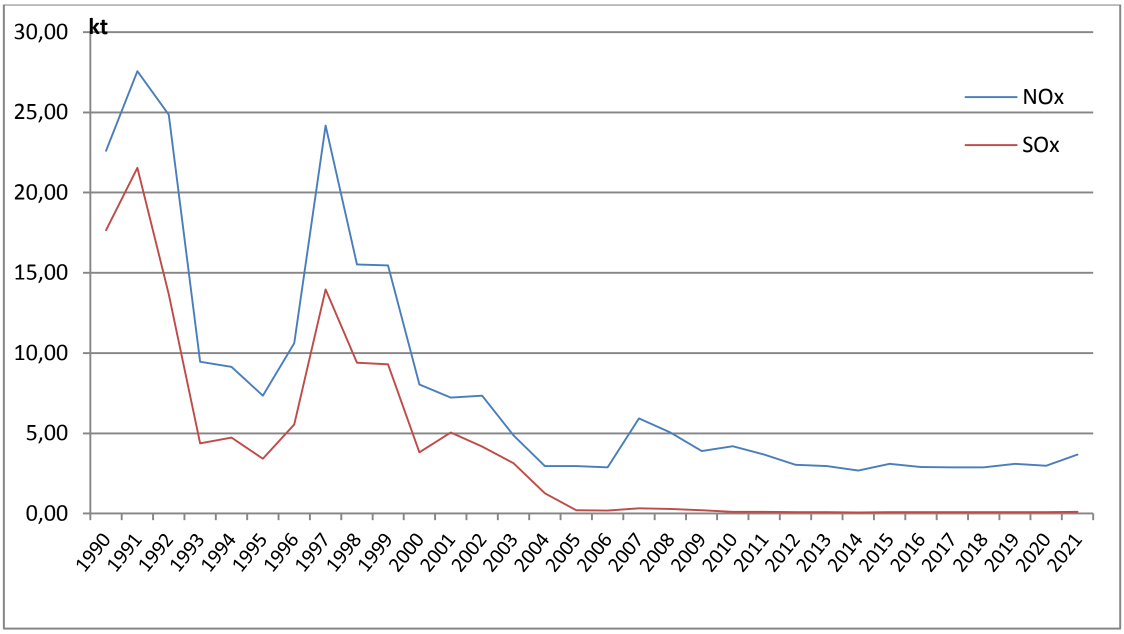


Figure 3.15.1. Emissions trend (kt) of NOx and SOx for NFR 1.A.3.d.ii - National navigation

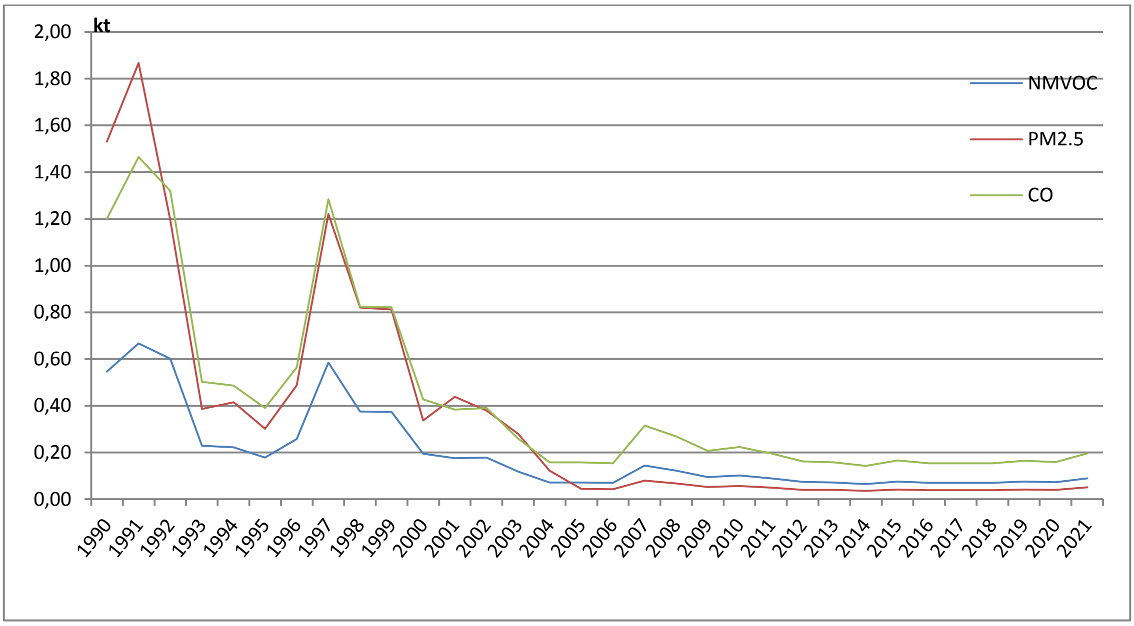


Figure 3.15.2. Emissions trend (kt) of NMVOC, $PM_{2.5}$ and CO for NFR 1.A.3.d.ii - National navigation

The emissions from NFR 1.A.3.d.i(ii) - International inland waterways are marked with IE notation and are included in the memo item NFR 1.A.3.d.i(i) - International maritime navigation.

The calculation for NFR 1.A.3.d.i(i) was made using the default Tier 1 emission factors from 2019 EMEP/EEA Guidebook update in December 2021, chapter 1.A.3.d, Table 0-1 and Table 0-2 and buer fuel oil and marine diesel oil from Energy Balance provided by N.I.S. Only from 2007 there are data.

The same assumption as for NFR 1.A.3.d.ii was used to estimate PM2.5 and TSP emissions (see above).

For the period 2007-2010, category 1.A.3.d.i(i) included fuel oil and marine diesel oil and therefore emission values are higher.

Table 3.15.4. International maritime bunkers (t) for memo item, NFR 1.A.3.d.i(i)

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Fuel oil (t)	14000	52000	9000	4000	-	-	-	-	-
Marine diesel oil (t)	20000	18000	6000	11000	9000	14000	41000	79000	44000

Year	2016	2017	2018	2019	2020	2021
Marine diesel oil (t)	31000	27527	17853	33720	42498	33471

Recalculations and improvements:

- There were no recalculations and improvements for this category.

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 - 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 1.8% 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

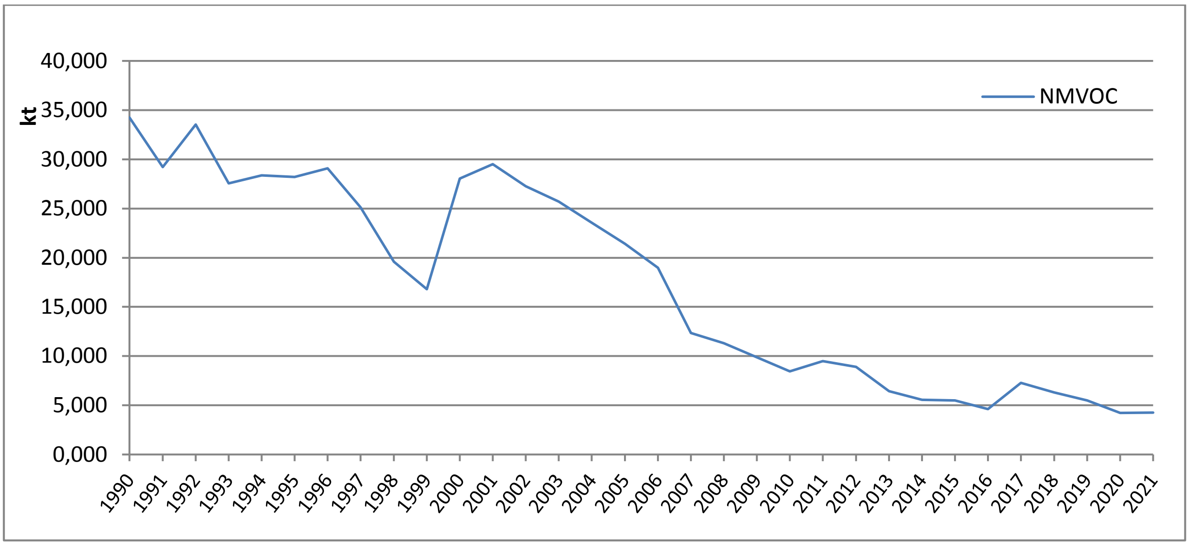


Figure 3.16.2 NMVOC Emissions Trend (kt) for NFR 1.B.1.a

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

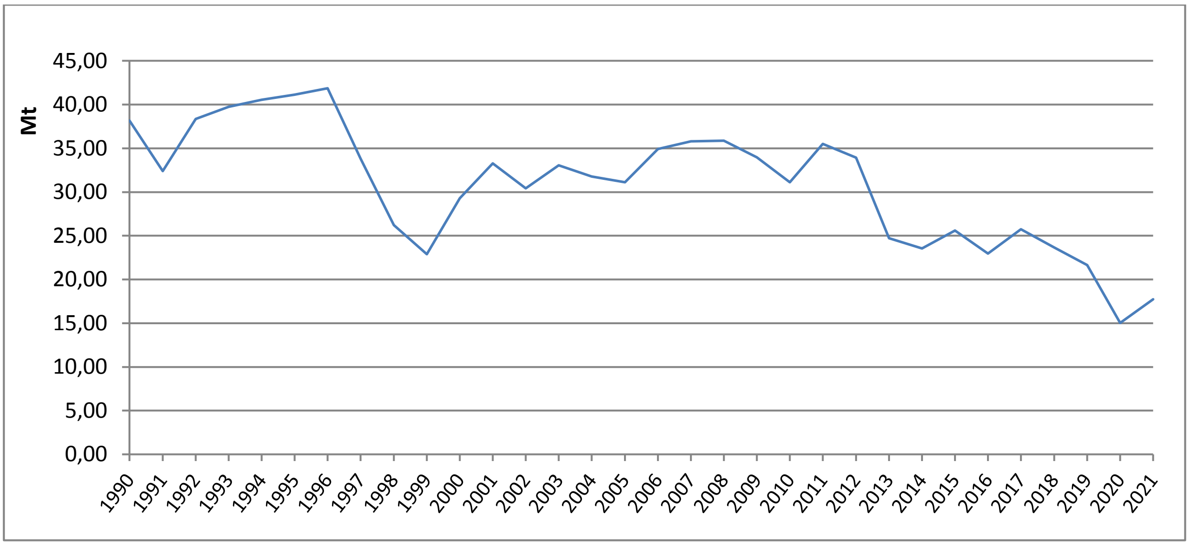


Figure 3.16.3 Activity data trend (Mt) for NFR 1.B.1.a

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 and has been 0 t for the period 2011 -2021.

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

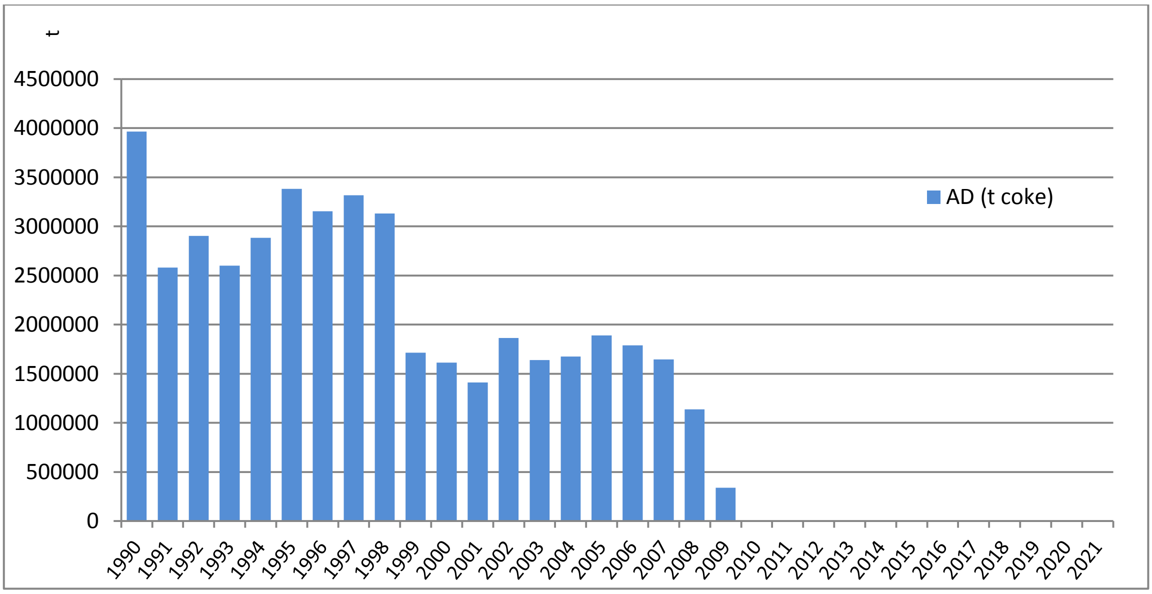


Figure 3.17.1. Activity data trends (t product) for NFR 1.B.1.b coke production

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:

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

- 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 1990-2021 time series.

Table 3.18.1 Emissions Trend (kt) for NFR 1.B.2.a.i for NMVOC 1990-2021

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
2021	2.015

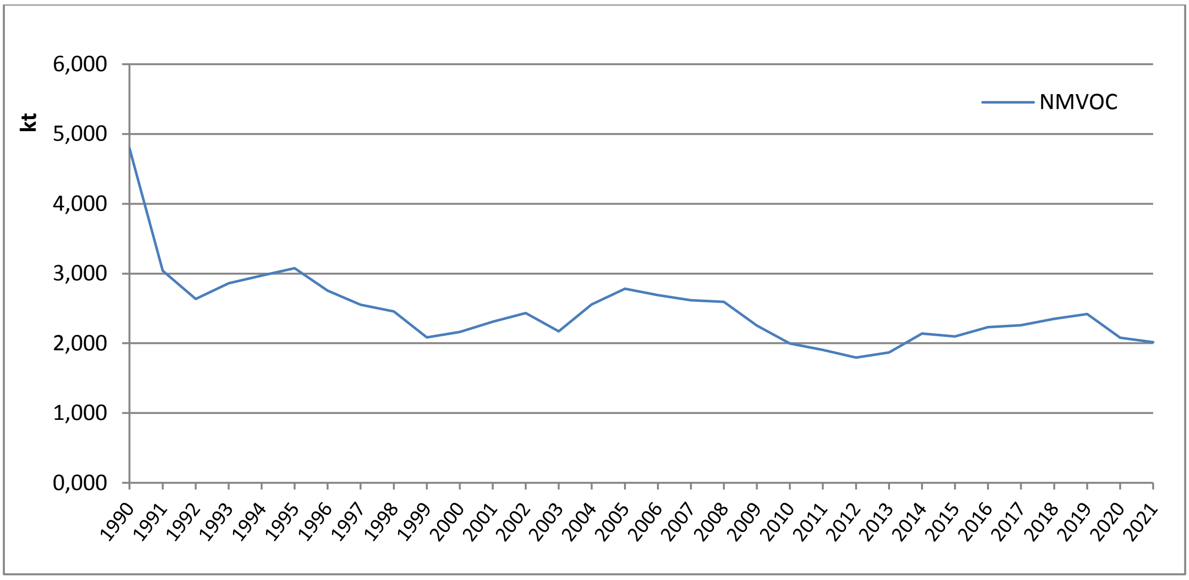


Figure 3.18.1 Emissions Trend (kt) for NFR 1.B.2.a.i for NMVOC

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.

In this submission, for 2015-2021, the activity data, obtained from economic operators, were also collected and revised, using in the calculation of SOx emissions, 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%.

In this submission for 2015-2021, for NH3 pollutant, we used abatement efficiency (99.5%) from Table 3-7 from 2019 EMEP/EEA Guidebook.

In 2021 NFR 1B2aiv was key source for NMVOC (1.76%), CO (13.7%), Cd (6.8%), Hg (13.86%) and Ni (17.5%) from national total. The tables and figures below show trends in activity data and 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 1990-2021

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

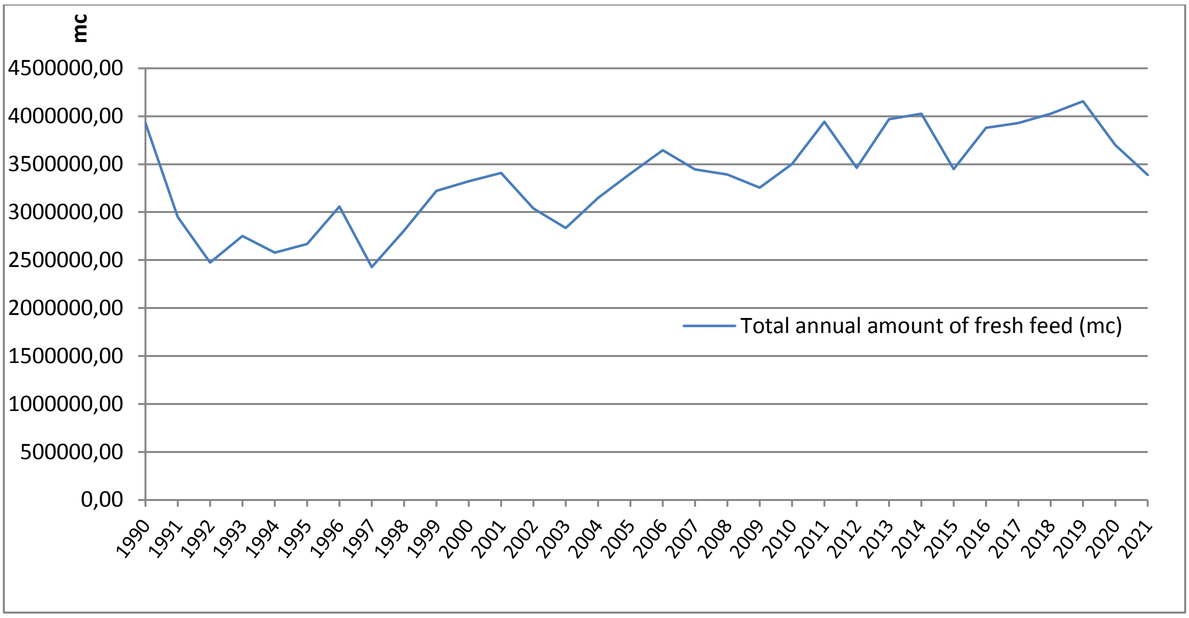


Figure 3.19.1 Activity data trends (m^3 total annual amount of fresh feed) for NFR 1.B.2.a.iv

Table 3.19.2 Emissions Trend (kt) for NFR 1.B.2.a.iv for NMVOC and CO, 1990-2021

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
2015	4.243	134.501
2016	4.724	151.216
2017	4.721	153.229
2018	4.843	156.935

Year	NMVOC (kt)	CO (kt)
2019	4.196	162.071
2020	4.389	144.214
2021	4.133	132.196

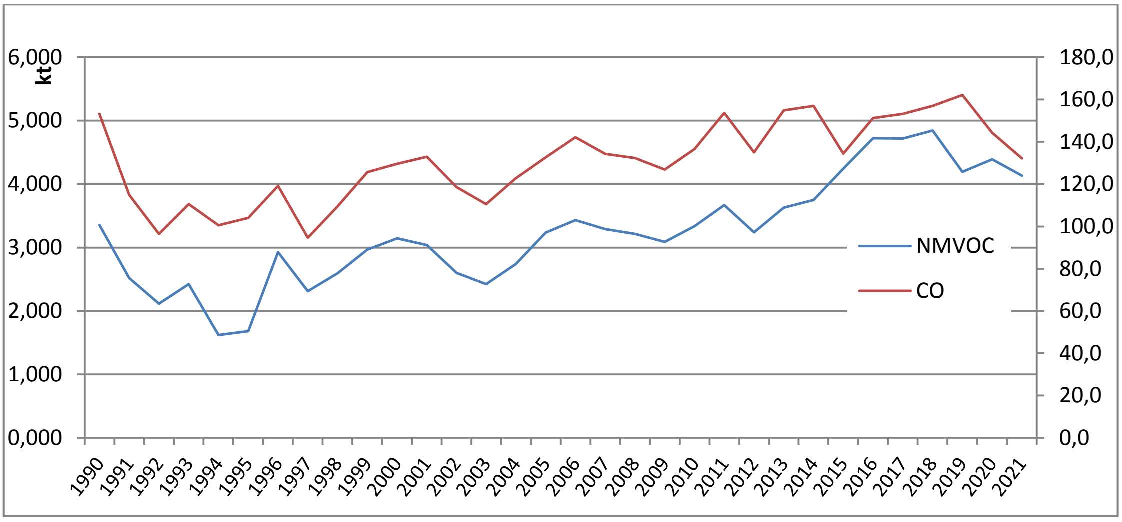


Figure 3.19.2 Emissions Trend (kt) for NFR 1.B.2.a.iv for NMVOC and CO

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

Recalculations: for time series 1990-2020, benzo(a), benzo(b), benzo(k), indeno and total PAH were recalculated due to mistake in the calculation unit of measure.

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 refuelling 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/m^3throughput/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 -2021

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

Year	NMVOC (kt)
2013	0.523
2014	0.543
2015	0.524
2016	0.566
2017	0.589
2018	0.531
2019	0.550
2020	0.499
2021	0.552

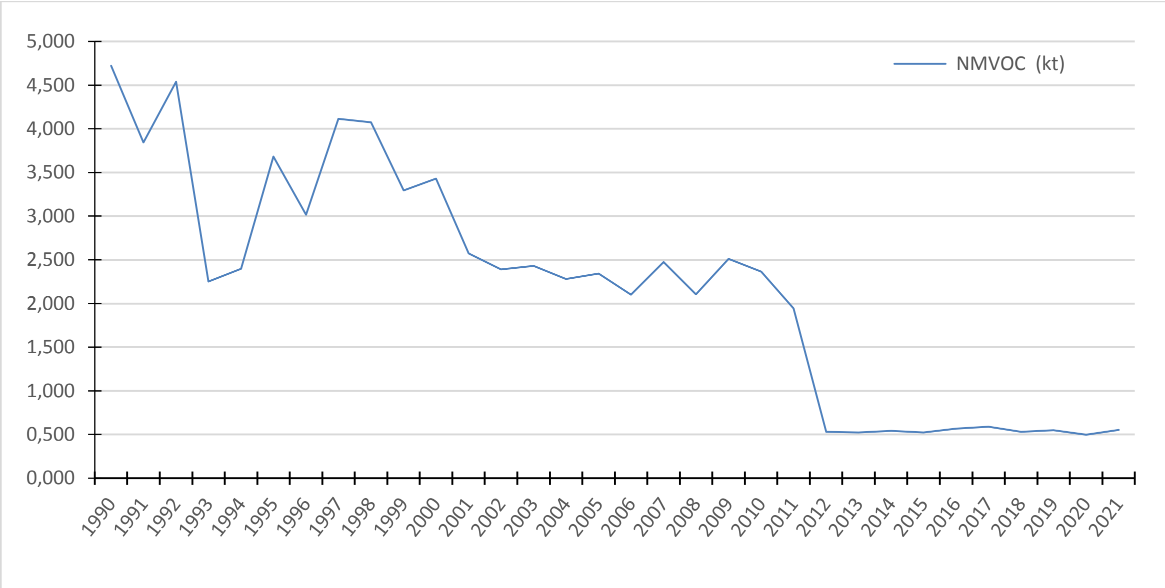


Figure 3.20.1. Emissions Trend (kt) for NFR 1.B.2.a.v for NMVOC

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 1990-2021

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

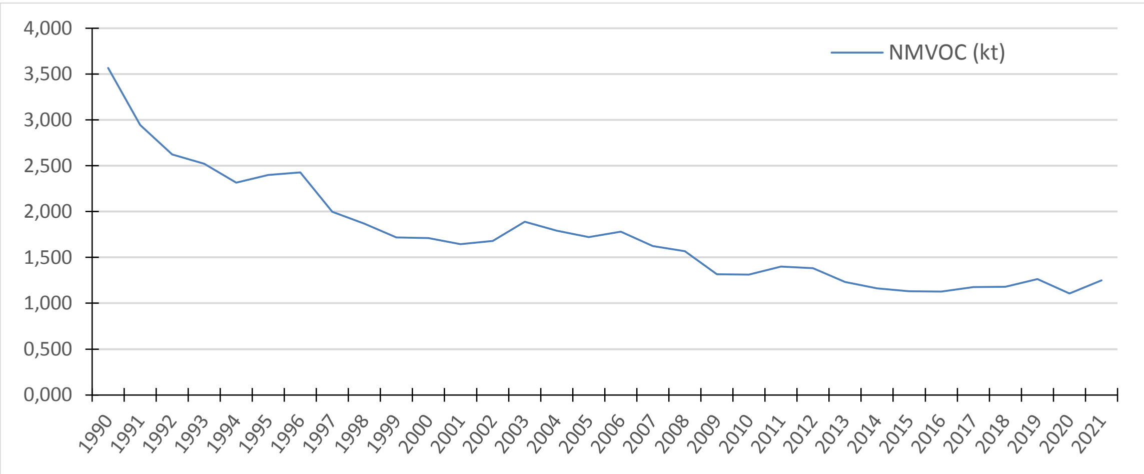


Figure 3.21.1. Emissions Trend (kt) for NFR 1.B.2.b. for NMVOC

It is observed that the emissions trend of NMVOC is decreasing for the 1990-2021 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".

For NFR 1.B.2.c, for the time series 2012-2021, activity data is represented by refinery gases flared (m^3).

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

The emissions are calculated based on Tier 1 methodology from 2019 EMEP/EEA Guidebook for SNAP 090206 (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).

For the time series 1990-2011, as activity data we still used the category "losses" of natural gas from the Energy Balance provided by N.I.S, together with default 2019 EMEP/EEA Guidebook emission factors (Table 3-1, Tier 1) for a preliminary estimate of pollutant emissions, due to the lack of activity data from economic operators.

Table 3.22.1. Emissions Trend (kt) for NFR 1.B.2.c. for SOx and NOx 1990-2021

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

Year	SO_X (kt)	NOx (kt)
2005	0.006	0.616
2006	0.008	0.877
2007	0.006	0.642
2008	0.008	0.856
2009	0.012	1.324
2010	0.006	0.646
2011	0.006	0.668
2012	0.004	0.472
2013	0.005	0.509
2014	0.005	0.490
2015	0.061	0.063
2016	1.112	0.797
2017	0.060	0.055
2018	1.117	0.795
2019	0.813	0.579
2020	0.195	0.147
2021	0.193	0.145

NOx and SOx emissions presented in above table with italic font are calculated for the time series 2012-2021 with activity data from economic operators. The chart below shows the variation of the pollutants for 1.B.2.c

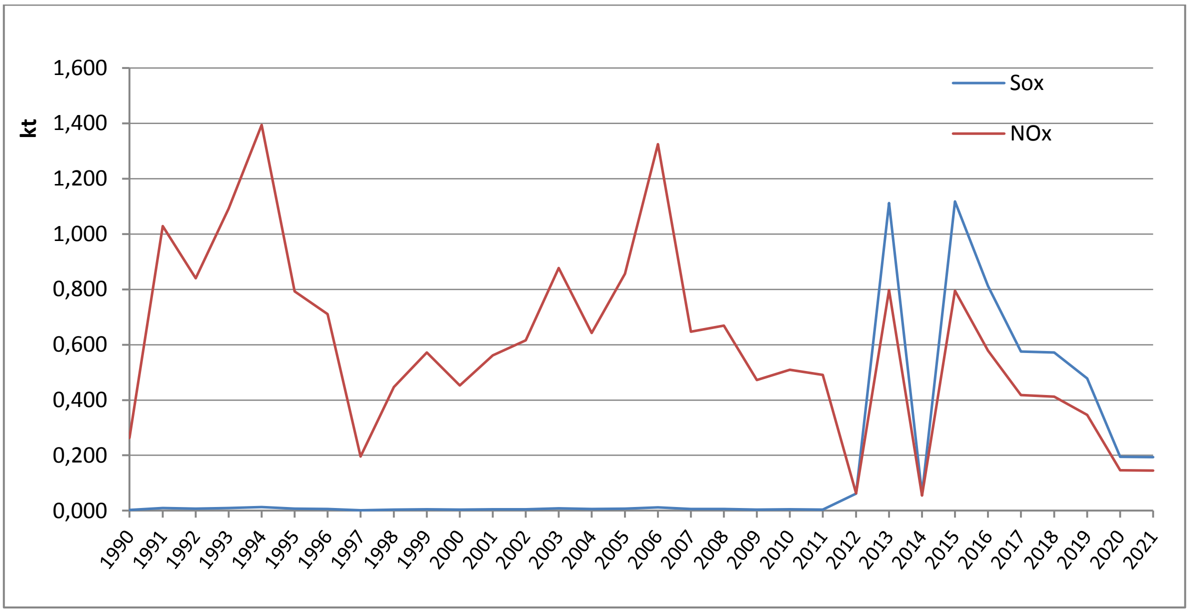


Figure 3.22.1. SO_X and NOx emissions trend (kt) for NFR 1.B.2.c

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 (2021)

Pollutant	NFR code	Category	Level assessment (%)
NMVOC	2D3g	Chemical products	7.18%
NMVOC	2D3a	Domestic solvent use including fungicides	4.25%
NMVOC	2H2	Food and beverages industry	3.50%
NMVOC	2D3i	Other solvent use (please specify in the IIR)	1.96%
PM10	2A5a	Quarrying and mining of minerals other than coal	3.17%
PM10	2D3b	Road paving with asphalt	1.98%
TSP	2D3b	Road paving with asphalt	10.04%
TSP	2B10a	Chemical industry: Other (please specify in the IIR)	7.73%
TSP	2A5a	Quarrying and mining of minerals other than coal	4.38%
TSP	2A2	Lime production	3.03%
Pb	2C1	Iron and steel production	51.68%
Cd	2C1	Iron and steel production	12.06%
Hg	2C1	Iron and steel production	12.92%
As	2C1	Iron and steel production	27.92%
Cr	2C1	Iron and steel production	37.56%
Ni	2C1	Iron and steel production	11.28%
Zn	2C1	Iron and steel production	10.45%
PCDD/F	2C1	Iron and steel production	15.12%
PCBs	2C1	Iron and steel production	70.45%

Industrial processes and product use sector mainly contributes to the PCBs emissions of the Inventory (70.45% of the total national), Pb emissions (54.95% of the total national), Cr emissions (38.28% of the total national), NMVOC emissions (20.78% of the total national), TSP emissions (30.53% of the total national), As (30.09% of the total national) and with a relatively low contribution to the emissions of the rest of pollutants reported.

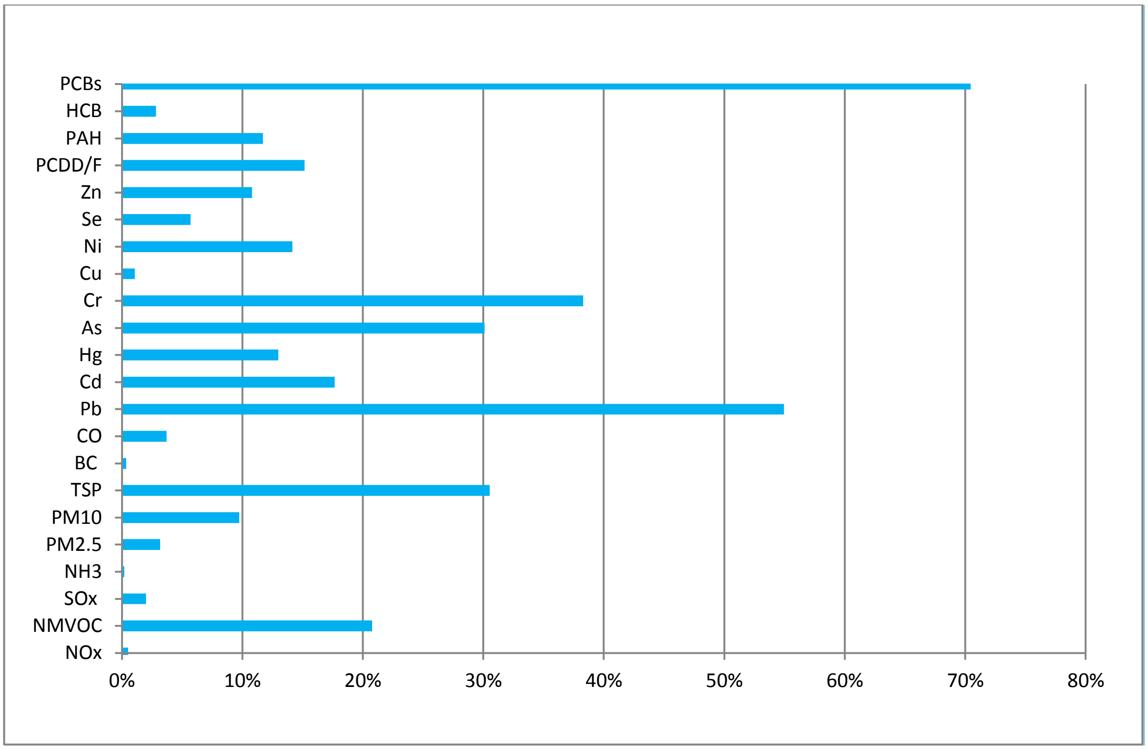


Figure 4.1. Emissions of pollutants (%) for IPPU sector in 2021

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 - EMEP EEA guidebook (2019) factors
2A2 Lime production	PM2.5, PM10, TSP, BC	T1 - 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

NFR	Pollutants Reported	Emission Factor tier and source
2B3 Adipic acid production	NOx, CO	T2 - EMEP EEA guidebook (2019) factors
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	T1 - EMEP EEA guidebook (2019) factor
2D3b Road paving with asphalt	NMVOC, PM2.5, PM10, BC, TSP	T1 - 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	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

NFR	Pollutants Reported	Emission Factor tier and source
2H2 Food and beverages industry	NMVOC	T2 - EMEP EEA guidebook (2019) factors
2H3 Other industrial processes (please specify in the IIR)	-	
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 from cement production applies the general equation:

$$Epollutant = ARproduction \times Efpollutant$$, 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 emission factors used to calculate the emissions from cement production are from 2019 EMEP/EEA Guidebook, chapter 2.A.1 Cement production, Table 3.1.

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
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2015	6203
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2017	6190
2018	6587
2019	7208
2020	7542
2021	7765

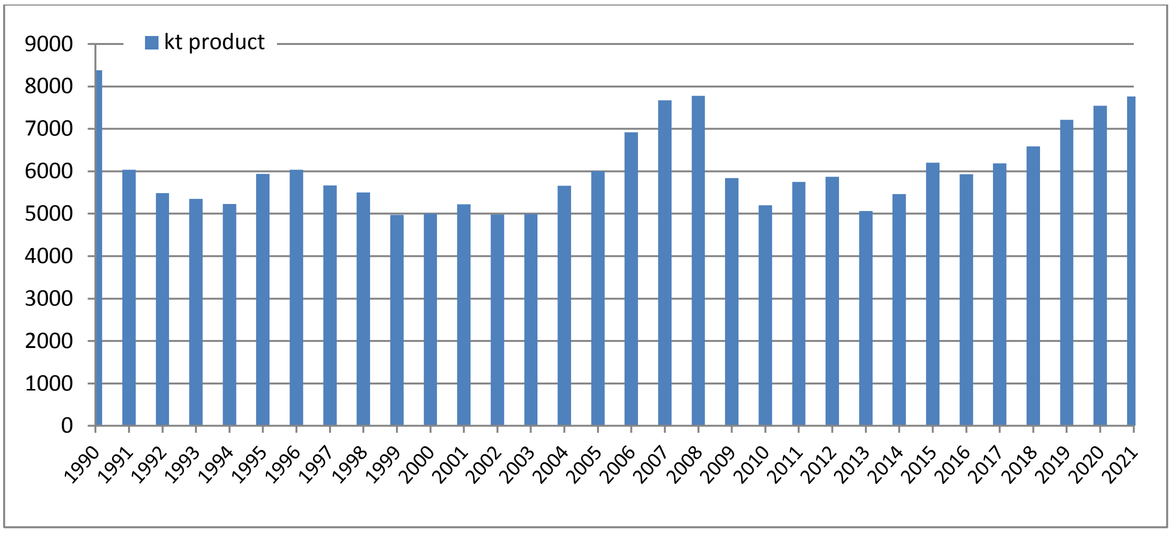

Figure 4.1.1. Activity data trend (kt product) for NFR 2.A.1. Cement production

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	0.856	1.541	1.713
2019	0.937	1.687	1.874
2020	0.980	1.765	1.961
2021	1.009	1.817	2.019

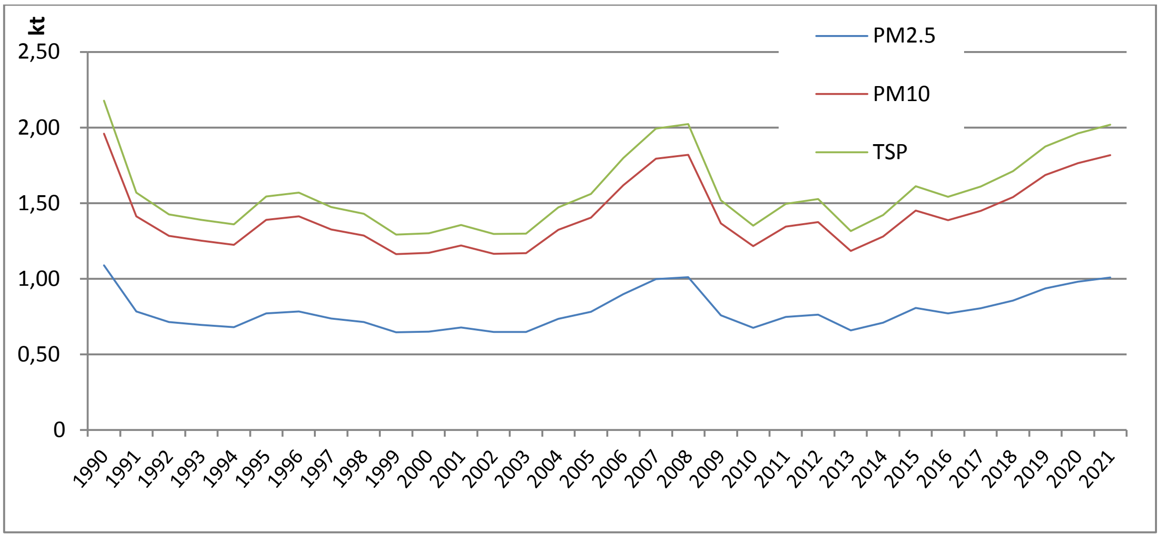

Figure 4.1.2. Emission Trends (kt) for NFR 2.A.1 Cement Production

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 2010-2021 time period emissions recorded variations related to clinker production activity.

Recalculations and improvements:

- There were not recalculations since the previous submission.

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.

NFR 2.A.2 is a key source category for TSP pollutant.

The emissions are calculated based on Tier 1 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.

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 2009-2021 calcium quicklime production is taken from the economic operators. For dolomitic lime produced, the N.I.S. activity data are used for the 2000-2021 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
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2014	1233
2015	1050
2016	1062
2017	1125
2018	1165
2019	1024
2020	695
2021	783

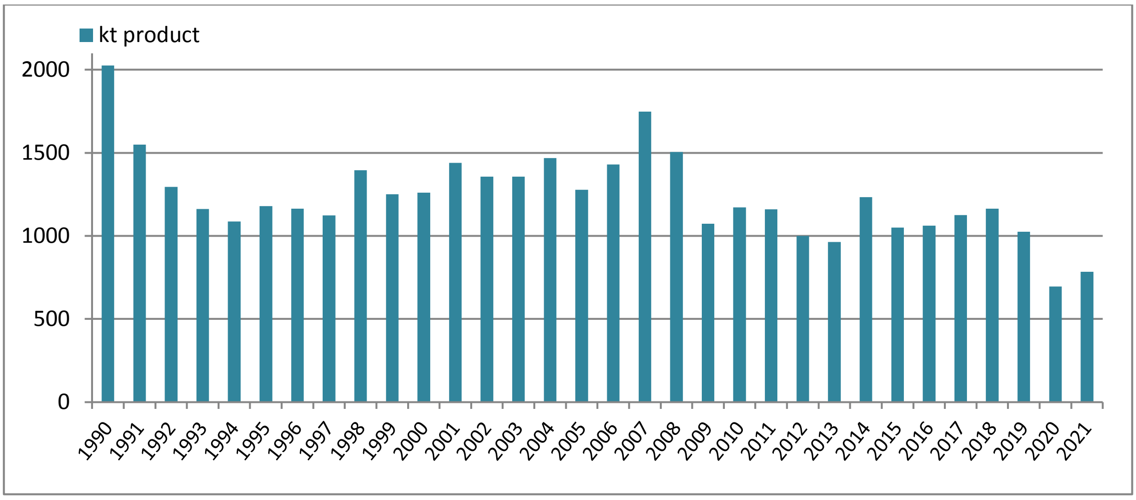


Figure 4.2.1. Activity data Trend (kt) for NFR 2.A.2. Lime production

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
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	0.815	4.076	10.482
2019	0.717	3.585	9.219
2020	0.486	2.431	6.252
2021	0.548	2.742	7.051

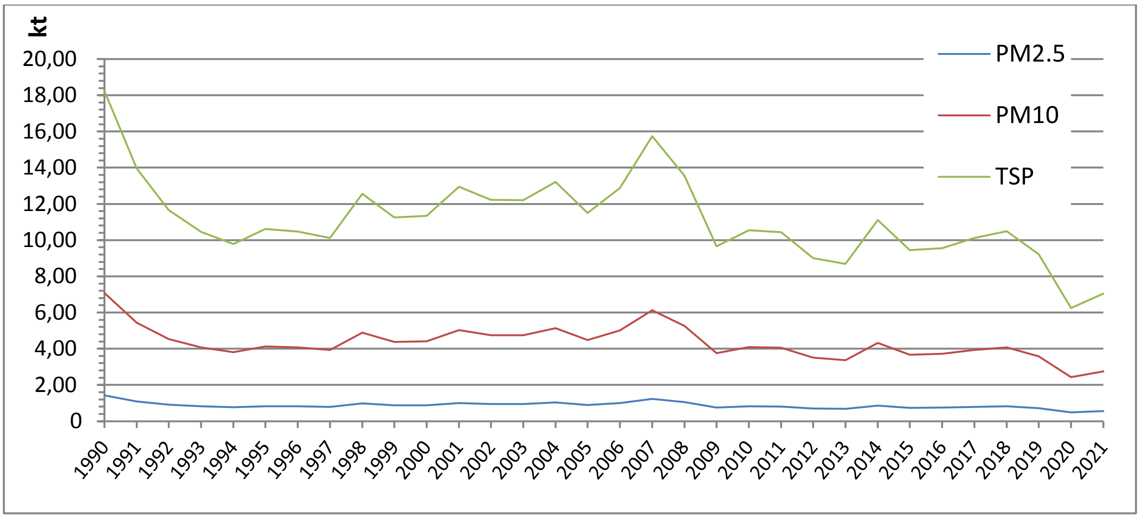


Figure 4.2.2. Emission Trends (kt) for NFR 2.A.2. Lime production

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:

- There were no recalculations and improvements for this category.

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
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

Year	kt product
2019	358.70
2020	423.40
2021	463.70

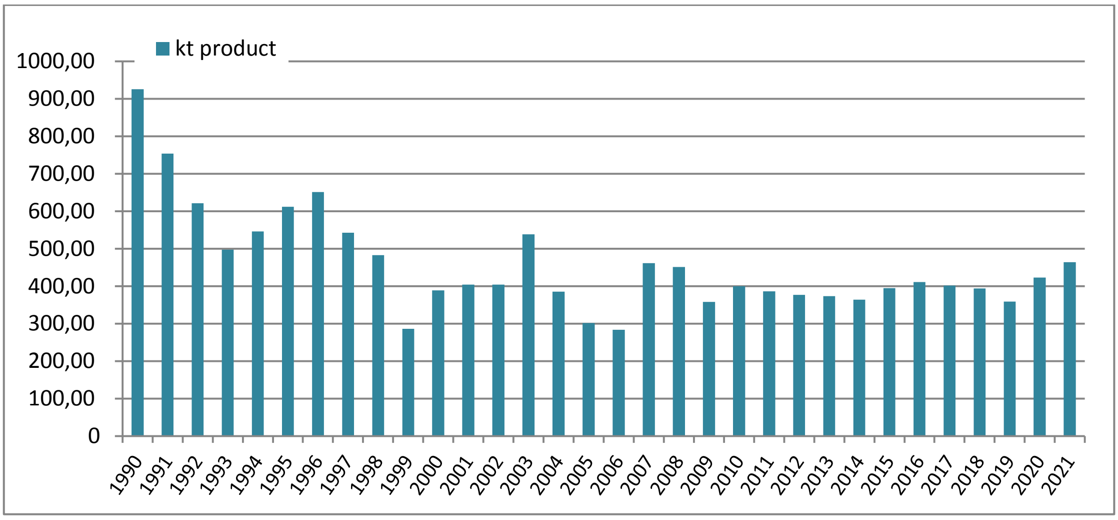


Figure 4.3.1. Activity data Trend (kt) for NFR 2.A.3. Glass production

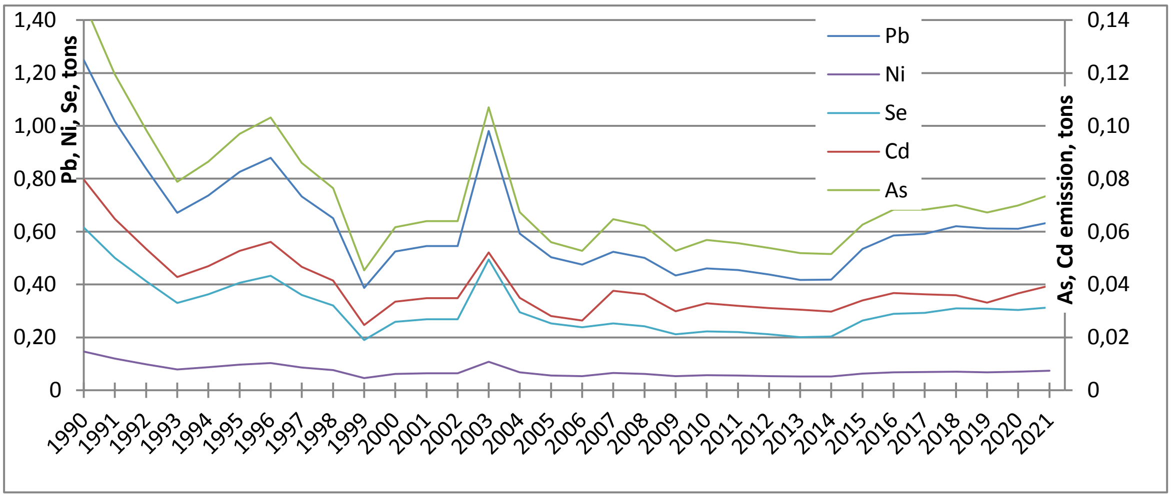
The emission trends for the glass production are shown in the following table and figure.

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
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

Year/Pollutant	Pb	Cd	As	Ni	Se
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

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 3.17%, respectively 4.38% 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 fertiliser 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
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

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

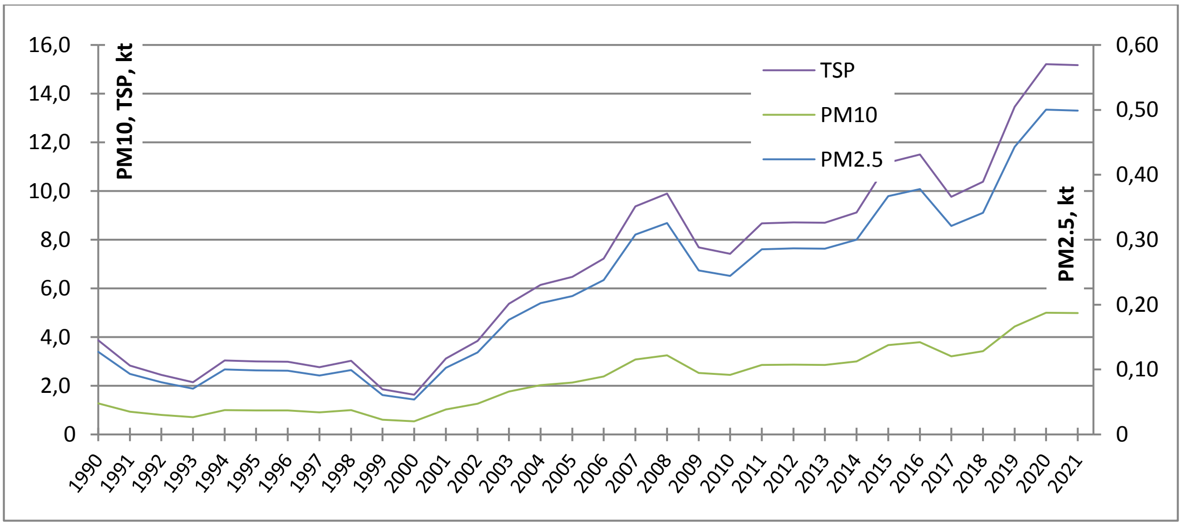


Figure 4.4.1. Emission Trends (kt) for NFR 2.A. 5.a Quarrying and mining of minerals other than coal

Recalculations and improvements:

- There were no recalculations and improvements for this category.

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/[m^2 · year])
- A affected = area affected by construction activity (m^2)
- 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 (m²) 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
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	4586780	2834449	2649127	396000

NFR 2.A.5.b is not a key source for any pollutant.
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

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
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
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	1.062	3.530

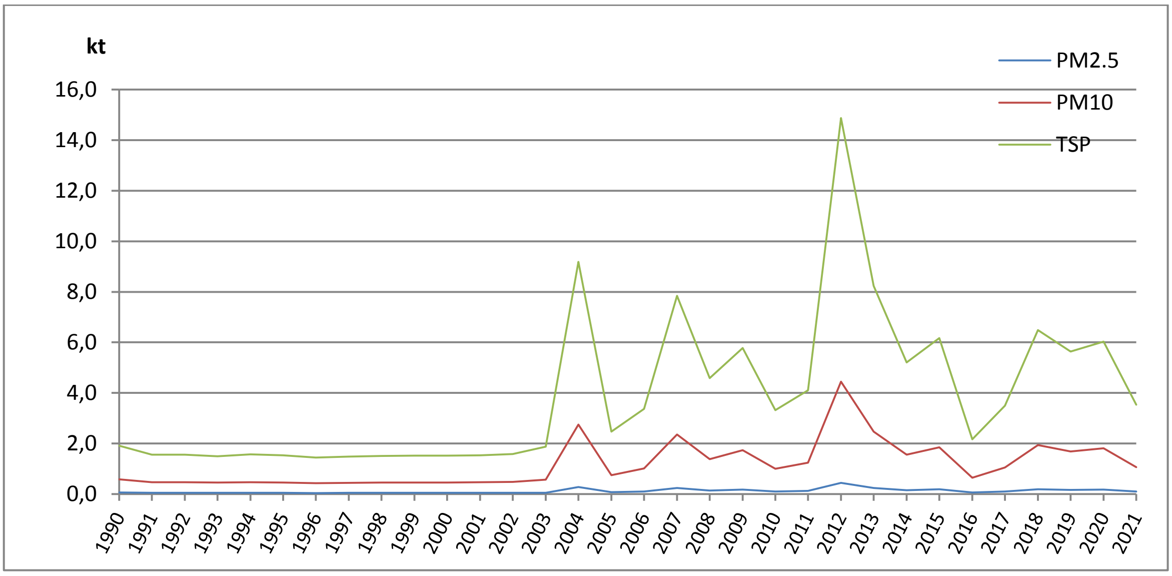


Figure 4.5.1. Emission Trends (kt) for NFR 2.A.5.b Construction and demolition

Particulate matter emissions followed the trend of activity data, with peaks in the years when new roads were built.

Recalculations and improvements:

- There were no recalculations and improvements for this category.

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

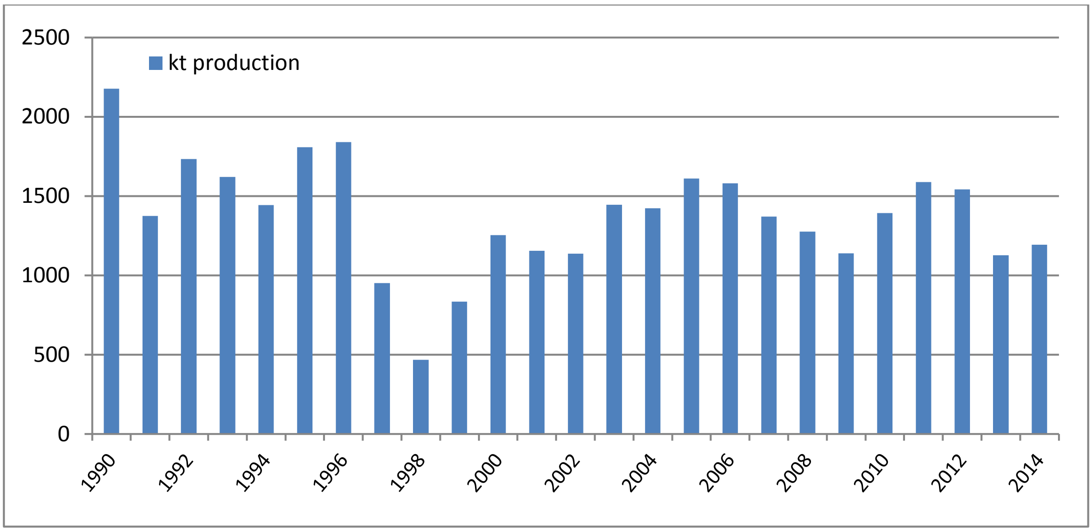


Figure 4.6.1. Activity data trend (t) for NFR 2.B.1. Ammonia production

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

Year/Pollutant	NOx	NH_3	CO
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

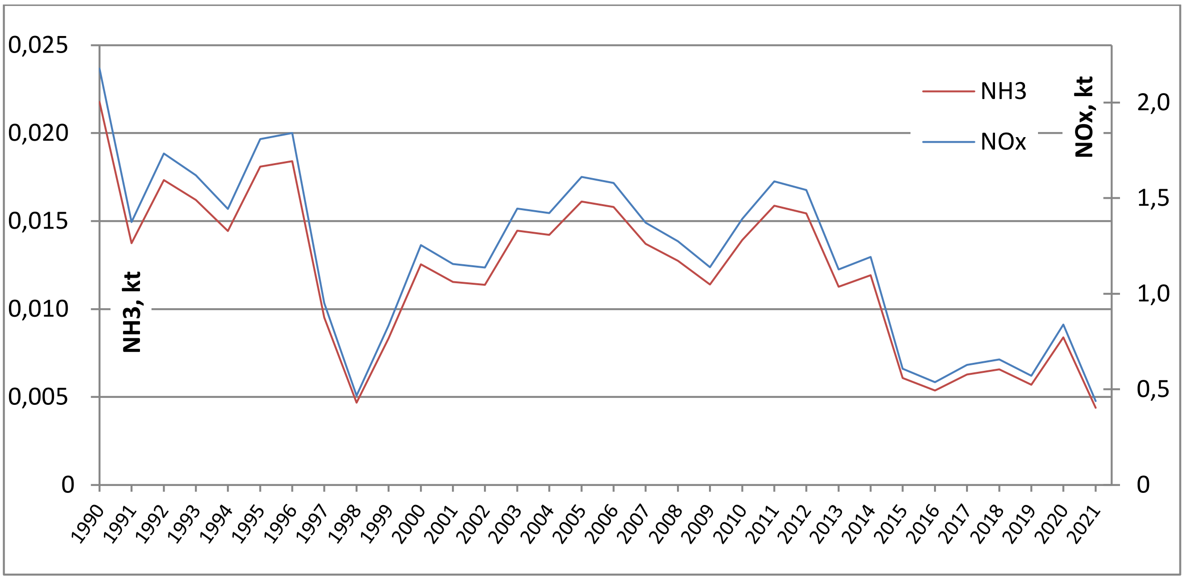


Figure 4.6.2a Total Emission Trends (kt) for NOx and NH_3 for NFR 2.B.1. Ammonia production

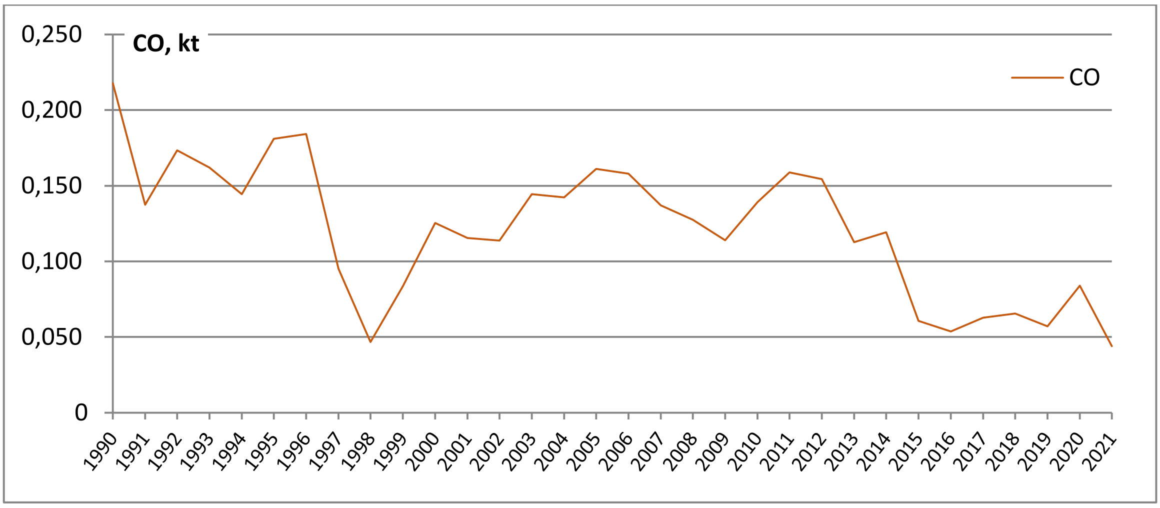


Figure 4.6.2b Total Emission Trends (kt) for CO for NFR 2.B.1. Ammonia production

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

Year/Pollutant	NOx
1998	3.858
1999	4.141
2000	5.643
2001	5.101
2002	5.353
2003	3.470
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

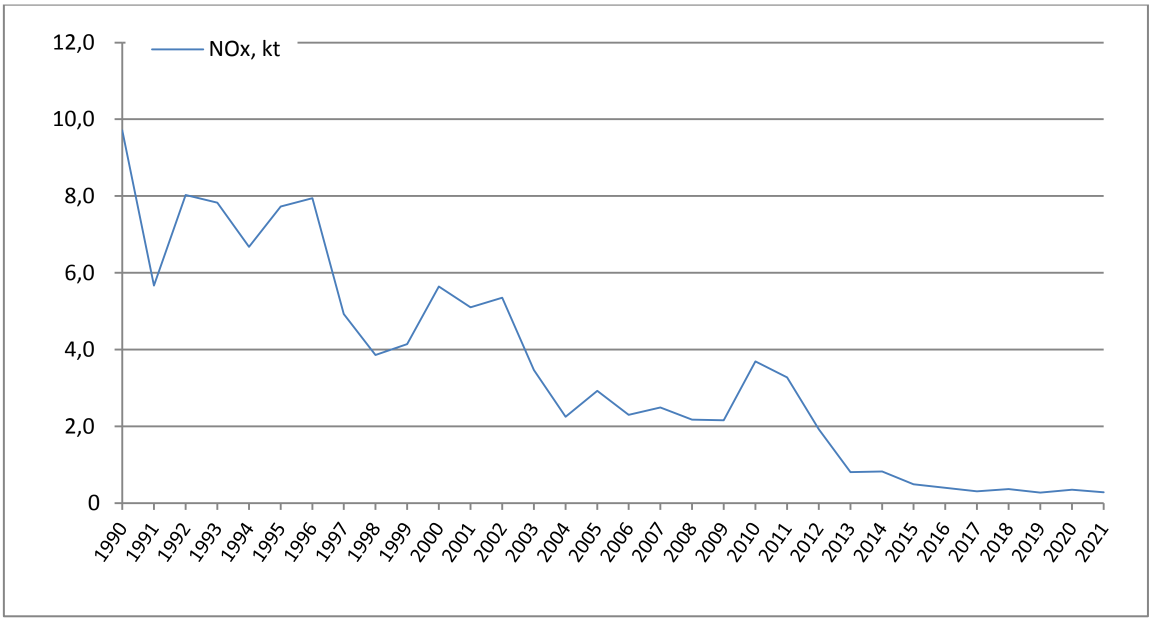


Figure 4.7.1. Emission trends (kt) for NOx for NFR 2.B.2. Nitric acid production

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

Year	NOx	CO
1998	0.07450	0.00372
1999	0.05969	0.00298
2000	0.07406	0.00370
2001	0.04258	0.00213

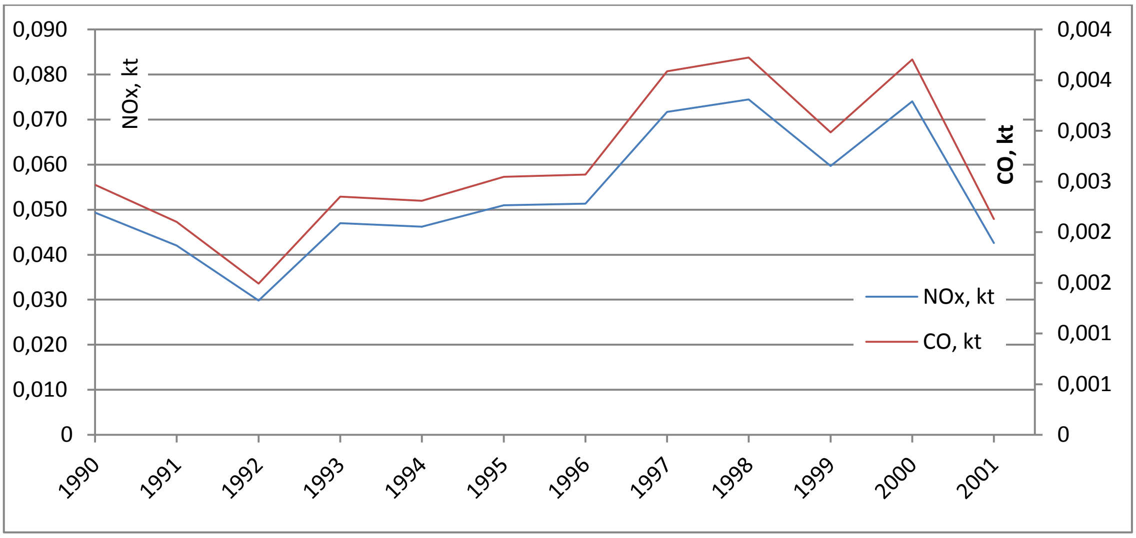


Figure 4.8.1. Emission trends (kt) for NFR 2.B.3 Adipic acid production

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

Year	kt production
1996	106
1997	91
1998	73
1999	54
2000	55
2001	53
2002	53
2003	45
2004	63
2005	34
2006	20
2021	0.00067

The emission trends are shown below in the following figure.

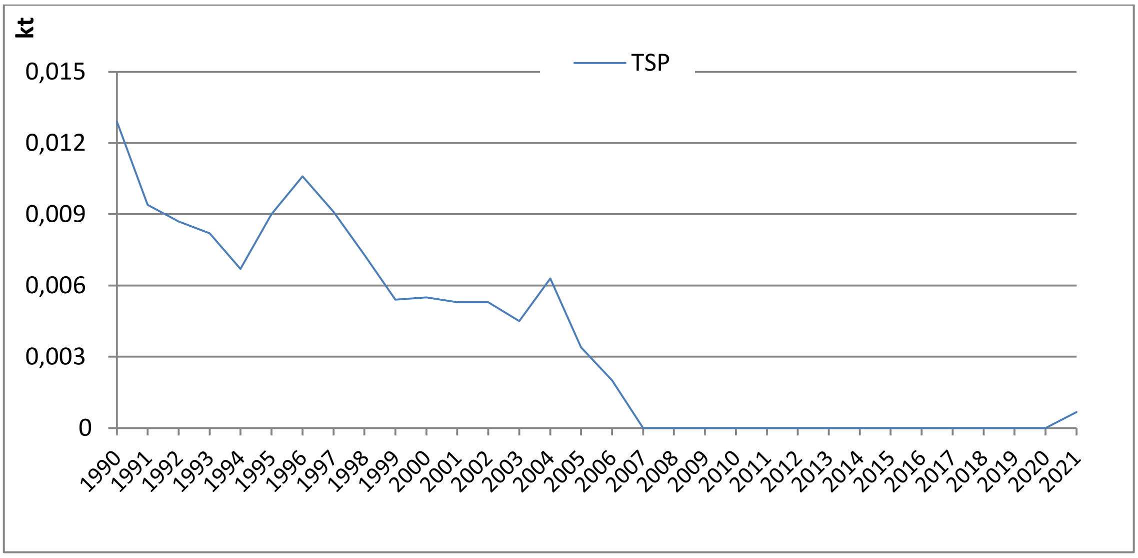


Figure 4.9.1. Total Emission trends (kt) for TSP for NFR 2.B.5 Carbide production

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 in year 2020 and 2021.

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

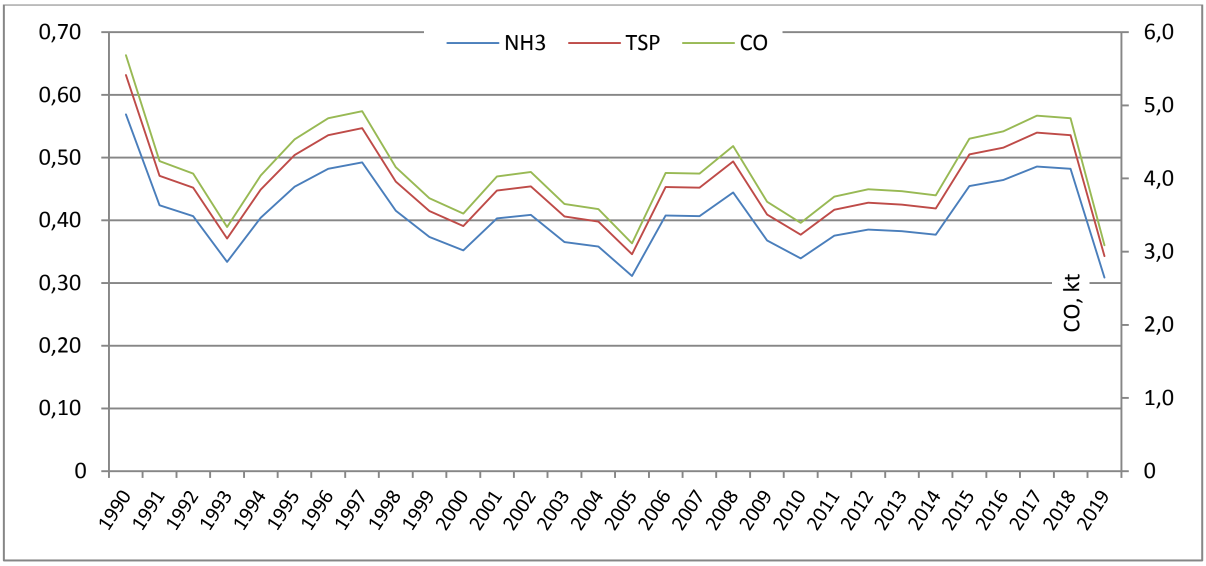


Figure 4.10.1. Emission trends (kt) for NFR 2.B.7 Soda Ash production

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).

NFR 2.B.10.a is key source category for TSP pollutants in 2021.

The methodology for estimating emissions from chemical 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

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.

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

Year/Pollutant	NMVOC (kt)	$PM_{2.5}$ (kt)	PM_{10} (kt)	TSP (kt)
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
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

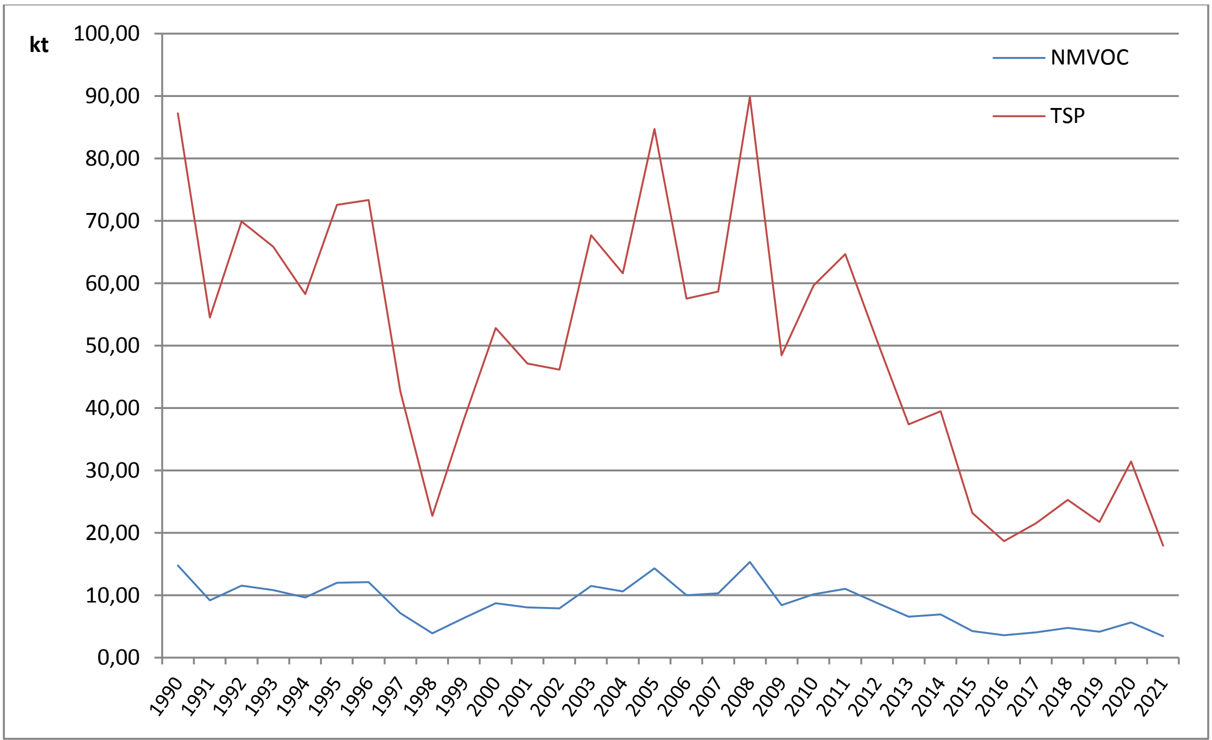


Figure 4.11.1 Emission Trends (kt) of NMVOC and TSP for NFR 2.B.10.a Other chemical industry

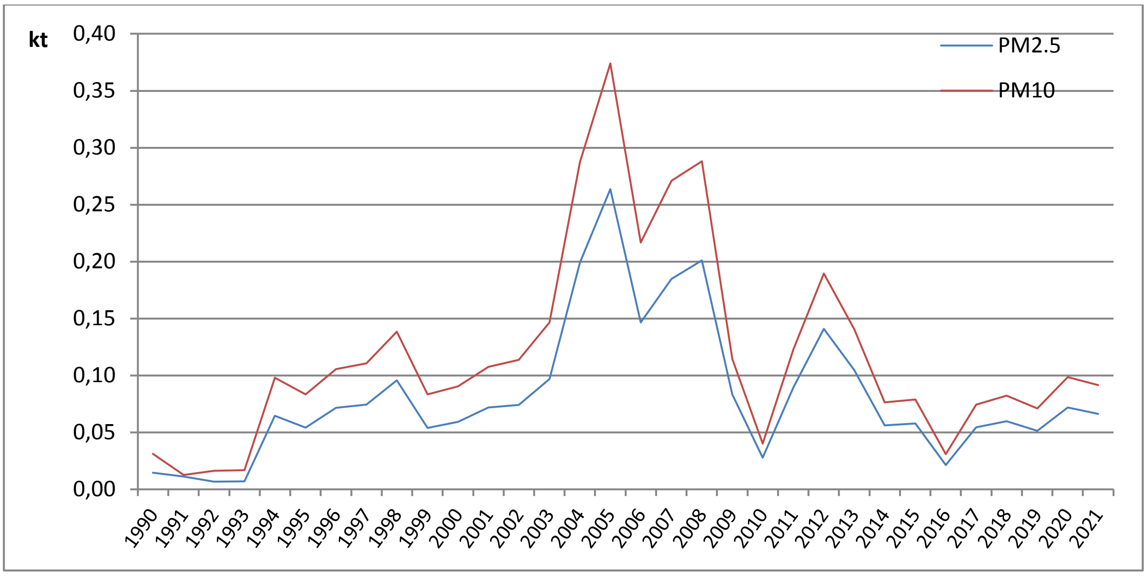


Figure 4.11.2 Emission Trends (kt) of $PM_{2.5}$ and PM_{10} for NFR 2.B.10.a Other chemical industry

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.

NFR 2.C.1 is a key category for emissions of Pb, Cd, Hg, As, Cr, Ni, Zn, PCDD/F and PCBs in 2021.

The methodology for estimating emissions from iron and steel production applies the general equation:

$$Epollutant = \sum_{technologies} ARproduction, technology \ x \ EFtechnology, pollutant$$

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.

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
2012	23.240	0.470	0.255	0.771	4.161	1.724	13.298	33.638	12.515

Year	Pb (t)	Cd (t)	Hg (t)	As (t)	Cr (t)	Ni (t)	Zn (t)	PCDD/F (g I-TEQ)	PCBs (kg)
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

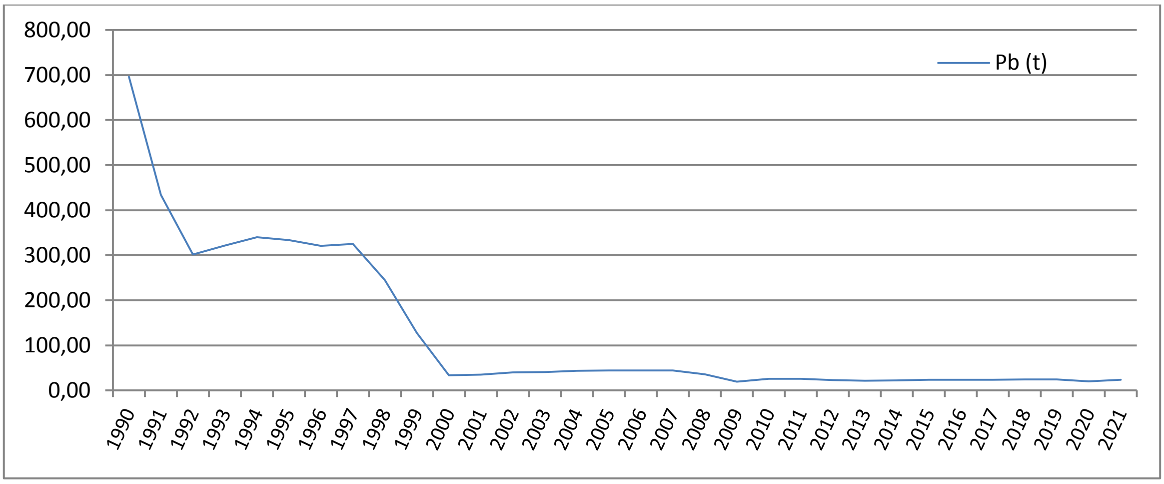


Figure 4.12.1.a Emission Trends of Pb (t) for NFR 2.C.1. Iron and steel production

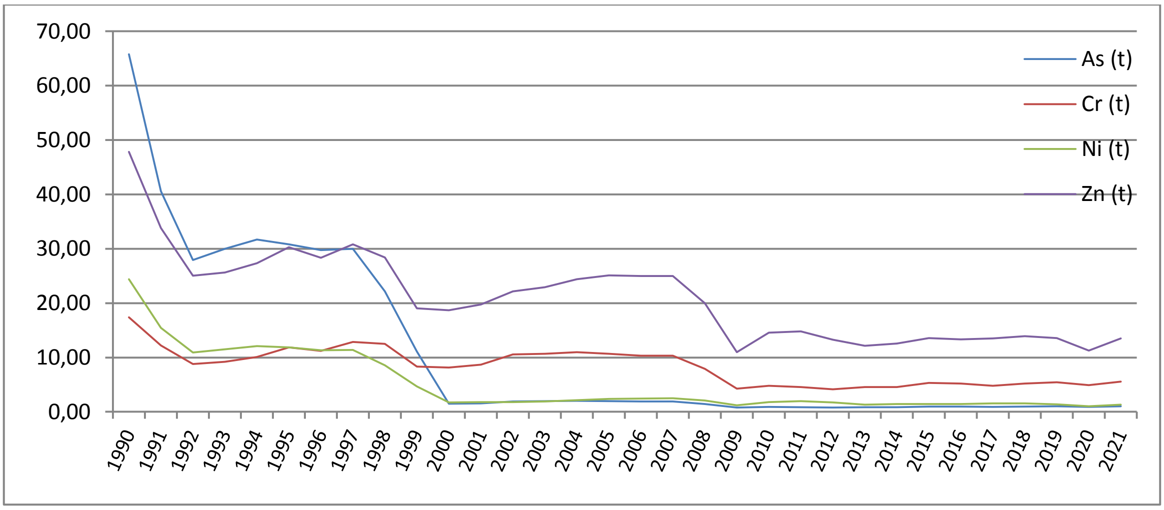


Figure 4.12.1.b Emission Trends of As, Cr, Ni and Zn (t) for NFR 2.C.1. Iron and steel production

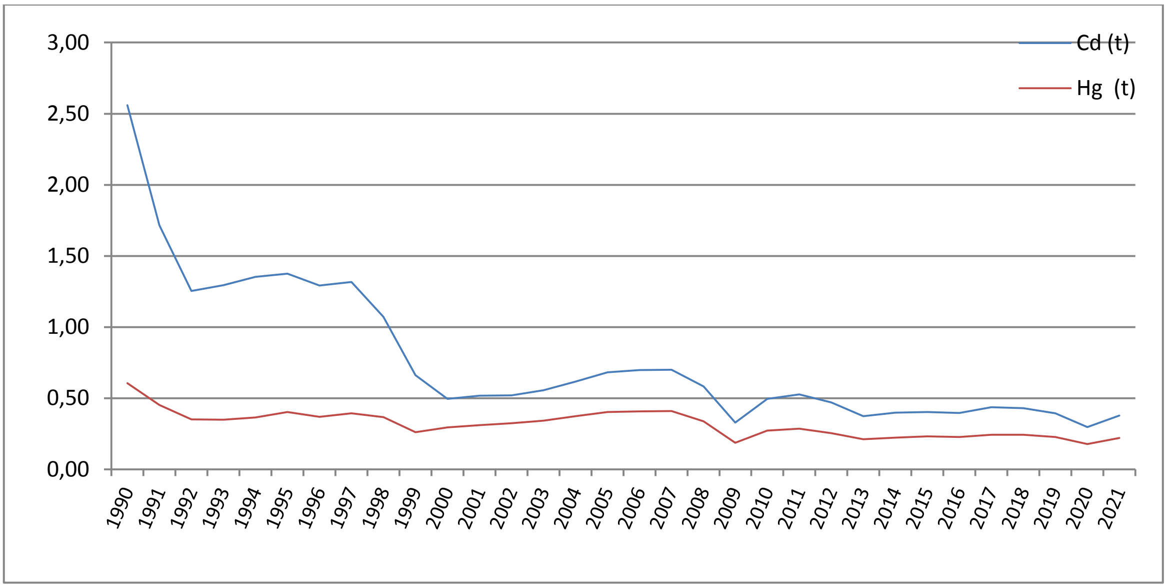


Figure 4.12.1.c Emission Trends of Cd, Hg (t) for NFR 2.C.1. Iron and steel production

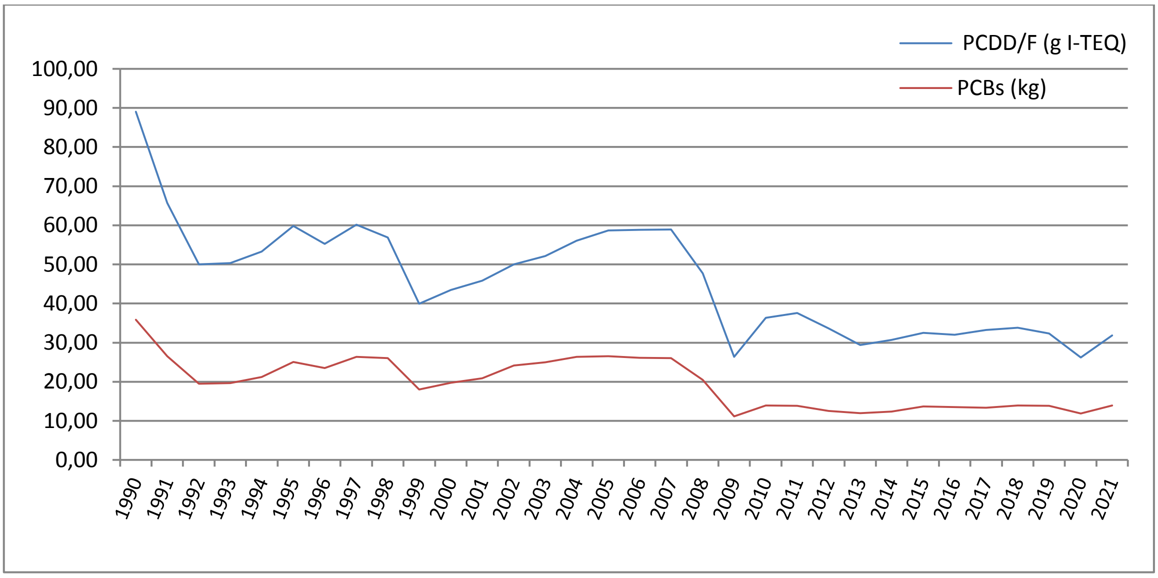


Figure 4.12.1.d Emission Trends of PCDD/F (g I-TEQ) and PCBs (kg) for NFR 2.C.1. Iron and steel production

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
2011	0.0141	0.0200	0.0236

Year/Pollutant	$PM_{2.5}$	PM_{10}	TSP
2012	0.0082	0.0116	0.0137

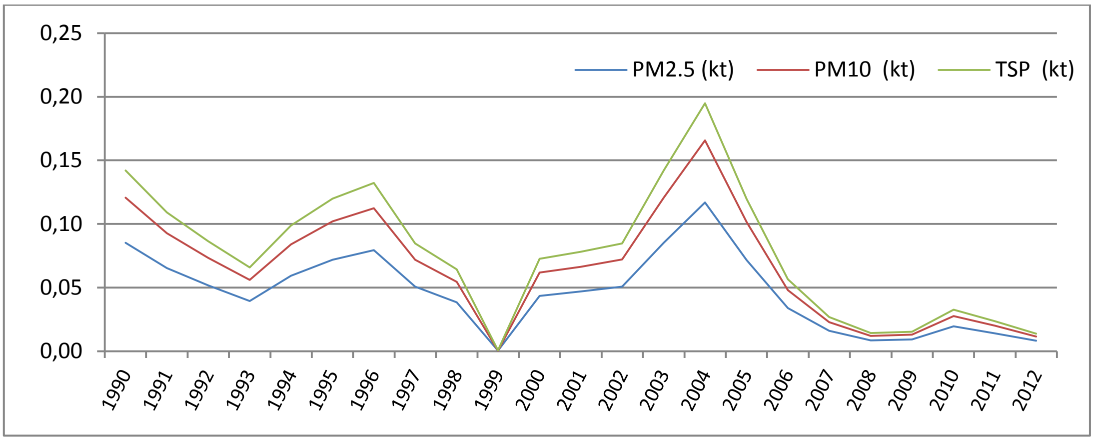


Figure 4.13.1. Total Emission Trends for NFR 2.C.2 Ferroalloys production for $PM_{2.5}$, PM_{10}, TSP (kt)

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:

$$\mathrm{Epollutant} = \sum_{\mathrm{technologies}} \mathrm{ARproduction, technology\ x\ EFtechnology, pollutant}$$

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

The emissions of CO follow the activity data trends for aluminium production which varied substantially from year to year with a peak in 2008.

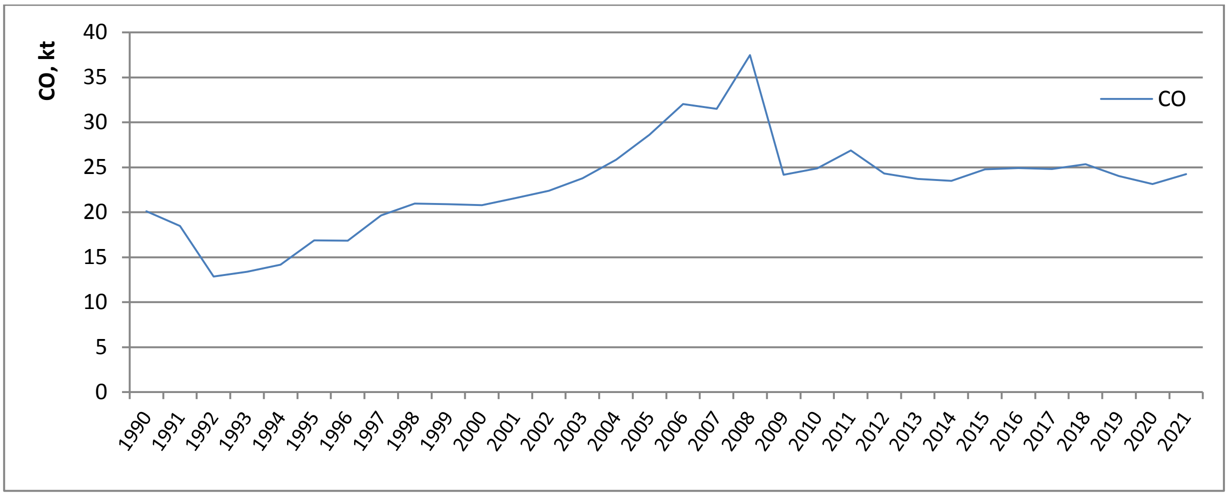


Figure 4.14.1. Emission Trends for CO (kt) for NFR 2.C.3. Aluminium production

Recalculations and improvements:

- There were not recalculations since the previous 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

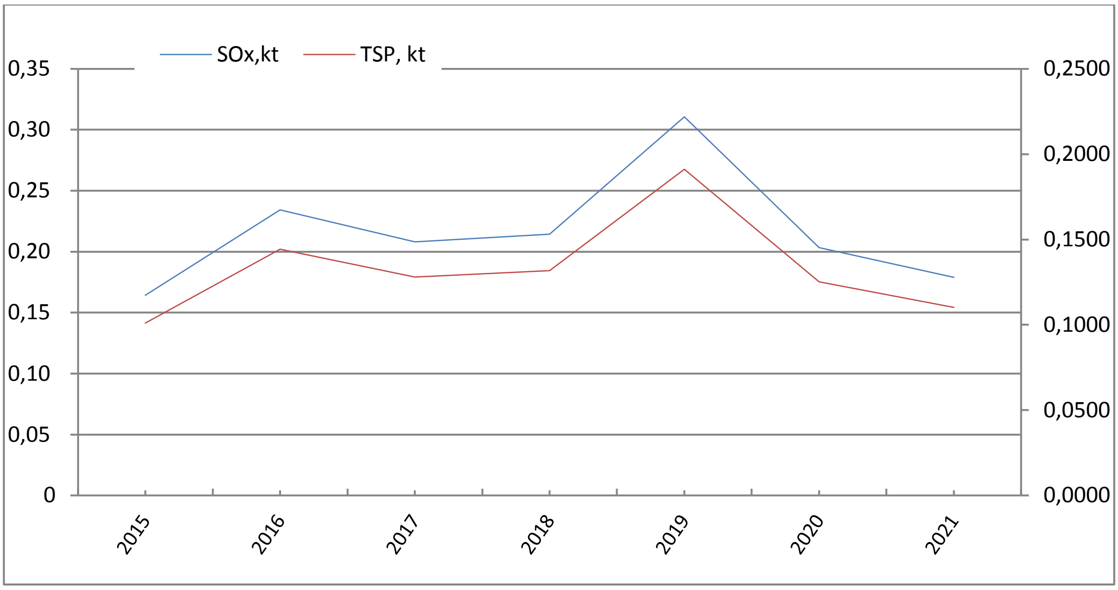


Figure 4.15.1. Emission Trends (kt) for NFR 2.C.4 Magnesium production

Recalculations and improvements:

- Here this category are calculated for the first time.

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

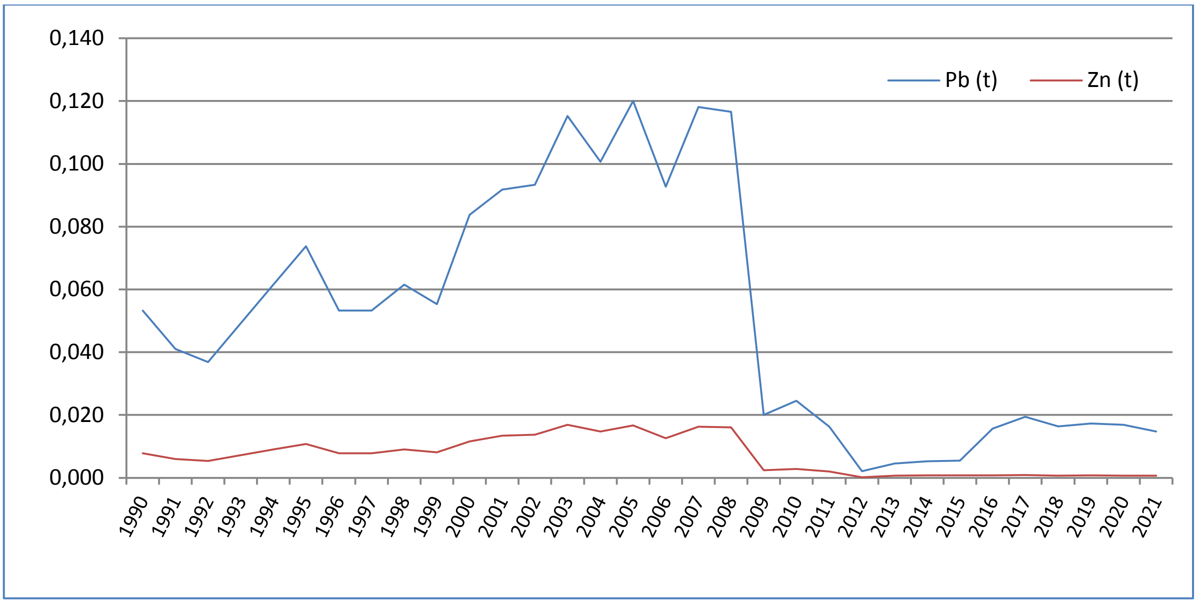


Figure 4.16.1 Total Emission Trends for NFR 2.C.5 Lead production

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

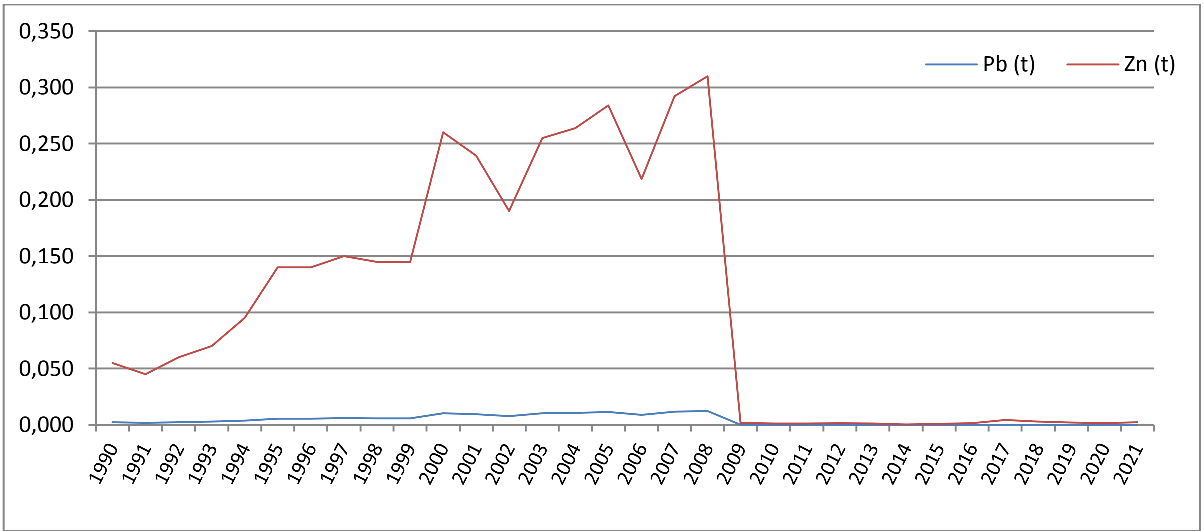


Figure 4.17.1 Total Emission Trends (t) for NFR 2.C.6 Zinc production

The 2021 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

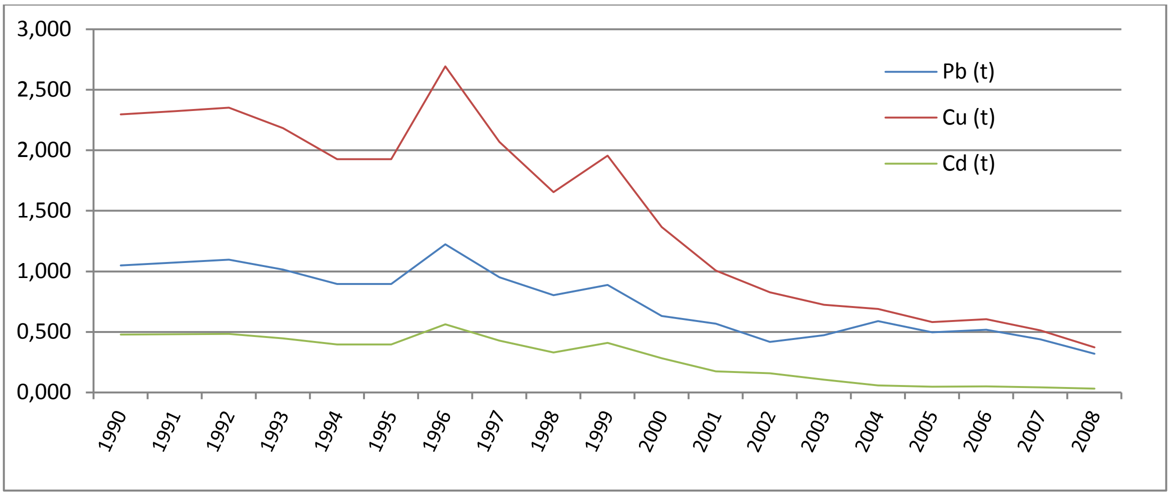


Figure 4.18.1 Total Emission Trends (t) for NFR 2.C.7a Copper production

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 still represented by the total population of Romania for time series 1990-2021 and is provided by EUROSTAT. For the 1990-2015 time series used the emission factor from NMVOC=0.5 kg/capita ("European solvent VOC emission inventories based on industry-wide"); for the 2016-2020 used the emission factors from ESIG and for 2021 year used EF calculated as the average of the 2018 and 2019 years (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 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.

The NMVOC emissions were then corrected in line with the 2019 EMEP/EEA Guidebook (Chapter 2.3.D.a, section 3.2.3) 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.

In 2021 NFR 2D3a was key source for NMVOC with 4.25% from national total.

Table 4.19.1. 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
2016	19643949
2017	19533481
2018	19414458
2019	19328838
2020	19201662
2021	19038098

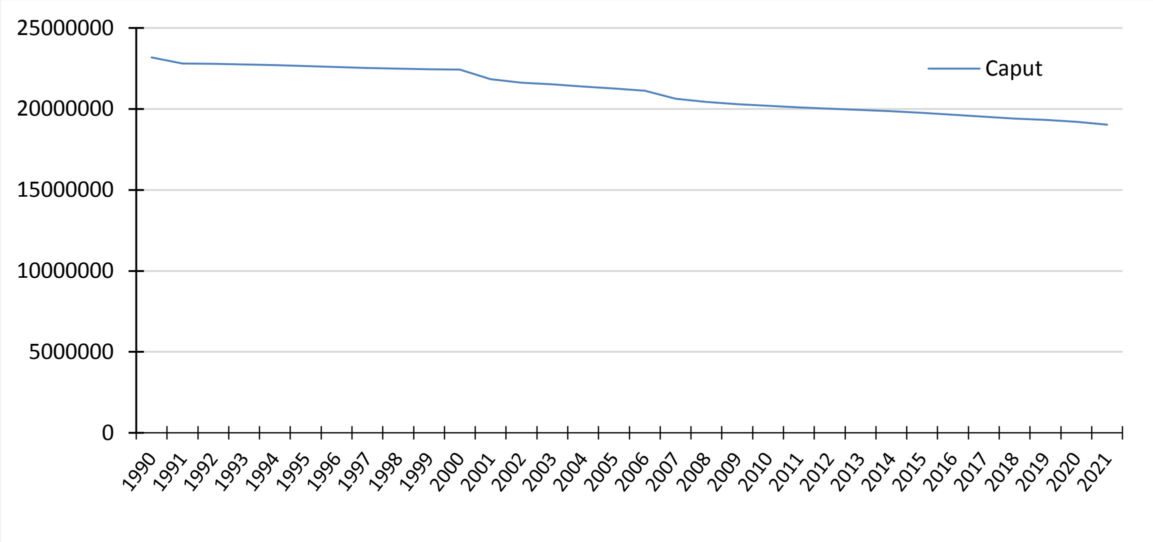


Figure 4.19.1. Activity data trends (caput) for NFR 2.D.3.a Domestic solvent use including fungicides

The emission trends are shown below in the following table and figure.

Table 4.19.2. Emission trends (kt) for NFR 2.D.3.a Domestic solvent use including fungicides

Year	NMVOC (kt)
1990	14.288
1991	14.052
1992	14.033
1993	14.014
1994	13.992
1995	13.957
1996	13.912
1997	13.877
1998	13.854
1999	13.834
2000	13.818
2001	13.451
2002	13.324
2003	13.258
2004	13.173
2005	13.095
2006	13.017
2007	12.712
2008	12.592
2009	12.503
2010	12.444
2011	12.380
2012	12.333
2013	12.289
2014	12.241
2015	12.174
2016	7.000

Year	NMVOC (kt)
2017	7.977
2018	9.025
2019	11.249
2020	15.853
2021	9.965

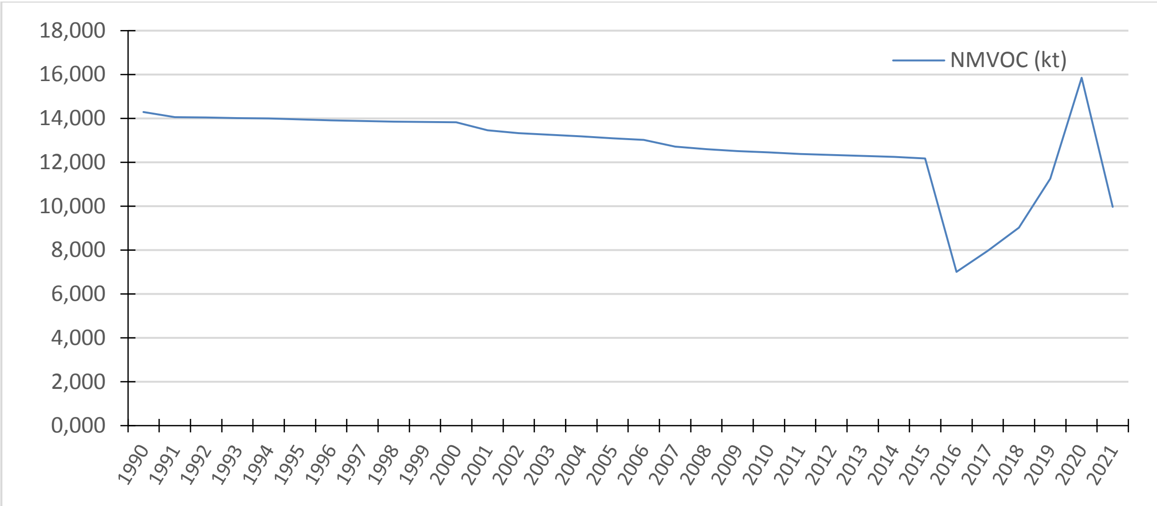


Figure 4.19.2. Emission trends (kt) for NFR 2.D.3.a Domestic solvent use including fungicides

The NMVOC emissions follow the activity data trends for NFR 2D3a Domestic solvent use including fungicides, which varied substantially from year to year due to variations in statistical population data.

Recalculations and improvement:

During the desk Review and according to the recommendations,

- activity data were revised (EUROSTAT);

- 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 2021, with a share of 10.04% from the national emissions of TSP and 1.98% from the national emissions of PM10.

The emissions to air from this sector are particulate matter (TSP, PM10, PM2.5), volatile organic compounds (NMVOC) and black carbon (BC).

Romania has studied the possibility of obtaining activity data corresponding to the paving purposes, in response to the 2022 review. According to 2019 EMEP Guidebook, “in the absence of any such information, however, it is good practice to select the emission factors for batch mix plants”, with whose emission factors the emissions for the entire time series have been calculated. The methodology for estimating emissions from road paving with asphalt use the Tier 2 approach from the 2019 EMEP Guidebook.

Romania has studied the possibility of obtaining activity data corresponding to paving purposes in response to the 2022 review. According to the 2019 EMEP Guidance, “in the absence of any such information, however, it is good practice to select emission factors for installations of batch mixing", with whose Tier 2 emission factor approach emissions were calculated for the entire time series.

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

Year/Pollutant	TSP (kt)	PM 10(kt)
2003	2.854	0.381
2004	14.282	1.904
2005	10.146	1.353
2006	14.241	1.899
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

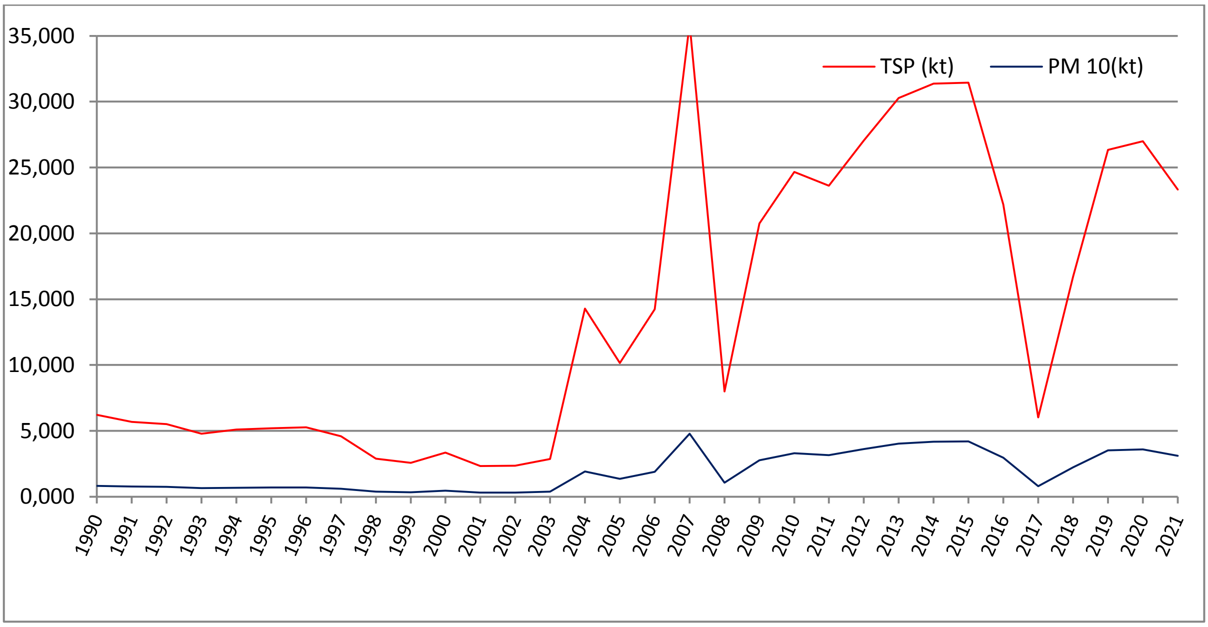


Figure 4.20.1. Total Emission Trends (kt) for NFR 2.D.3.b Road paving with asphalt

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.

The entire time series was recalculated with Tier2 approach for this category.

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:

$Epollutant = ARproduction \times EFpollutant$

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.

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

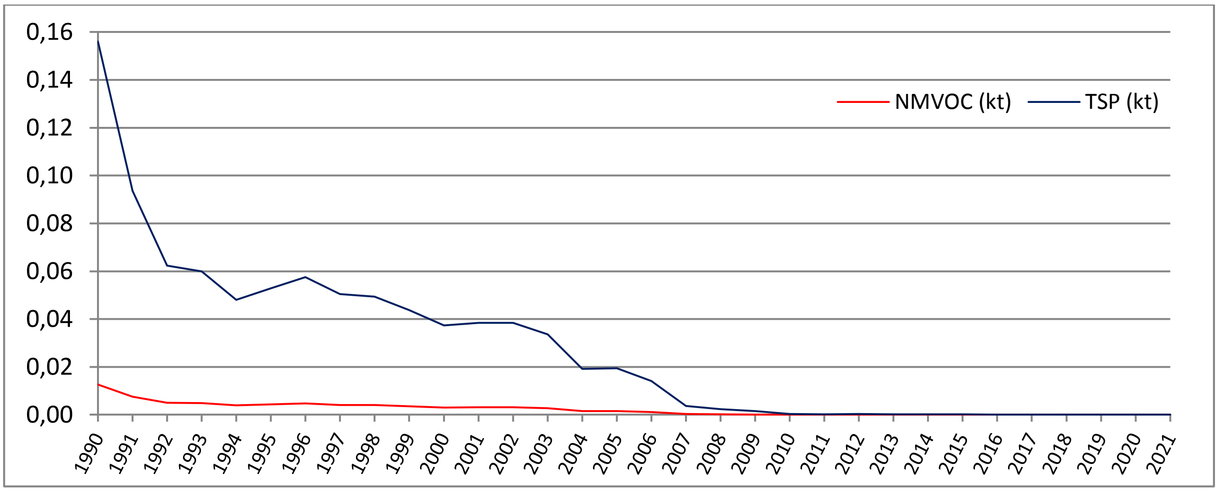


Figure 4.21.1. Total Emission Trends (kt) for NFR 2.D.3.c Asphalt Roofing

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 source category refers to "the use of paints the industrial and domestic sectors. The term paint is taken to include all materials applied as a continuous layer to a surface with the exception of glues and adhesives which are covered by NFR source category "Other solvent and product use (SNAP 060405)".

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.

For time series 1990-2007 was calculated NMVOC emissions from industrial coating application: manufacture of automobiles (SNAP activity 060101) and other industrial coating applications (SNAP activity 060108), because we do not have activity data for the other activities.

The activity data are represented by numbers of automobiles and other vehicle type (split by buses, trucks, other transport vehicle) provided by the N.I.S. It used Tier 2 default emission factor for NMVOC (Table 3-6 and Table 3-12 from 2019 EMEP/EEA Guidebook).

The emission trends are shown below in the following table and figure.

Table 4.22.1. Emission trends (kt) for NFR 2.D.3.d Coating applications

Year/Pollutant	NMVOC (kt)
1990	1.058
1991	0.911
1992	0.744
1993	1.545
1994	1.400
1995	1.200
1996	1.480
1997	1.457
1998	1.490
1999	1.214
2000	0.897

Year/Pollutant	NMVOC (kt)
2001	0.914
2002	0.918
2003	1.145
2004	1.429
2005	1.964
2006	1.957
2007	2.090

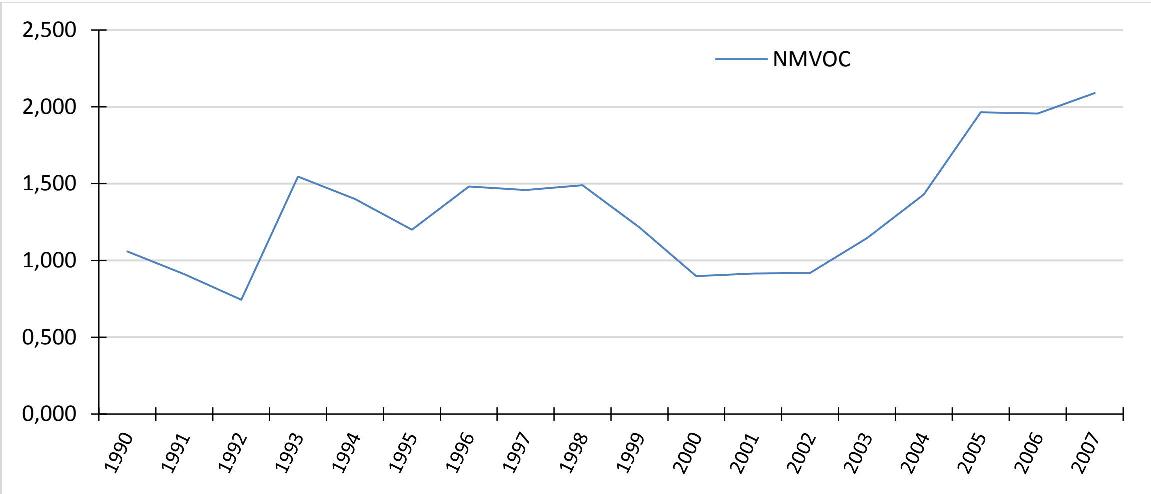


Figure 4.22.1. Emission trends (kt) for 2.D.3.d Coating applications

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.

For the 2008-2021 series, the activity data, respectively the solvent consumption (kt) and the NMVOC emission, 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). At SNAP 060101 “Manufacture of automobiles” and SNAP 060108 “Other industrial paint application” solvent consumption (kt) and NMVOC emissions (kt) from SNAPs: 060106 “Boat building” and 060107 “Wood” were added.

The tables below show the variation of solvent consumption (kt) and NMVOC emissions (kt) in the period 2008-2021.

Table 4.22.2. Activity data trends (kt solvent consumption) for NFR 2.D.3.d Coating applications

Year	Solvent consumption (kt)
2008	13.34
2009	10.62
2010	11.80
2011	10.87
2012	10.65
2013	10.76
2014	10.54
2015	11.54
2016	10.51

Year	Solvent consumption (kt)
2017	10.60
2018	11.20
2019	9.78
2020	8.29
2021	11.04

Table 4.22.3. Emission trends (kt) for NFR 2.D.3.d Coating applications

Year/Pollutant	NMVOC (kt)
2008	6.187
2009	5.117
2010	4.397
2011	3.351
2012	4.872
2013	5.311
2014	5.365
2015	6.115
2016	5.650
2017	4.745
2018	4.642
2019	3.659
2020	2.603
2021	3.823

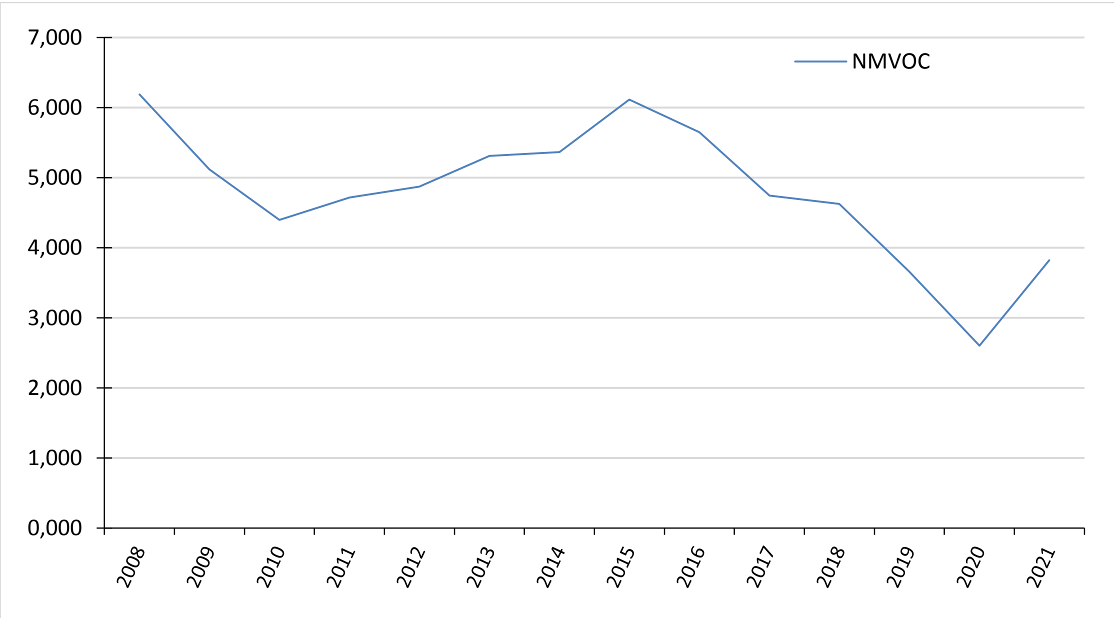


Figure 4.22.3. Emission trends (kt) for 2.D.3.d Coating applications

In 2021 NFR 2D3d was key source for NMVOC with 1.63% from national total.

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;
- EFpollutant is the emission factor for this pollutant.

In this year the trichlorethylene consumption for NFR 2D3e-Degreasing, was used as the activity data on the advice of experts from the NECD Improving Capacity Building project.

As activity data was considered consumption of trichlorethylene (TRI) as a solvent used for degreasing.

AD = Consumption (TRI) = Production + Imports – Exports (kg).

Production/import/export data were provided by N.I.S. for PRODROM code 201413741. 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 TRI (kt)
1990	5.559
1991	5.559
1992	5.559
1993	5.559
1994	5.559
1995	7.429
1996	6.736
1997	1.895
1998	4.074
1999	8.259
2000	2.927
2001	2.126
2002	0.773
2003	0.716
2004	0.659
2005	0.602

Year	Consumption of TRI (kt)
2006	0.545
2007	0.488
2008	0.492
2009	0.497
2010	0.183
2011	0.831
2012	0.921
2013	1.010
2014	1.100
2015	0.917
2016	0.734
2017	0.550
2018	0.367
2019	0.184
2020	0.00008
2021	0.000053

Table 4.23.2. Emission trends (kt) for NFR 2.D.3.e Degreasing

Year	NMVOC (kt)
1990	2.557
1991	2.557
1992	2.557
1993	2.557
1994	2.557
1995	3.417
1996	3.099
1997	0.872
1998	1.874
1999	3.799
2000	1.347
2001	0.978
2002	0.356
2003	0.329
2004	0.303
2005	0.277
2006	0.251
2007	0.224
2008	0.226
2009	0.229
2010	0.398
2011	0.382
2012	0.424
2013	0.465
2014	0.506
2015	0.422
2016	0.337
2017	0.253
2018	0.169

Year	NMVOC (kt)
2019	0.084
2020	0.00004
2021	0.00002

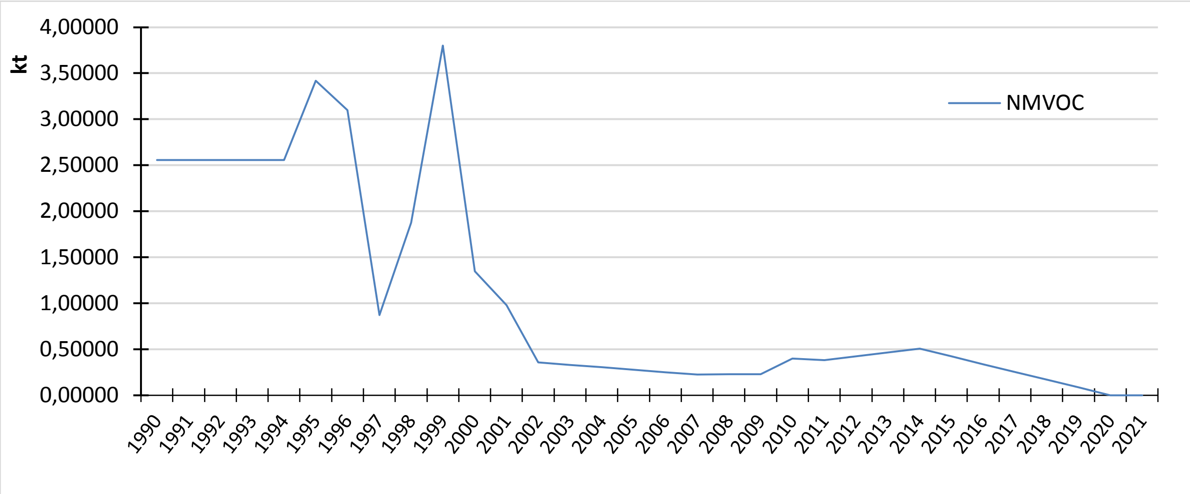


Figure 4.23.2. Emission trends (kt) for NFR 2.D.3.e Degreasing

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.
There were no recalculations and improvements for this category.

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 perchloroethylene (PER) as a solvent used for dry cleaning. We assumed the entire amount of perchloroethylene (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
2021	0.43

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

Year	NMVOC (kt)
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

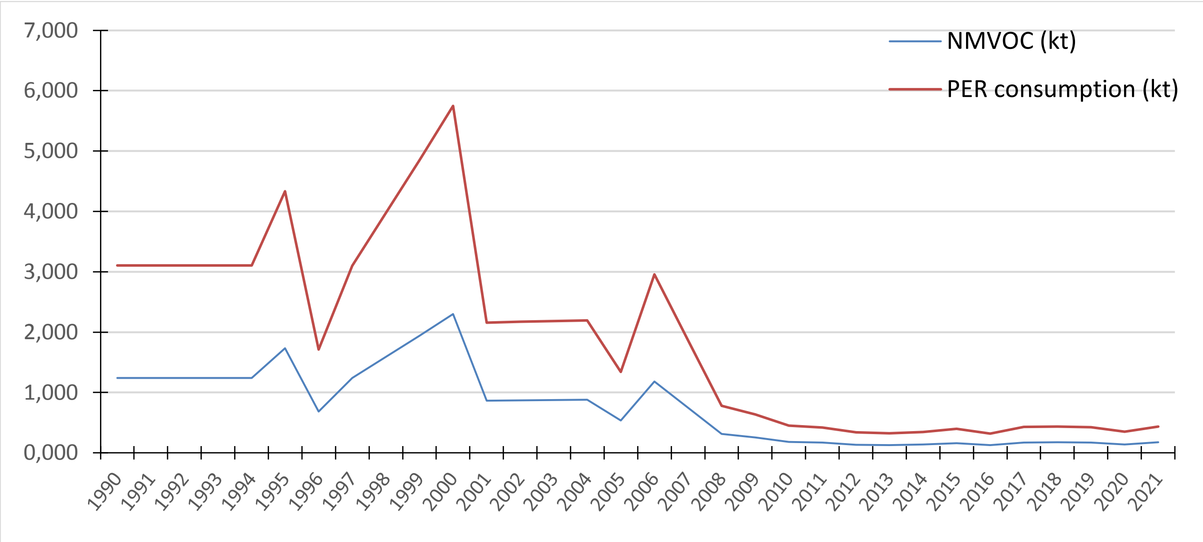


Figure 4.24.1. Emission trends (kt) for NFR 2.D.3.f Dry cleaning

It can be observed 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

The following chemical products are included:

- 060301 Polyester processing
- 060302 Polyvinylchloride processing
- 060303 Polyurethane foam processing (not available between 1990-1999);
- 060304 Polystyrene foam processing (not available between 1990-1992);
- 060305 Rubber processing;

- 060306 Pharmaceutical products manufacturing;
- 060307 Paints manufacturing;
- 060308 Inks manufacturing (not available between 1990-2007);
- 060309 Glues manufacturing (not available between 1990-1992)
- 060310 Asphalt blowing
- 060313 Leather tanning

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.

For SNAP 060301 (polyester processing), SNAP 060302 (polyvinylchloride processing), SNAP 060303 (polyurethane foam processing), SNAP 060304 (polystyrene foam processing), SNAP 060305 (rubber processing -for time series 1990-2007), SNAP 060307 (paints manufacturing), SNAP 060308 (inks manufacturing), SNAP 060309 (glues manufacturing) and SNAP 060310 (asphalt blowing) the activity data consist of the total productions of each product. These data are provided by the N.I.S. in the Statistical Yearbook and by the economic operators.

The emissions were estimated, based on 2019 EMEP/EEA Guidebook, chapter NFR 2.D.3.g Chemical products Table 3-1 (for SNAP 060302-polyvinylchloride processing and SNAP 060301-polyester processing), Table 3-3 (for SNAP 060303-polyurethane foam processing), Table 3-4 (for SNAP 060304-polystyrene foam processing), Table 3-5 (for SNAP 060305-rubber processing - for time series 1990-2007), Table 3-8 (for SNAP 060310-asphalt blowing), Table 3-11 (for SNAP 060307-paints manufacturing, SNAP 060308-inks manufacturing, SNAP 060309-glues manufacturing).

For SNAP 060306 (pharmaceutical products manufacturing), SNAP 060313 (leather tanning) the activity data consist of 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 (for the time series 2008-2021); same thing for SNAP 060305 (rubber processing) on the 2008-2021 period.

Table 4.25.1. Activity data trends (kt solvents; kt product) for NFR 2.D.3.g Chemical products

Year	kt solvents	kt product
1990		1165.00000
1991		1001.00000
1992		845.00000

Year	kt solvents	kt product
1993		601.95300
1994		643.20000
1995		673.41500
1996		639.02200
1997		609.44500
1998		498.38600
1999		424.87700
2000		489.53001
2001		453.32000
2002		453.21652
2003		527.46411
2004		593.38263
2005		537.83886
2006		620.95146
2007		617.40210
2008	0.669554	797.37346
2009	0.612467	521.75423
2010	0.918996	466.91652
2011	0.836947	479.91975
2012	0.979222	623.02703
2013	0.983649	668.22756
2014	1.101788	716.46671
2015	1.106588	755.44473
2016	0.852799	739.94978
2017	1.108841	684.09132
2018	1.1098913	684.11645
2019	0.949689	681.87848
2020	1.118656	695.68652
2021	0.800712	772.65372

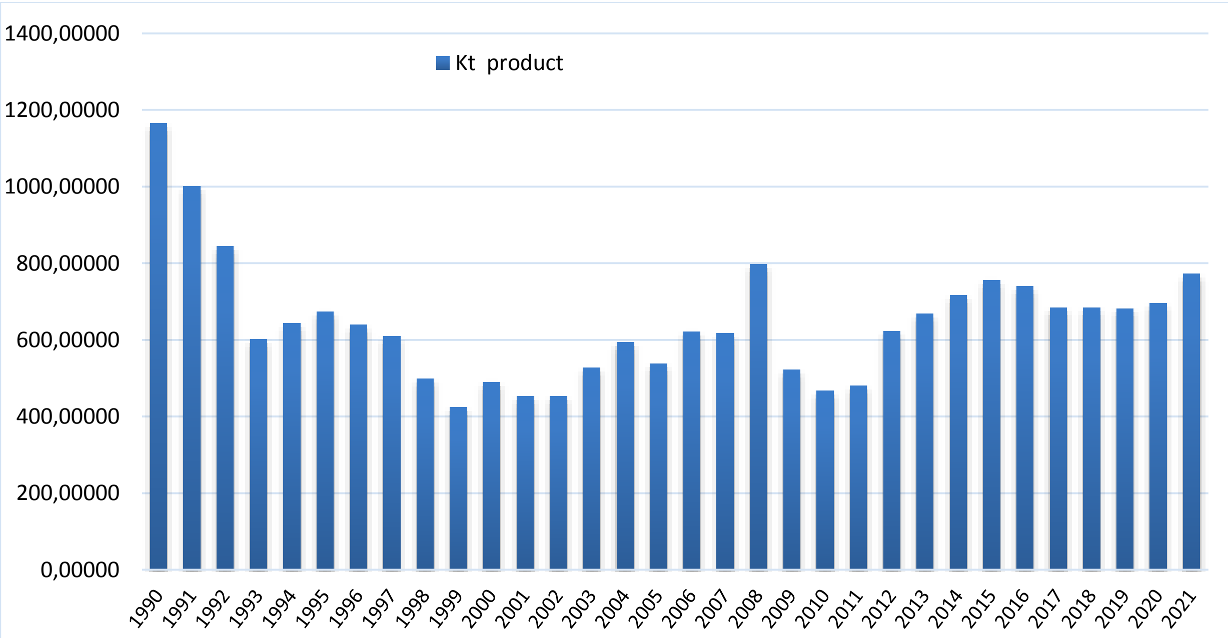


Figure 4.25.1. Activity data trends Kt products for NFR 2.D.3.g Chemical products

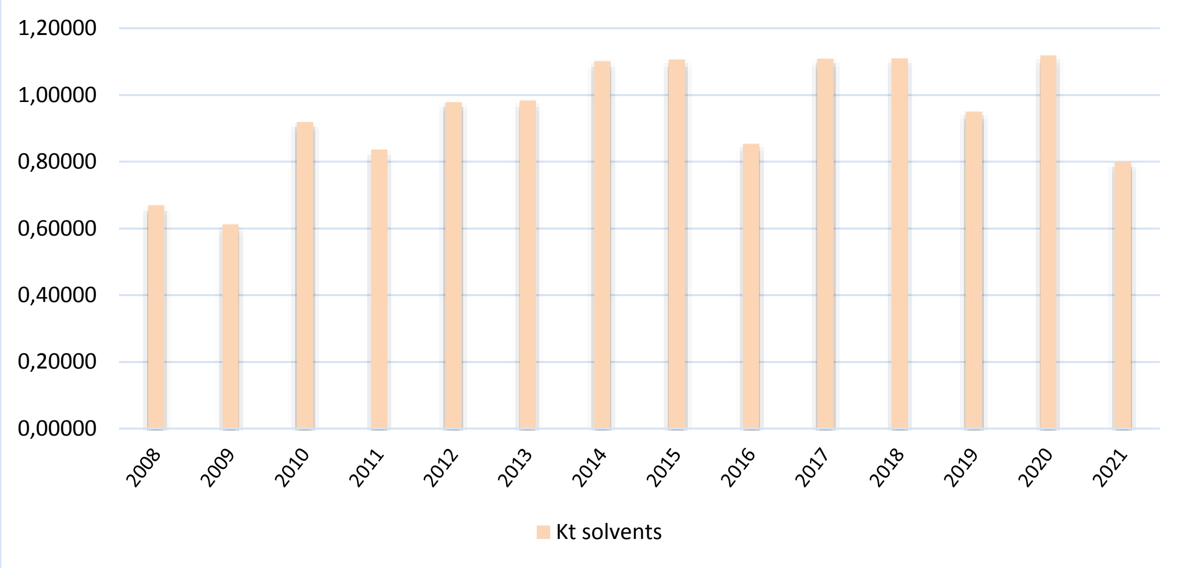


Figure 4.25.2. Activity data trends Kt solvents for NFR 2.D.3.g Chemical products

Table 4.25.2. Emission trends (kt) for NFR 2.D.3.g Chemical products

Year/Pollutant	NMVOC
1990	19.06080
1991	16.87280
1992	15.04140
1993	11.87930
1994	12.56603
1995	12.95306
1996	12.63445
1997	11.55890
1998	9.28088
1999	7.83088
2000	9.77249
2001	8.31606
2002	8.16952
2003	9.79860
2004	10.76681
2005	9.68793
2006	12.14376
2007	10.93839
2008	15.08552
2009	10.61938
2010	9.21017
2011	10.12442
2012	12.03899
2013	11.84439
2014	13.48345
2015	14.50211
2016	15.56265
2017	14.44386
2018	14.62858
2019	14.87764

Year/Pollutant	NMVOC
2020	15.12533
2021	16.80758

The emission trends are shown below in the following table and figure.

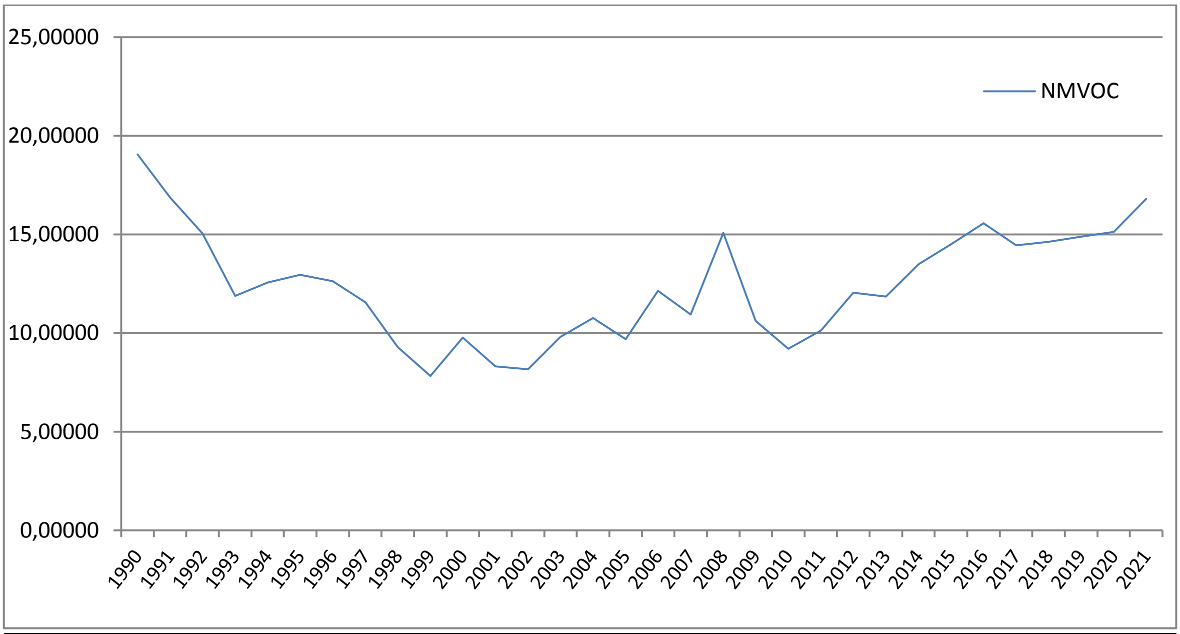


Figure 4.25.3. Emission trends (kt) for NFR 2.D.3.g Chemical products

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 7.18% of the total national emissions of NMVOC in 2021.

Recalculations and improvement:
- SNAP 060303 (polyurethane foam processing) the activity data for period 2002-2008 was extrapolated;
- SNAP 060301 (polyester processing) is the new SNAP;
- SNAP060301 (polyester processing) the activity data for period 2007-2009 was extrapolated;
- recalculation the NMVOC emissions for entire period 1990-2020.

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 emissions were estimated, based on 2019 EMEP/EEA Guidebook, chapter NFR 2.D.3.h Printing, Table 3-1.

The activity data for the 2005, 2006 and 2007 years, represent the total ink consumption for printing activities. For 2008-2021 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 1990-2004 there is no information.

Table 4.26.1. Activity data trends (kt Ink used) for NFR 2.D.3.h Printing

Year	kt solvents	kt Ink used
2005		0.0810
2006		0.4930
2007		0.5010
2008	2.4570	
2009	2.4092	
2010	3.0327	
2011	3.2410	
2012	3.3160	
2013	3.3773	
2014	3.2453	
2015	3.8248	
2016	3.3136	
2017	3.7530	
2018	3.4598	
2019	3.8463	
2020	3.4036	
2021	3.8155	

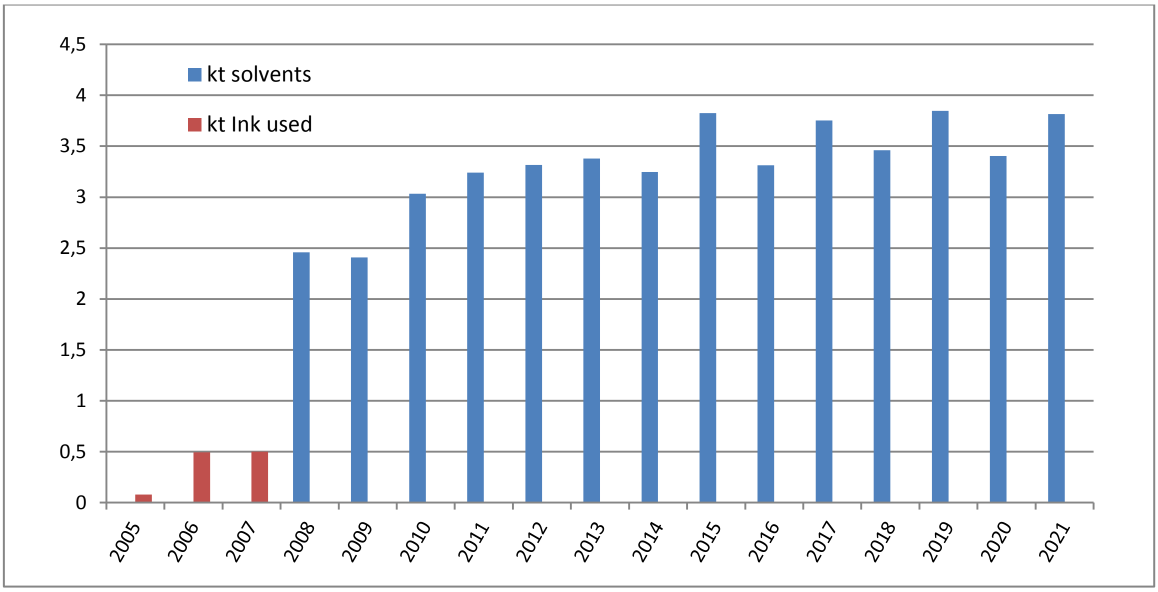


Figure 4.26.1. Activity data trends (kt Ink used and kt solvents) for NFR 2.D.3.h Printing

The emission trends are shown below in the following table and figure.

Table 4.26.2. Emission trends (kt) for NFR 2.D.3.h Printing

Year/Pollutant	NMVOC
2005	0.04057
2006	0.24673
2007	0.25050
2008	1.31641
2009	0.98909
2010	1.15090
2011	1.23200
2012	0.66891
2013	0.57201
2014	0.68466
2015	0.65510
2016	0.53404
2017	0.66677
2018	0.64328
2019	0.49345
2020	0.56423
2021	0.60662

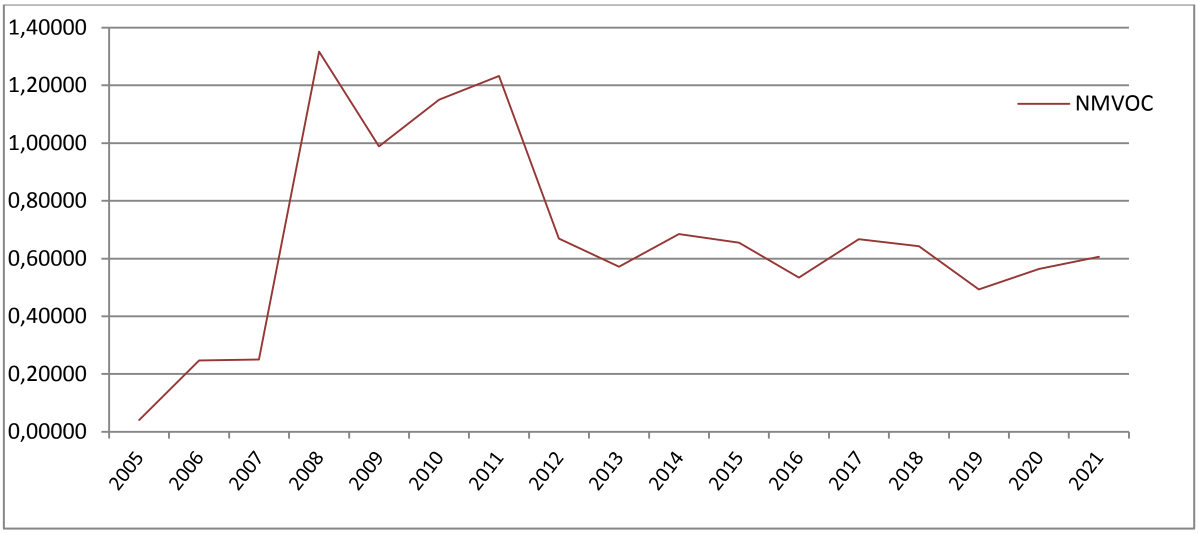


Figure 4.26.2. Emission trends (kt) for NFR 2.D.3.h Printing

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:
-updated activity data and recalculation NMVOC emissions for the years 2018 and 2020

4.27 NFR 2.D.3.i Other solvent use

The following "Other solvent use" are included:

- SNAP 060404 Fat, edible and non-edible oil extraction;
- SNAP 060405 Application of glues and adhesives;
- SNAP 060406 Preservation of wood;
- SNAP 060407 Underseal treatment and conservation of vehicles

For SNAP 060407 the activity data used are the total population provided by N.I.S. in the Statistical Yearbook; for the calculation of the NMVOC emissions was used the weighted average emission factor of IIASA (2019 EMEP/EEA Guidebook, Table 3-10).

For the SNAP 060404, SNAP 060405, SNAP 060406 on the 2008-2020 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 the SNAP 060404 on the 1990-2007 time period the activity data represent the total products of edible oils provided by N.I.S. in the Statistical Yearbook; for the calculation of the NMVOC emissions was used EF determinated

Table 4.27.1 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)	1754.967	1205.477	1391.051	1126.566	949.6676	1161.141
NMVOC emissions (t	905.5572	831.664	1043.6236	958.335	861.7274	1072.361
solvent/product	0.005739948	0.004500614	0.004632459	0.004702238	0.004460102	0.005569318

EF determined = ∑ solvent/product for 2008-2013 time period / 6
EF determined = 4.934113349 kg NMVOC/t product

The methodology for estimating emissions of SNAP 060404 (fat, edible and non-edible oil extraction) for 1990-2007 time period and SNAP 060407 (preservation of wood) for entire period 1990-2021 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 4.27.2. 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		23192274
1991	236		22810035
1992	216		22778533
1993	213		22748027
1994	194		22712394
1995	224		22656145
1996	236		22581862
1997	246		22526093
1998	173.322		22488595
1999	244.6		22455485
2000	253.349		22430457
2001	295.959		21833483
2002	228.382		21627509
2003	243.496		21521142
2004	258.083		21382354
2005	264.312		21257016
2006	337.596		21130503
2007	219.92		20635460
2008		2274.516	20440290
2009		1798.628	20294683
2010		2091.401	20199059
2011		1722.807	20095996
2012		1594.7401	20020074
2013		1764.441	19947311
2014		1704.116	19870647

Year/Pollutant	Kt products	kt solvents	Population [caput]
2015		1761.27	19760585
2016		1291.95	19643949
2017		1535.157	19533481
2018		1168.814	19414458
2019		1823.13403	19328838
2020		1159.27755	19201662
2021		1211.0216	19038098

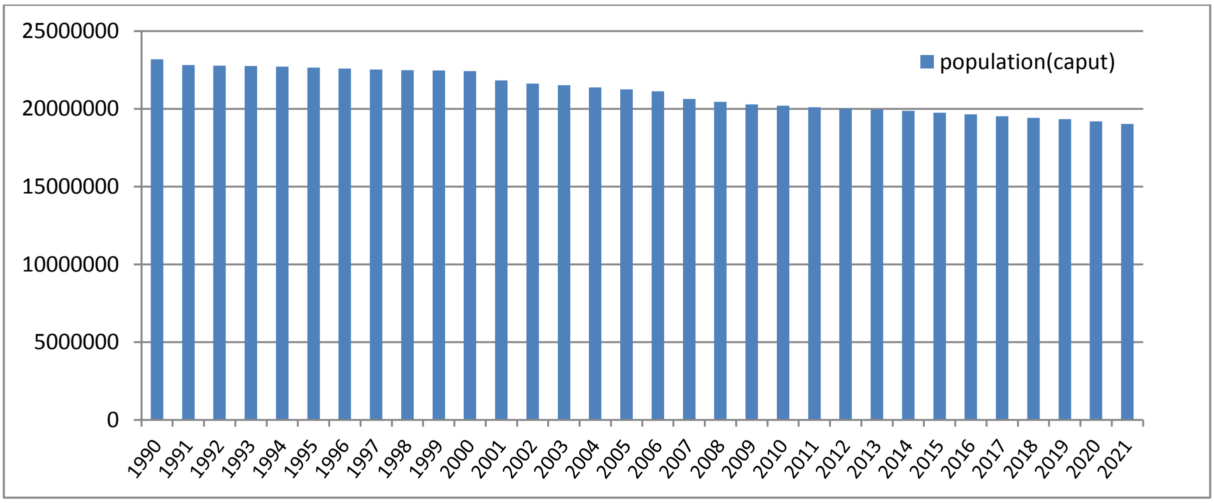


Figure 4.27.2. Activity data trends (total population) for NFR 2.D.3.i. Other solvent use

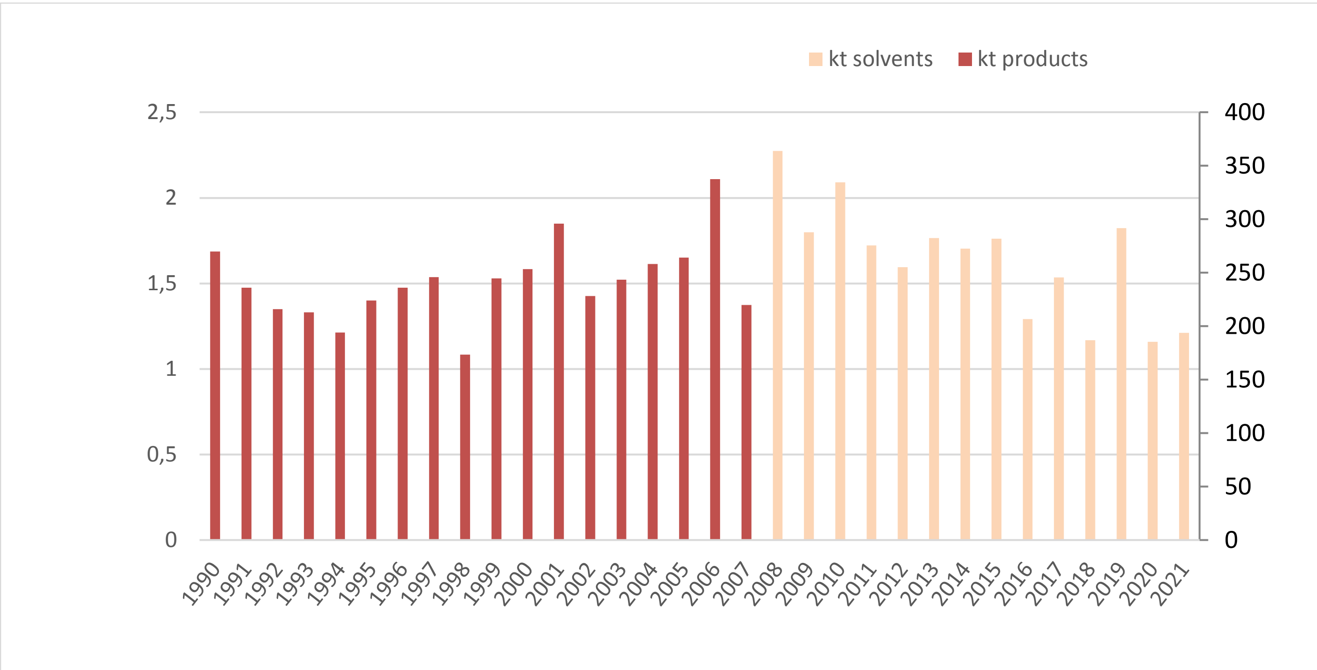


Figure 4.27.3. Activity data trends (kt solvents and kt products) for NFR 2.D.3.i. Other solvent use

Table 4.27.3. Emission trends (kt) for NFR 2.D.3.i Other solvent use

Year/Pollutant	NMVOC
1990	5.970665404
1991	5.72645775
1992	5.621475083
1993	5.600571543
1994	5.49969679
1995	5.63647039
1996	5.68082315
1997	5.719010484
1998	5.352909394
1999	5.697981125
2000	5.736144083
2001	5.826991853
2002	5.452364475
2003	5.505665264
2004	5.549881575
2005	5.555548567
2006	5.89183753
2007	5.212202208
2008	5.2562062
2009	5.0570955
2010	5.2883162
2011	5.1635782
2012	5.2390991
2013	5.3705482
2014	5.1750394
2015	5.172699
2016	4.6525258
2017	4.8670172
2018	4.5096236
2019	5.1741901
2020	4.55691895
2021	4.584092

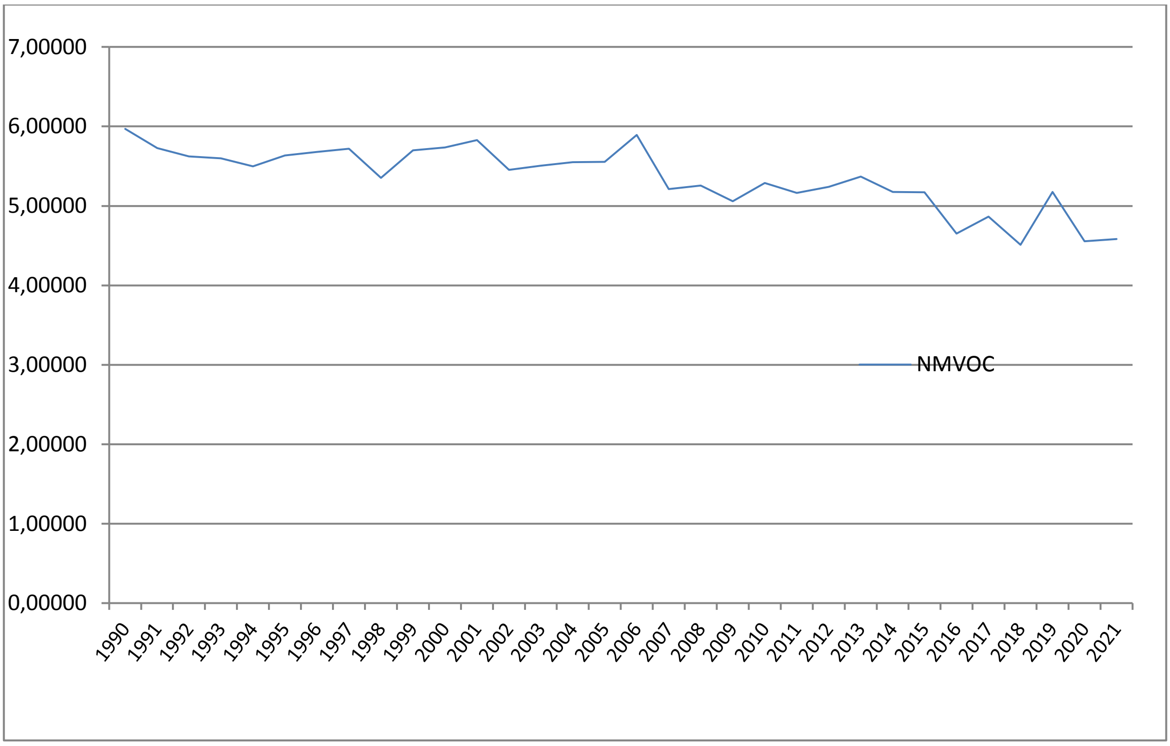


Figure 4.27.3. Emission trends (kt) for NFR 2.D.3.i Other solvent use

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 1.96% of total national NMVOC emissions for the year 2021.

Recalculations and improvement:

- For the SNAP 060407 (preservation of wood) activity data was update by EUROSTAT (total population for 1991-2001 and 2013, 2014, 2018, 2020)

- Correction of activity data (total solvents) for 2019 and 2020

- New calculation algorithm for time serie 1990-2007 for SNAP 060404 (activity data represented total edible oils by N.I.S.)

- 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 2008-2021 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

Year	Tobacco (t)	Fireworks (t)
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

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
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	0.505	0.799	0.843	0.852	1.541
2019	0.477	0.730	0.804	0.819	1.337
2020	0.458	0.619	0.690	0.705	1.119
2021	0.477	0.727	0.780	0.791	1.374

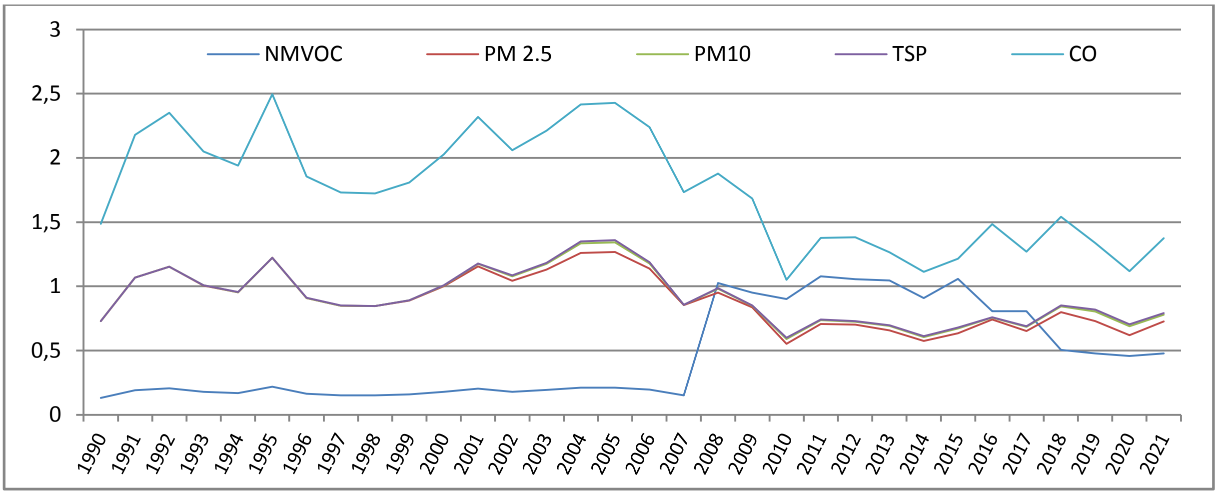


Figure 4.28.1. Emission Trends for NFR 2.G Other product use (kt)

The emissions of all pollutants vary for the time series together with the variation activity data; the NMVOC trend does not follow the curves of the other emissions due to the sum of the measured emissions for the new category "Use of shoes".

Recalculation: The activity data for SNAP 060603 - Use of shoes, was recalculated for the period 2008-2020, as a result of the reviewing the solvent consumption.

As a result of the review of solvent consumption, the activity data for SNAP 060603 - Use of shoes, the NMVOC emissions for this category has been recalculated for the period 2008-2020.

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

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- new category estimation;
- Meat, poultry and cans – new category estimation.

This was a key source category for emissions of NMVOC in 2021, sharing 3.5% from the total national emissions of this pollutant.

The NMVOC emissions from food and beverages manufacturing are taken into account for this subcategory.

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 060605 – Bread and 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
1990	10.009
1991	7.920
1992	7.145
1993	6.016
1994	7.063
1995	8.076
1996	9.614
1997	8.015
1998	8.332
1999	7.385
2000	9.361
2001	10.118
2002	10.496
2003	11.274
2004	10.938
2005	10.426
2006	11.413
2007	9.765
2008	10.419
2009	9.640
2010	8.247
2011	9.413
2012	9.942
2013	10.296
2014	10.363
2015	11.413
2016	10.685
2017	10.799
2018	7.578
2019	8.681
2020	7.301
2021	8.202

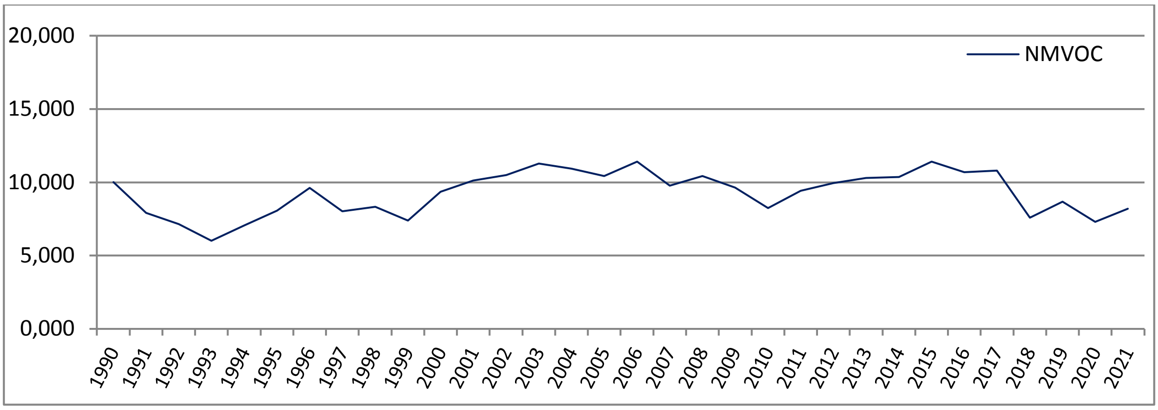


Figure 4.30.1. Emission trends (kt) for NFR 2.H.2 Food and beverages industry

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 entire time series was recalculated and improved with the estimations for two new subcategories: SNAP 040605 - cakes, biscuits and breakfast cereals, and SNAP 040627 – total meat, including meat subsequently canned, and calibration with GHG's values, as mention above.

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

Year/Activity data	1000 m^3 product
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
2014	5909.00
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2018	5143.00
2019	5144.21
2020	5452.99
2021	5373.32

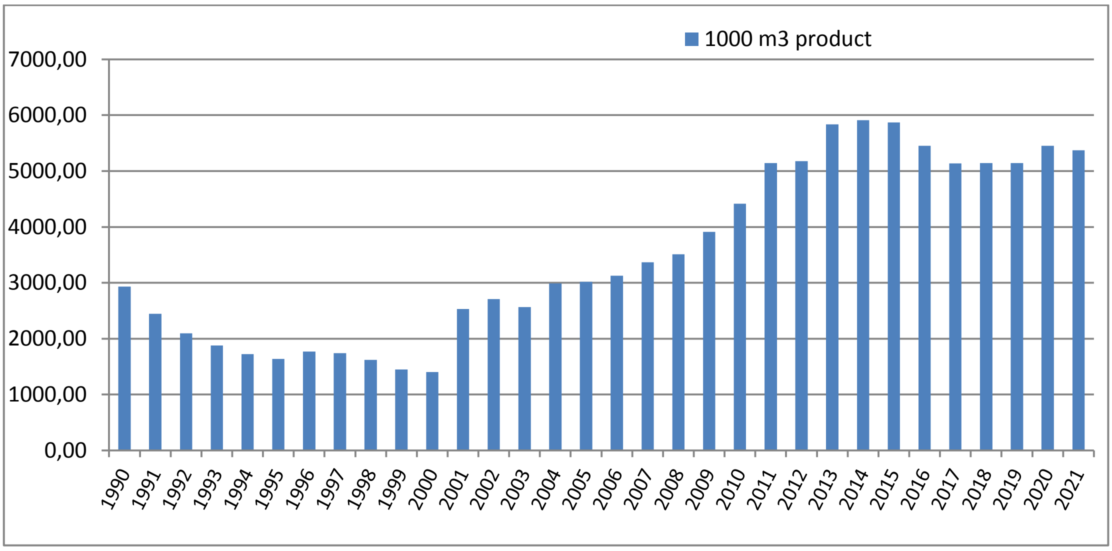

Figure 4.31.1. Activity data trend for NFR 2.I Wood Processing

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

Year/Pollutant	TSP (kt)
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

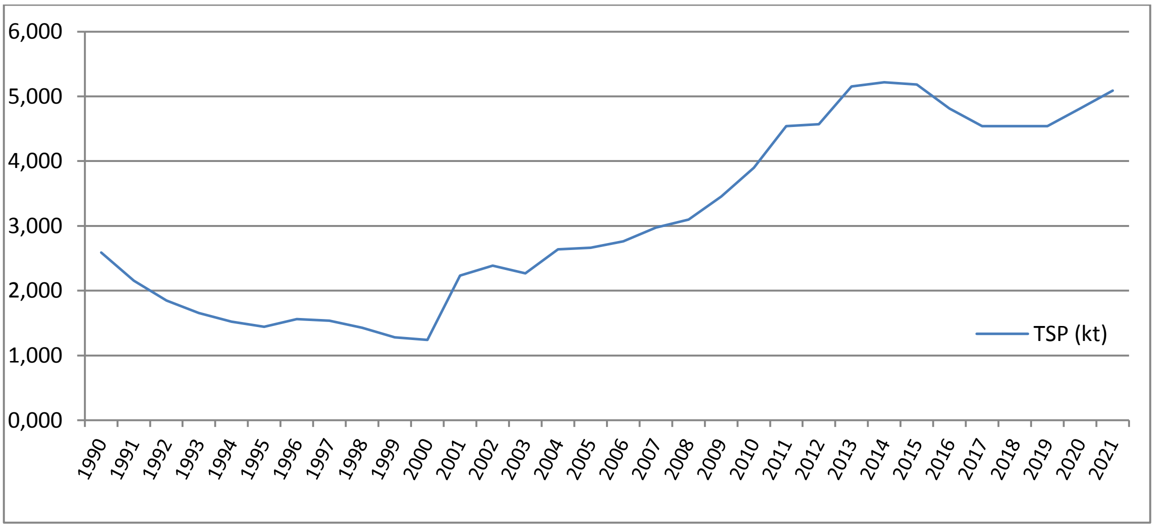

Figure 4.31.2. Emission trends (kt) for NFR 2.I Wood Processing

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 An 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 2021

	NH_3	NOx	SOx	NMVOC	$PM_{2.5}$	PM_{10}	TSP
National total (kt)	158.60	214.16	66.28	234.22	116.14	157.23	232.44
Agriculture total (kt)	141.44	32.41	0.00160	58.06	1.41	24.24	35.11
Weight percentage (%)	89.18%	15.13%	0.0024%	24.79%	1.21%	15.42%	15.10%

For the year 2021, the main part of the NH_3 emission (89.18%) from the national total is related to the agricultural sector, while the contribution of NMVOC share from agriculture accounts for 24.79% of the national total. The TSP, PM_{10} and $PM_{2.5}$ emissions from manure management are 15.10%, 15.42% and 1.21%, respectively, of the national total. The inventory also includes the NOx emissions from application of inorganic fertilisers and animal manure, which results in 15.13% of the national total. The total SOx emissions from agriculture is lower, 0.0024% 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*
	3B4gii	*Manure management - Broilers*
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*
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 5.3. 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

NFR	Pollutants Reported	Emission Factor tier and source
3Da2a Animal manure applied to soils	NOx, NMVOC, NH3	T1 – NOx, EMEP EEA guidebook (2019) factors 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 - 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.

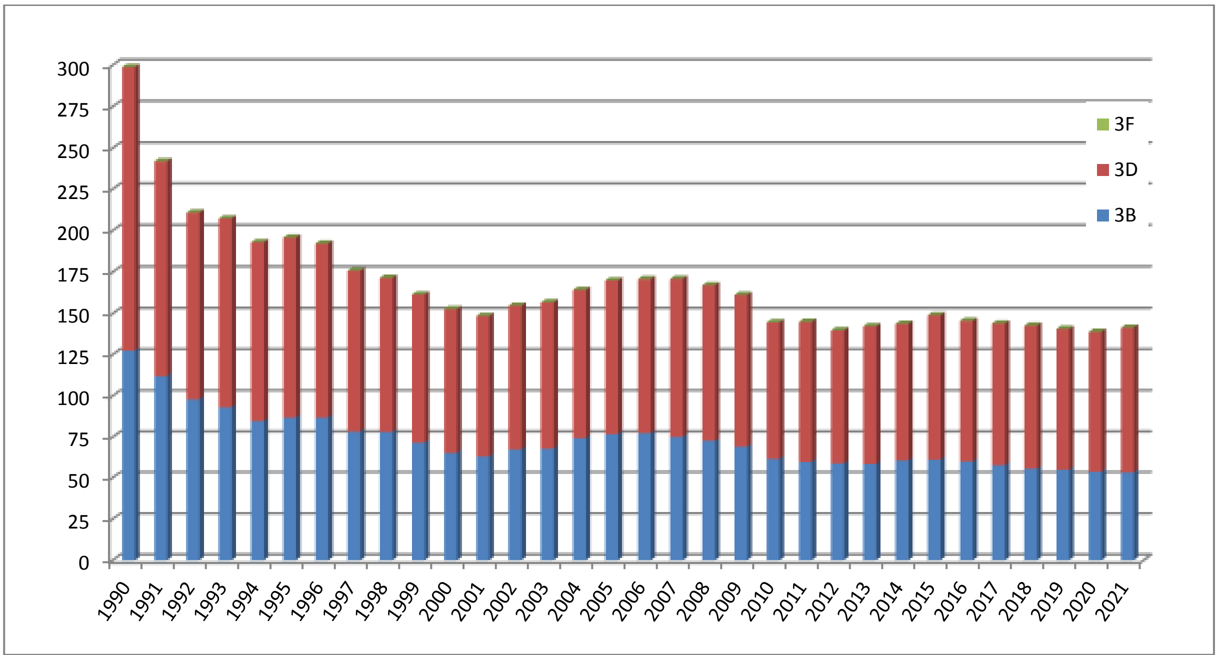

Figure 5.1 Distribution of the NH_3 emission by the agricultural sources for the 1990-2021 period

For the year 2021, the distribution of ammonia (NH_3) emissions by agriculture sources was as follows: 37.69% from manure management, 62.3% from manure applied to soils and only 0.0099% from burning fields.

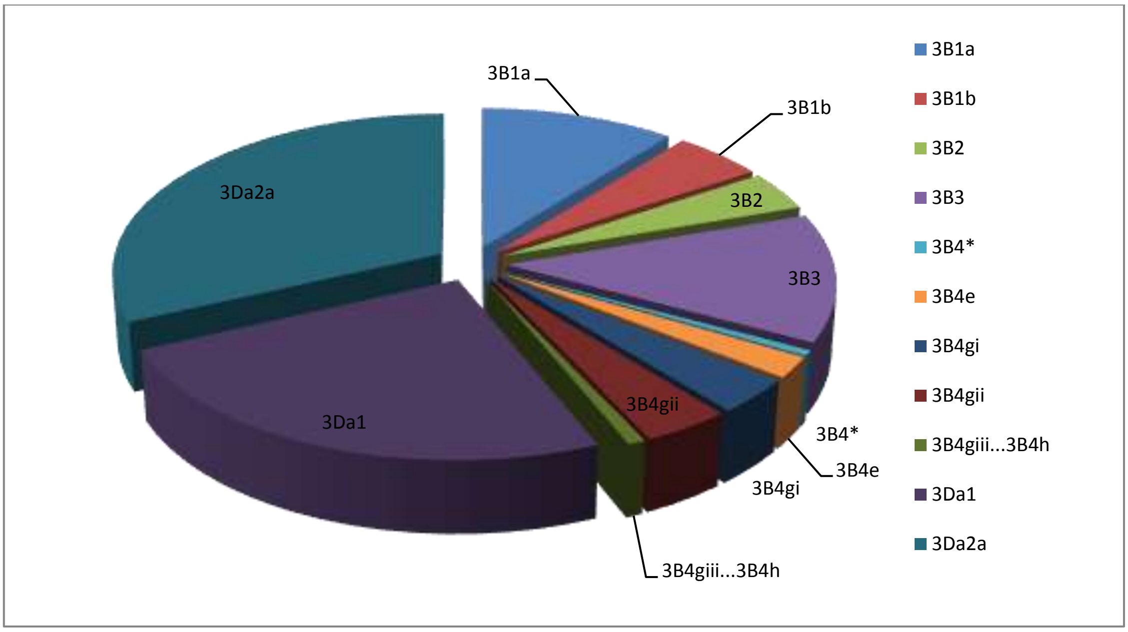

Figure 5.2 - Share of NH_3 emissions by the agriculture sector for 2021

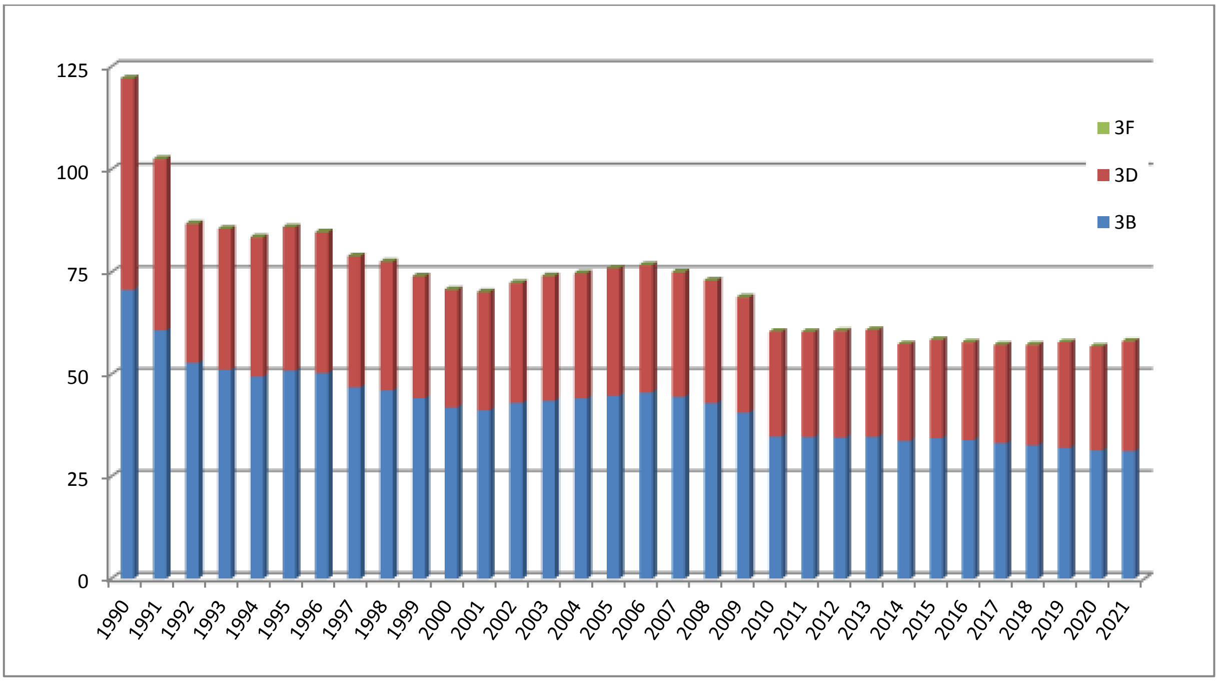

Figure 5.3 Distribution of the NMVOC emissions by the agricultural sources for 1990-2021 period

For the year 2021, the distribution of NMVOC emissions by agricultural sources was as follows: 53.63% from manure management, 46.33% from manure applied to soils and only 0.0381% from burning fields.

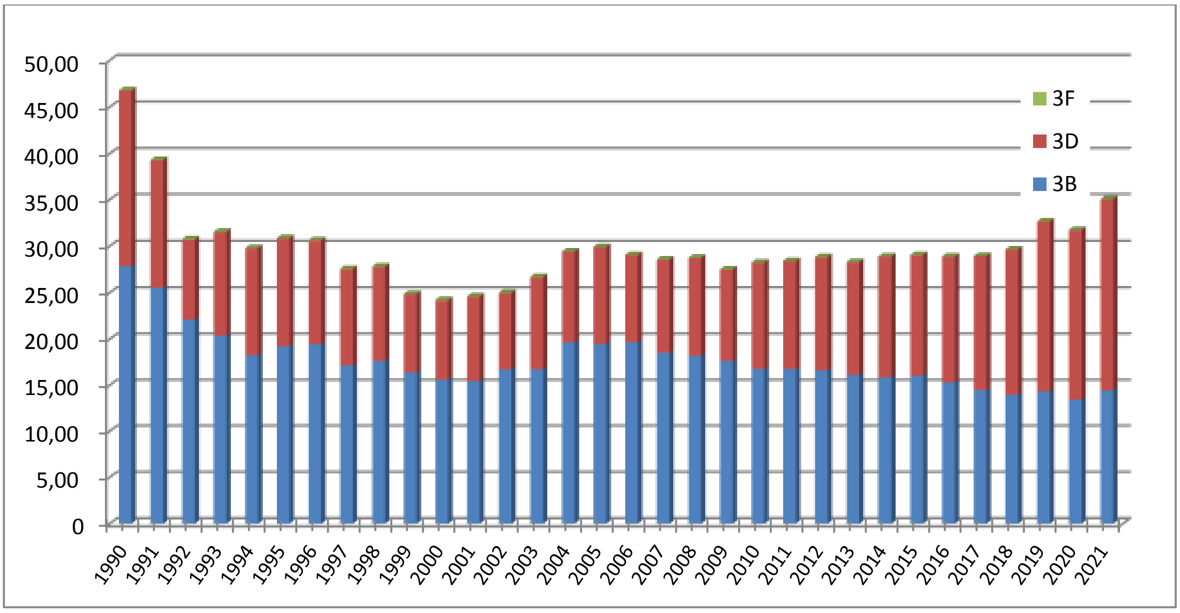

Figure 5.4 Distribution of TSP emissions by the agricultural sources for the 1990-2021 period

For the year 2021, the distribution of TSP emissions by the agricultural sources was as follows: 41.2% from manure management, 58.7% from manure applied to soils and only 0.104% 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 2021. 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.

Following the response to the questionnaires at the local level, new activity data were added to this year's inventory, for NFR 3B4giii, 3B4giv, for the years 1990-2018, and for the years 2019 and 2020 the number of heads was recalculated.

In 2021, 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 2021, the key categories were represented as percentage from total national emissions, as follow:
- NMVOC: dairy cattle (5.78%), non-dairy cattle (2.29%), broilers (1.48%);
- NH_3: swine (10.07%), dairy cattle (8.33%);
- TSP: laying hens (3.44%).

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. So, 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 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 1, 2). 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 *"Romanian Projections for Pollutants Emissions to 2030"* for certain livestock categories, as follow: dairy cattle, non-dairy cattle – 3% until 2013, 30% since 2014; finishing pigs – 40% until 2013, 60% since 2014; sows – 30% until 2013, 60% since 2014.

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 2014-2021), finishing pigs (for period 2016-2021) and laying hens (for period 2013-2021) (Annex A, Table 3).

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 4 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 entire time series.

The **NOx emissions** is based on the Tier 1 methodology (Table 3.3 – stored manure NO) of the EMEP/EEA Guide 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 by the trend of the activity data and the main pollutants over the period 1990-2021.

Table 5.4 - Activity data trends (*Population Size (1000 head)*) for the livestock categories in Romania

Year/Pollutant	Dairy cattle	Non-dairy cattle	Sheep	Fattin g pigs	Sows	Buffal os	Goats	Horse s	Layin g hens	Broile rs	Turke ys	Other poultr y	Rabbi ts
1990	3002	2314	14062	11052	951	65	1005	670	51475	69879	5.5	19.8	1330
1991	2430	1873	13879	10183	771	52	954	749	50213	55797	4.8	17.4	1000
1992	2055	1584	12079	9060	792	44	805	721	42406	45301	4.0	14.5	640
1993	2007	1547	11499	8584	678	43	776	751	37981	38532	4.1	14.9	771
1994	1942	1497	10897	7182	576	42	745	784	36233	33905	3.9	14.2	800
1995	1950	1504	10381	7370	590	42	705	806	38574	41931	4.1	14.9	1000
1996	1916	1477	9663	7651	584	41	654	816	38883	39579	3.6	13.2	1000
1997	1805	1391	8938	6591	506	39	610	822	35089	31516	3.4	12.4	1000

Year/Pollutant	Dairy cattle	Non-dairy cattle	Sheep	Fatting pigs	Sows	Buffalos	Goats	Horses	Laying hens	Broilers	Turkeys	Other poultry	Rabbits
1998	1753	1352	8409	6679	515	38	585	839	37272	32190	3.7	13.3	1200
1999	1702	1312	8121	5443	405	37	558	858	38497	30632	3.0	10.7	1300
2000	1601	1234	7657	4474	323	34	538	864	40760	29302	3.0	10.8	1300
2001	1562	1204	7251	4113	334	34	525	860	42156	29245	2.8	10.0	540
2002	1606	1238	7312	4696	362	35	633	879	44667	32698	3.2	11.4	552
2003	1616	1246	7447	4810	335	35	678	897	44122	32481	2.9	10.6	564
2004	1566	1208	7425	6069	426	34	661	840	51889	35105	4.9	15.7	576
2005	1626	1191	7611	6128	494	45	687	834	49725	36807	4.6	15.6	570
2006	1639	1254	7678	6295	520	41	727	805	50278	34691	4.8	16.4	479
2007	1573	1214	8469	6122	442	32	865	862	45208	36811	4.0	12.9	495
2008	1483	1170	8882	5797	376	30	898	820	45529	38828	3.3	12.5	458
2009	1419	1063	9141	5434	359	30	917	764	45046	38776	2.9	18.3	456
2010	1179	797	8417	5073	356	25	1241	611	44504	36318	3.5	19.5	268
2011	1154	814	8533	4983	381	21	1236	596	45464	34340	18.5	19.0	276
2012	1147	842	8834	4836	399	20	1266	575	45402	34697	16.8	20.5	297
2013	1155	849	9136	4797	384	18	1313	548	42541	36776	85.0	37.7	290
2014	1173	825	9518	4663	378	20	1417	525	42739	32604	66.6	37.5	288
2015	1176	898	9810	4552	375	18	1440	503	43663	34580	368.3	37.5	292
2016	1177	853	9875	4347	361	20	1483	520	40833	34015	784.4	57.1	297
2017	1160	832	9982	4056	350	19	1503	481	38312	34130	783.4	63.2	278
2018	1143	815	10176	3616	309	19	1539	448	38134	34917	887.6	54.6	259
2019	1124	779	10358	3525	308	19	1594	406	40728	33531	992.8	112.2	275
2020	1107	749	10281	3469	316	20	1612	408	36525	33492	949.0	94.2	254
2021	1068	741	10087	3321	299	18	1493	374	39352	36820	931	45.9	237

5.1 NFR 3.B.1.a Manure management - Dairy cattle

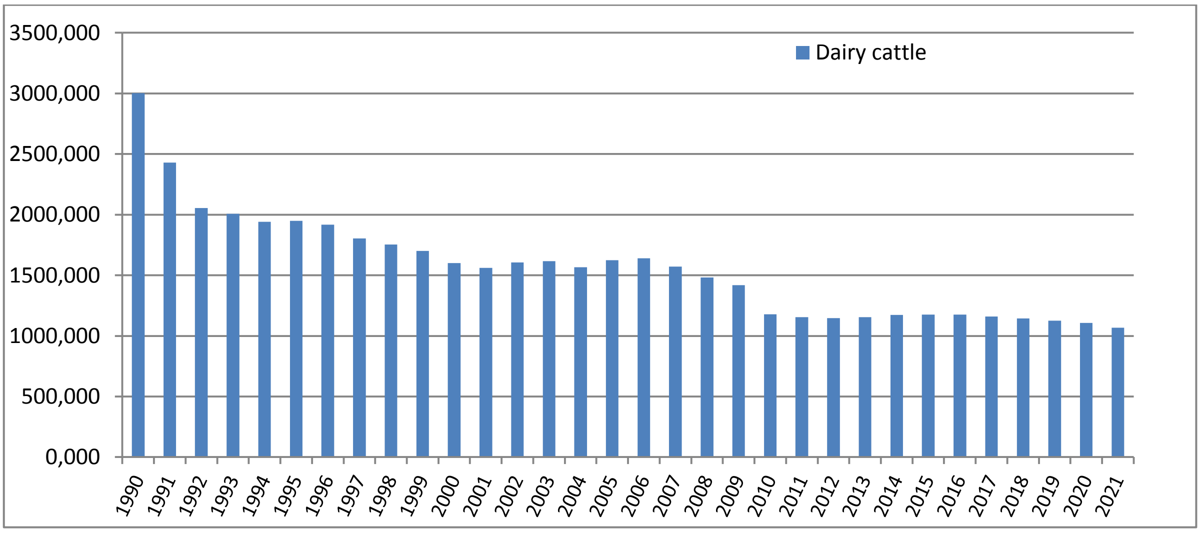

Figure 5.1.1. Activity data trends (*Population Size (1000 head)*) for NFR 3.B.1.a Manure management - Dairy cattle

Activity data for dairy cattle with which the graph was obtained are presented in table 5.4 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

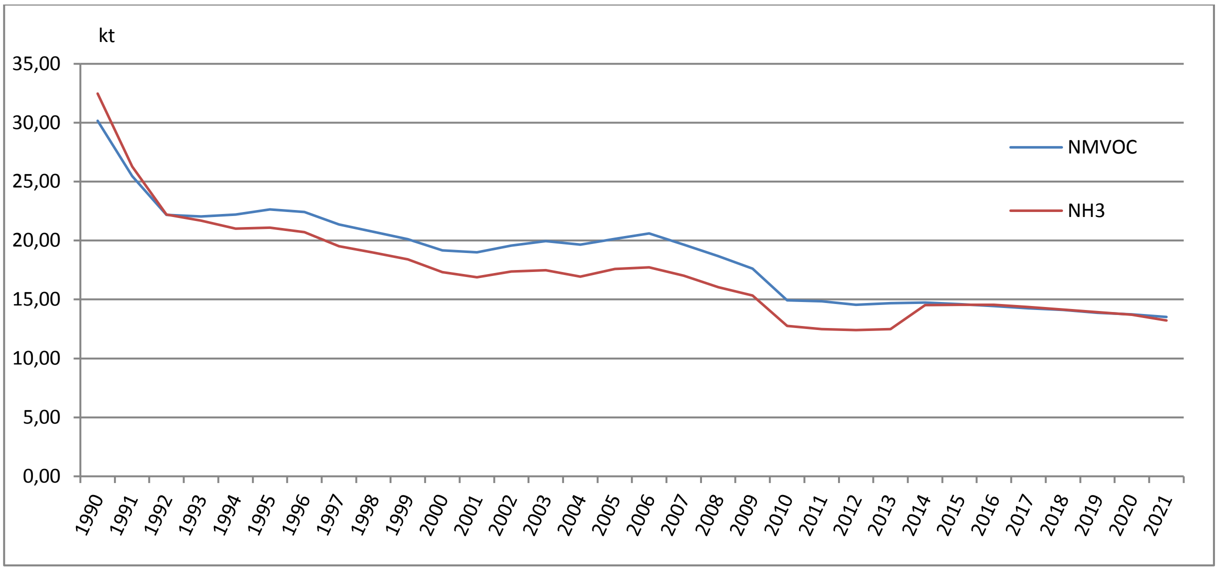

Figure 5.1.2. Emission trends (kt) for NFR 3.B.1.a Manure management - Dairy cattle

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 category.

5.2 NFR 3.B.1.b Manure management - Non-dairy cattle

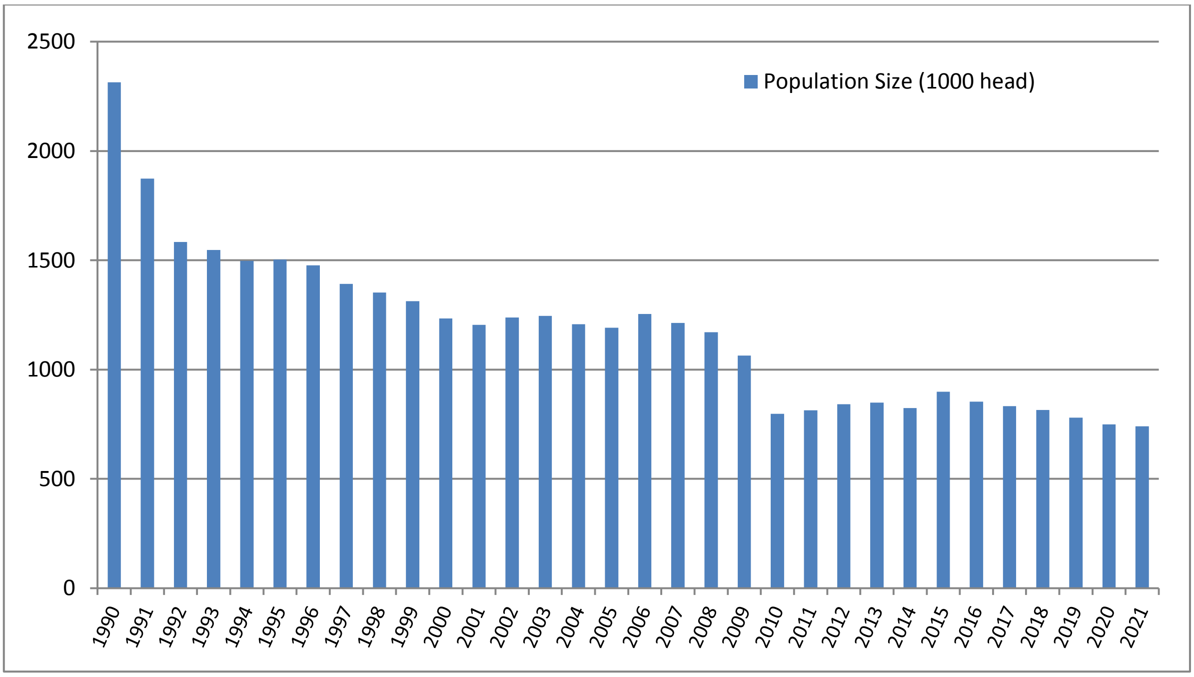

Figure 5.2.1 Activity data trends (*Population Size (1000 head)*)
for NFR 3.B.1.b Manure management - Non-dairy cattle

Activity data for non-dairy cattle with which the graph was obtained are presented in table 5.4 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	9.699	8.760
2007	9.392	8.482
2008	9.054	8.177
2009	8.227	7.430
2010	6.167	5.570
2011	6.295	5.686
2012	6.514	5.883
2013	6.571	5.935
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

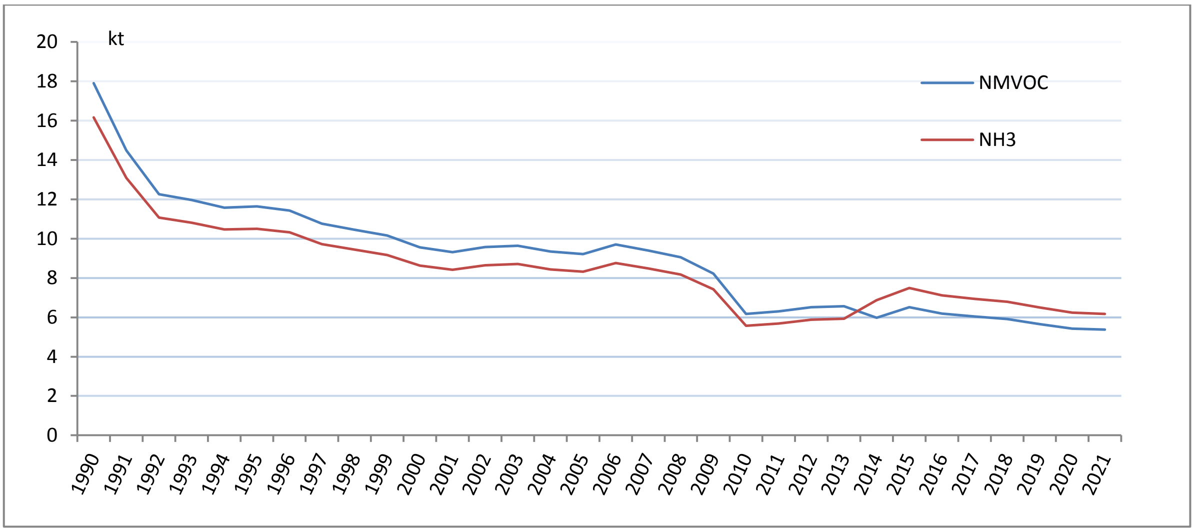

Figure 5.2.2 Emission trends (kt) for NFR 3.B.1.b Manure management - Non-dairy cattle for NMVOC and NH_3

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

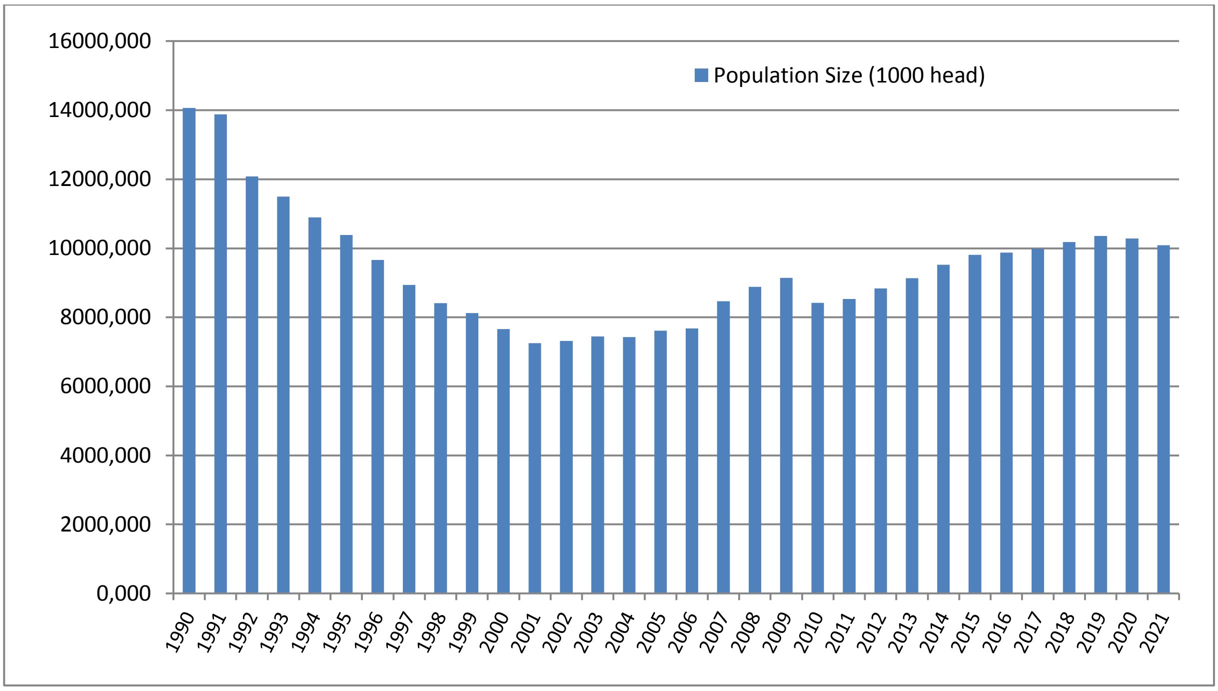

Figure 5.3.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.2 Manure management – Sheep

Activity data for sheep with which the graph was obtained are presented in table 5.4 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

Year/Pollutant	NMVOC	NH_3
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
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

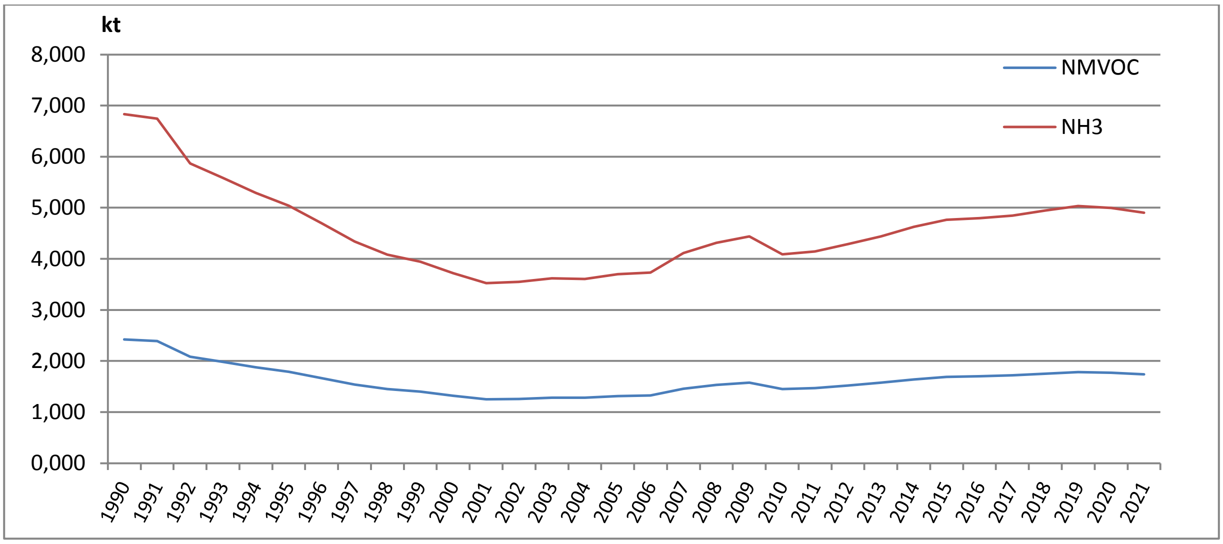

Figure 5.3.2 Emission trends (kt) for NMVOC, NH_3 for 3.B.2 Manure management – Sheep

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.

5.4 NFR 3.B.3 Manure management – Swine

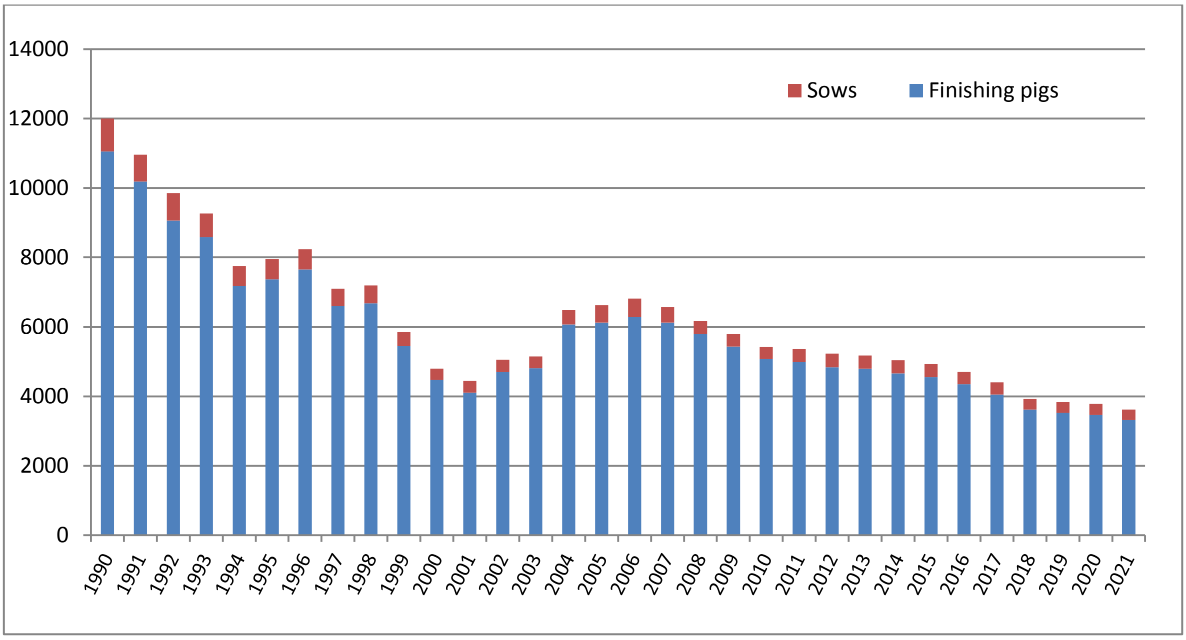

Figure 5.4.1 Activity data trends (Population Size (1000 head))
for NFR 3.B.3 Manure management – Swine

Activity data for swine (finishing pigs and sows) with which the graph was obtained are presented in table 5.4 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	6.090	45.981	1.621	5.857
1991	5.611	42.366	1.314	4.748
1992	4.992	37.694	1.350	4.878
1993	4.730	35.713	1.155	4.176
1994	3.957	29.880	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	3.680	27.788	0.878	3.172
1999	2.999	22.645	0.690	2.494
2000	2.465	18.614	0.550	1.989
2001	2.266	17.112	0.569	2.057
2002	2.588	19.537	0.617	2.229
2003	2.650	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	3.468	27.694	0.886	3.205

Year/Pollutant	NMVOC finishing	NH3 finishing	NMVOC sows	NH3 sows
2007	3.373	26.430	0.754	2.725
2008	3.194	25.301	0.641	2.318
2009	2.994	23.588	0.612	2.213
2010	2.795	22.259	0.606	2.190
2011	2.746	20.716	0.649	2.344
2012	2.664	19.443	0.679	2.456
2013	2.643	19.088	0.654	2.363
2014	2.570	18.565	0.645	2.564
2015	2.508	17.932	0.638	2.539
2016	2.395	17.199	0.615	2.448
2017	2.235	15.978	0.596	2.371
2018	1.993	14.440	0.526	2.093
2019	1.943	14.329	0.526	2.092
2020	1.911	14.078	0.538	2.140
2021	1.830	13.954	0.509	2.023

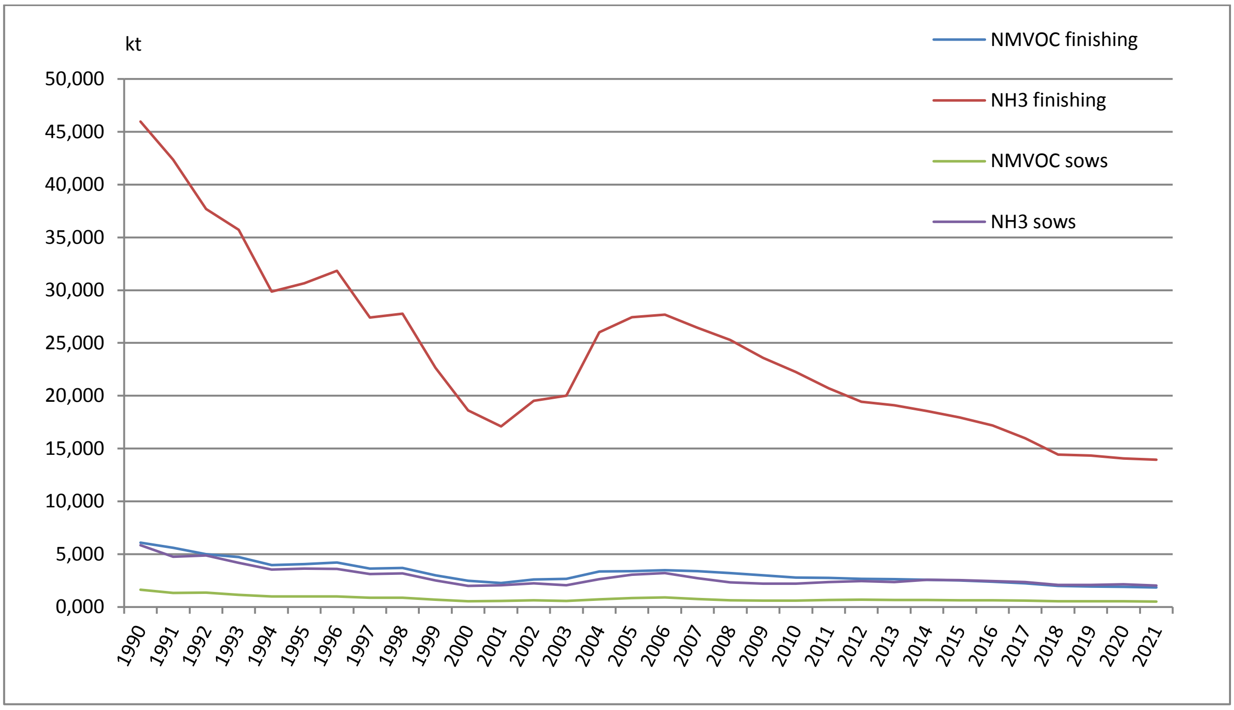

Figure 5.4.2 Emission trends (kt) for 3.B.3 Manure management – Swine

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.

5.5 NFR 3.B.4.a Manure management - Buffalo

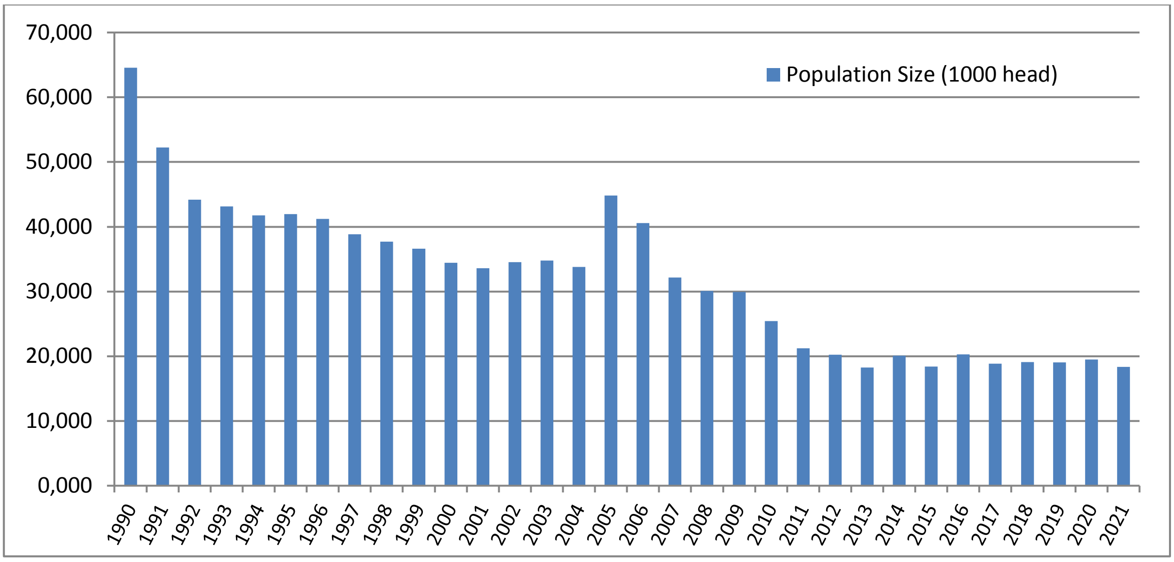

Figure 5.5.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.a Manure management – Buffalo

Activity data for buffalos with which the graph was obtained are presented in table 5.4 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
2014	0.088	0.086
2015	0.081	0.079

Year/Pollutant	NMVOC	NH_3
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

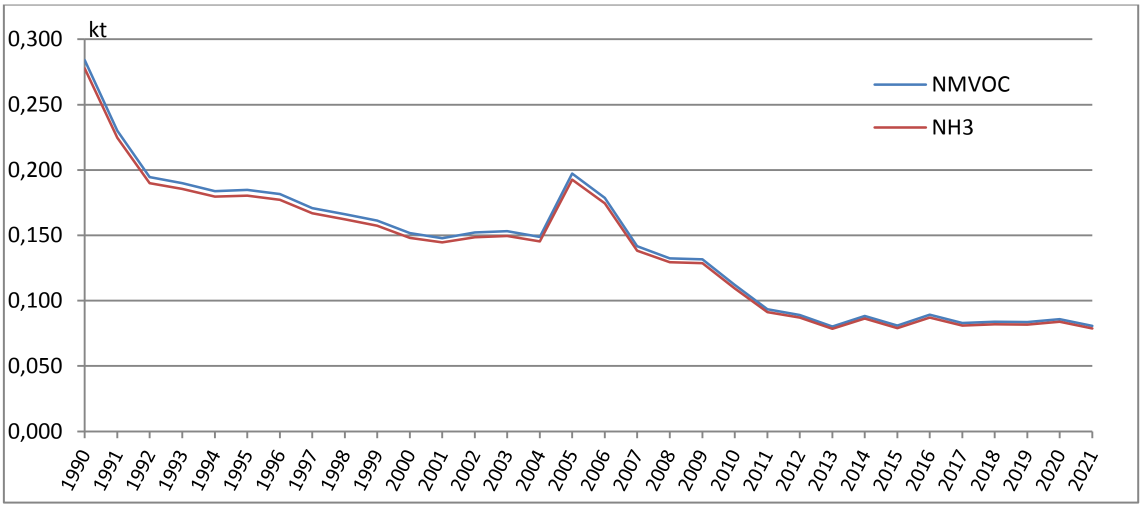

Figure 5.5.2 Emission trends (kt) for NFR 3.B.4.a Manure management - Buffalo

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.

5.6 NFR 3.B.4.d Manure management - Goats

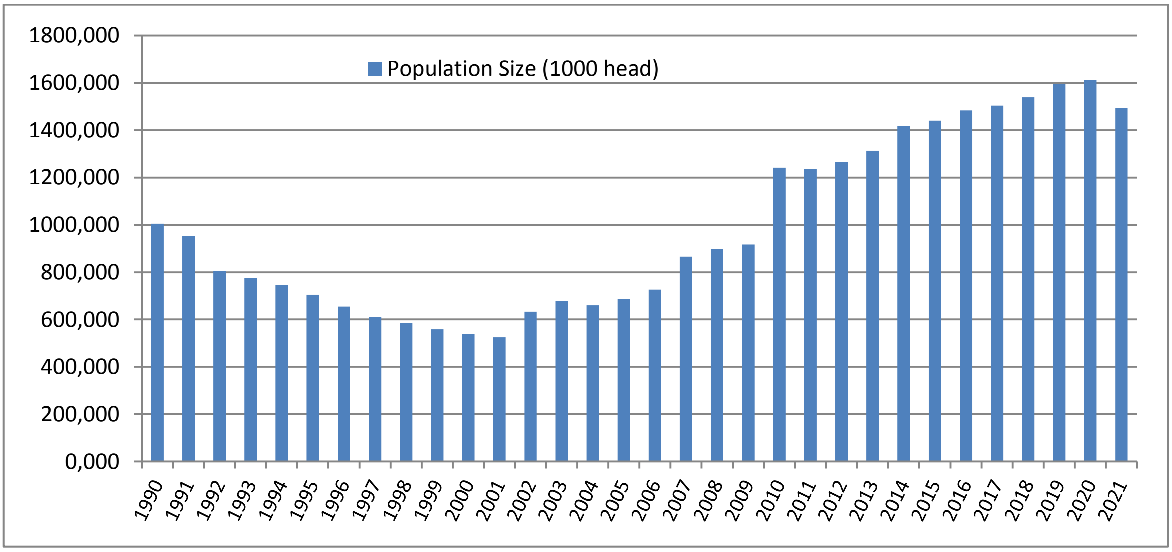

Figure 5.6.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.d Manure management – Goats

Activity data for goats with which the graph was obtained are presented in table 5.4 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

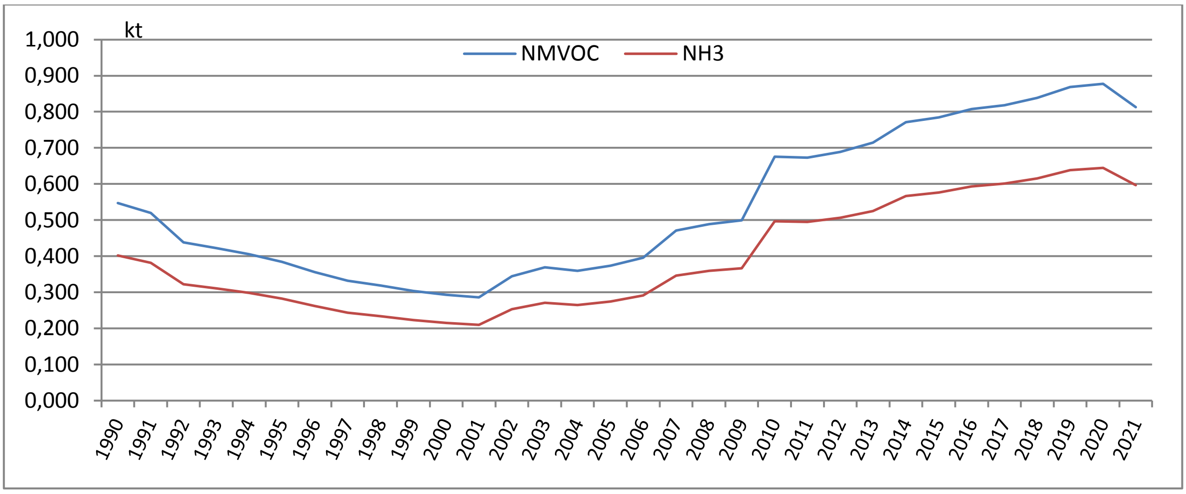

Figure 5.6.2 Emission trends (kt) for NFR 3.B.4.d Manure management – Goats

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.

5.7 NFR 3.B.4.e Manure management – Horses

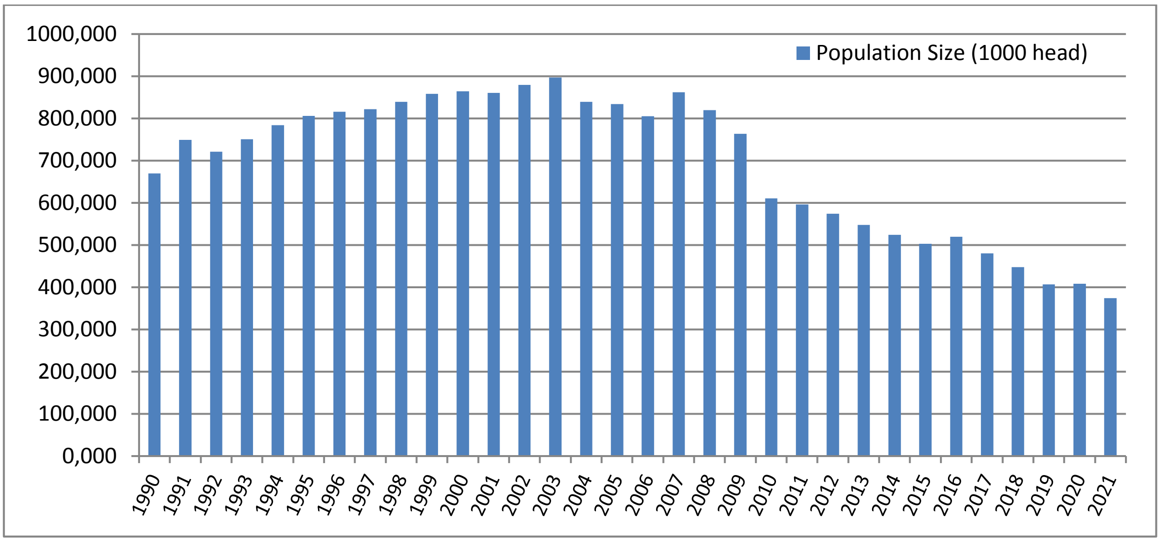

Figure 5.7.1 Activity data trends (*Population Size (1000 head)*)
for NFR 3.B.4.e Manure management – Horses

Activity data for horses with which the graph was obtained are presented in table 5.4 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
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

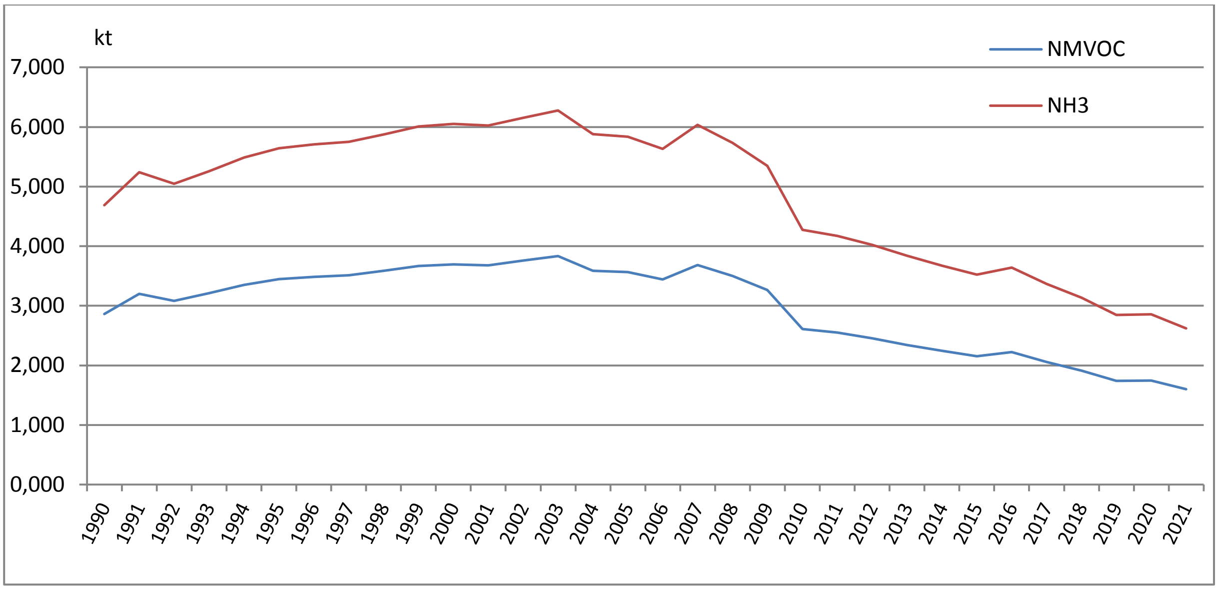

Figure 5.7.2 Emission trends (kt) for NFR 3.B.4.e Manure management - Horses

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.

5.8 NFR 3.B.4.g.i Manure management - Laying hens

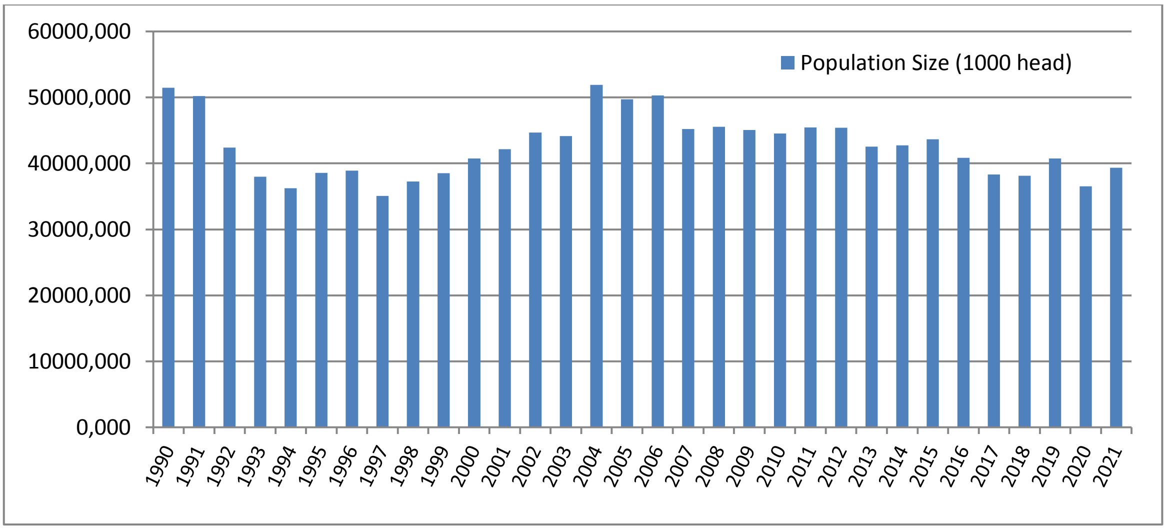

Figure 5.8.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.g.i Manure management - Laying hens

Activity data for laying hens with which the graph was obtained are presented in table 5.4 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	1.705	4.413	7.987

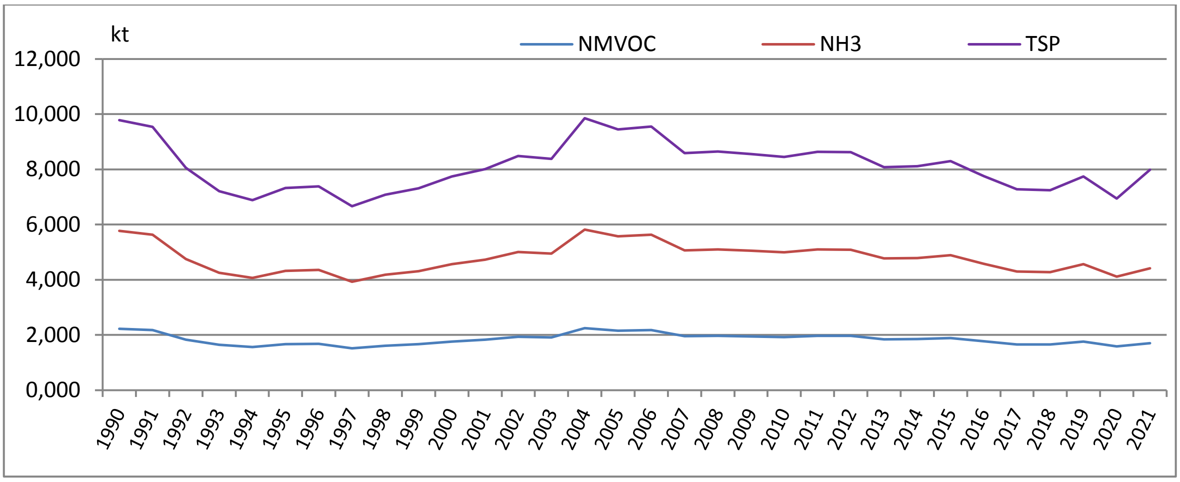

Figure 5.8.2 Emission trends (kt) for NFR 3.B.4.g.i Manure management - Laying hens

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.

5.9 NFR 3.B.4.g.ii Manure management – Broilers

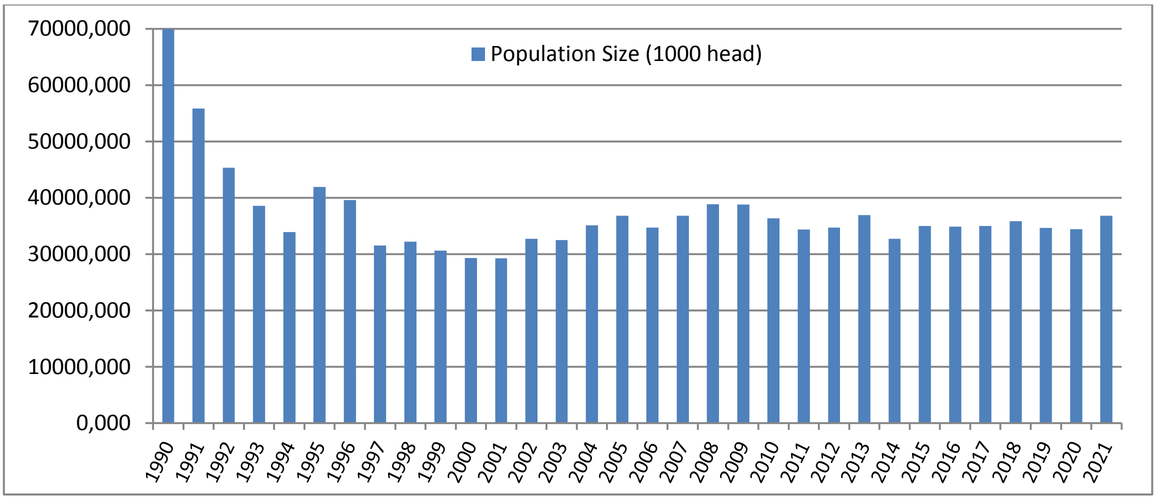

Figure 5.9.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.g.ii Manure management – Broilers

Activity data for broilers with which the graph was obtained are presented in table 5.4 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	6.571	9.088
1991	5.247	7.256
1992	4.260	5.891
1993	3.624	5.012

1994	3.189	4.410
1995	3.944	5.453
1996	3.722	5.147
1997	2.964	4.099
1998	3.028	4.187
1999	2.881	3.984
2000	2.756	3.811
2001	2.750	3.804
2002	3.075	4.253
2003	3.055	4.224
2004	3.302	4.566
2005	3.462	4.788
2006	3.263	4.513
2007	3.462	4.788
2008	3.652	5.050
2009	3.647	5.044
2010	3.416	4.724
2011	3.232	4.469
2012	3.265	4.515
2013	3.469	4.797
2014	3.075	4.252
2015	3.289	4.548
2016	3.277	4.531
2017	3.288	4.547
2018	3.371	4.662
2019	3.163	4.374
2020	3.165	4.377
2021	3.461	4.787

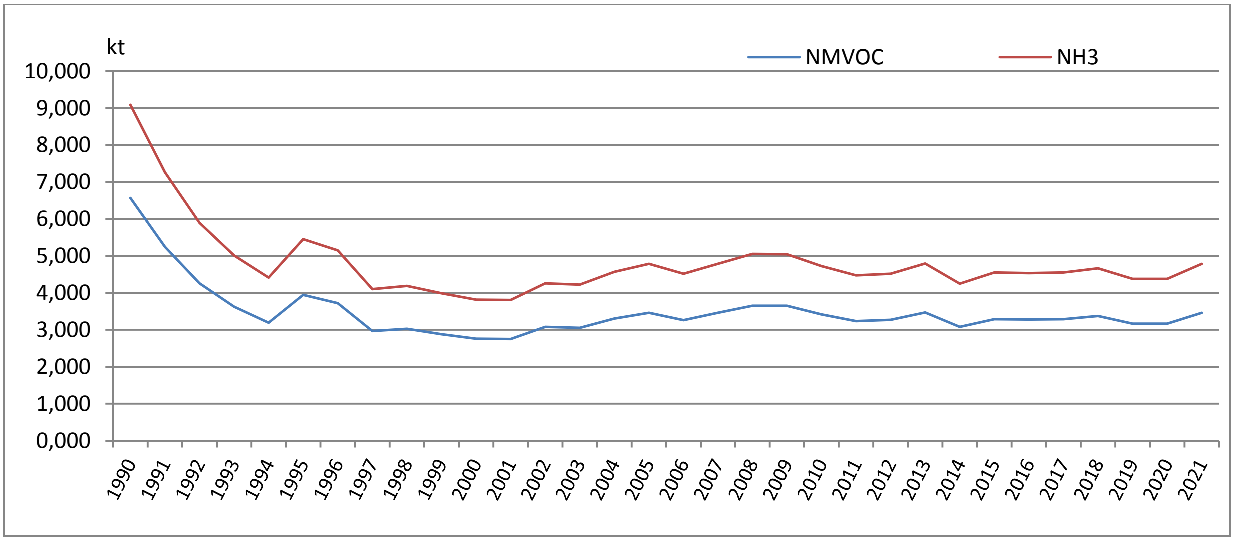

Figure 5.9.2 Emission trends (kt) for NFR 3.B.4.g.ii Manure management – Broilers

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.

5.10 NFR 3.B.4.g.iii Manure management – Turkeys and 3.B.4.giv Manure management – Other poultry

This year the activity data were completed for the entire time series 1990-2018, and for the years 2019 and 2020 they were corrected, following the answers to national questionnaires (Table 5.4. above).

In the “Other poultry” subcategory, duck farms, partridges, pheasants and guinea fowls were reported.

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

Year/Pollutant	Turkeys	Other poultry
1990	5.47	19.78
1991	4.81	17.41
1992	4.00	14.47
1993	4.12	14.91
1994	3.93	14.23
1995	4.12	14.90
1996	3.64	13.17
1997	3.42	12.37
1998	3.68	13.33
1999	2.96	10.71
2000	2.98	10.79
2001	2.77	10.04
2002	3.16	11.42
2003	2.93	10.60
2004	4.88	15.70
2005	4.56	15.55
2006	4.79	16.38
2007	3.97	12.86
2008	3.30	12.48
2009	2.93	18.29
2010	3.46	19.45
2011	18.45	19.02
2012	16.79	20.48
2013	85.02	37.70
2014	66.56	37.51

2015	368.32	37.51
2016	784.36	57.10
2017	783.44	63.21
2018	887.61	54.58
2019	992.82	112.16
2020	948.99	94.21
2021	930.62	45.92

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	0.0061	0.0056
2009	0.0014	0.0016	0.0089	0.0082
2010	0.0017	0.0019	0.0095	0.0088
2011	0.0090	0.0103	0.0093	0.0086
2012	0.0082	0.0094	0.0100	0.0092
2013	0.0416	0.0476	0.0184	0.0170
2014	0.0325	0.0373	0.0183	0.0169
2015	0.1801	0.2063	0.0183	0.0169
2016	0.3836	0.4392	0.0279	0.0257
2017	0.3831	0.4387	0.0309	0.0284
2018	0.4340	0.4971	0.0267	0.0246
2019	0.4855	0.5560	0.0548	0.0505
2020	0.4641	0.5314	0.0461	0.0424
2021	0.4551	0.5211	0.0225	0.0207

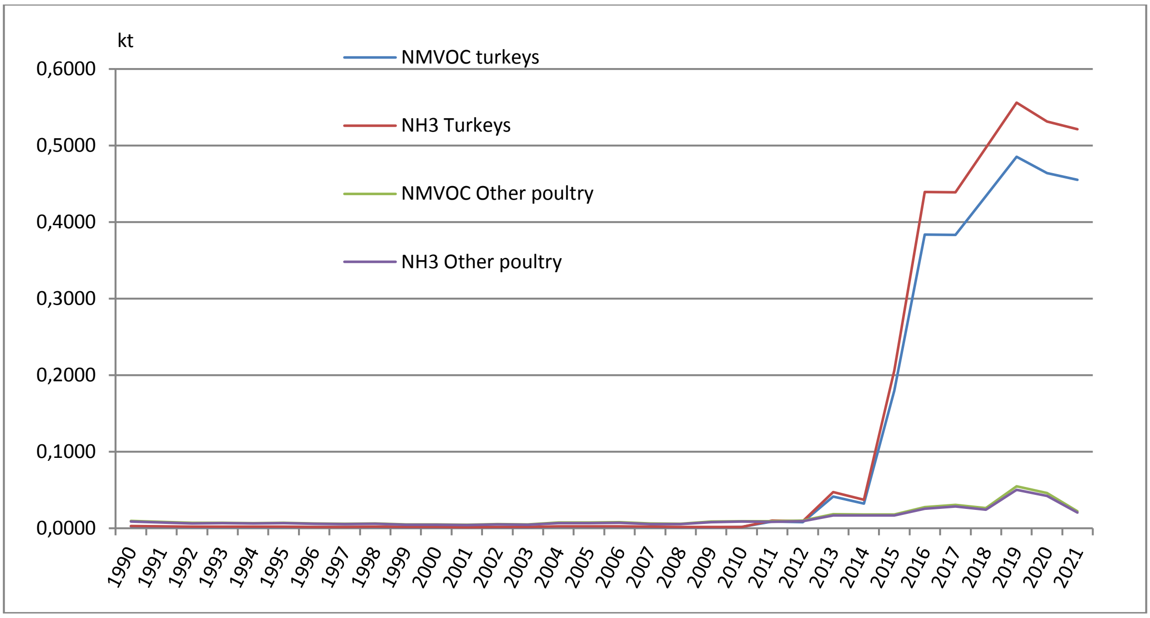

Figure 5.10.1 Emission trends (kt) for NFR 3.B.4.g.iii Manure management – Turkeys and NFR 3.B.4.g.iv Manure management – Other poultry

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.

5.11 NFR 3.B.4.h Manure management – Rabbits

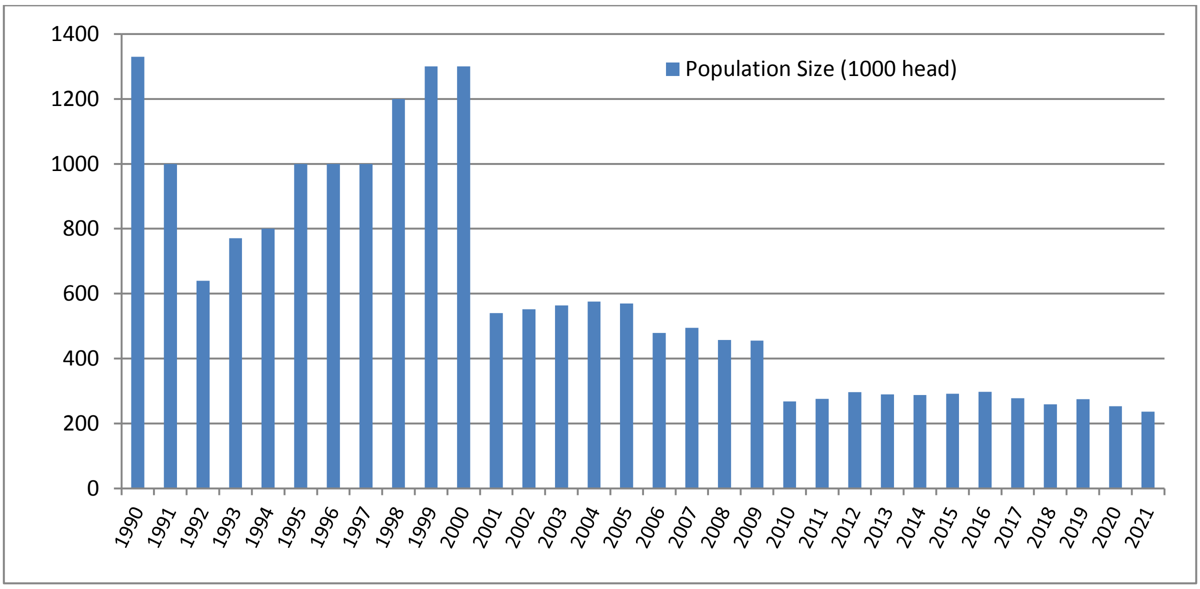

Figure 5.11.1 Activity data trends (*Population Size (1000 head)*) for NFR 3.B.4.g.ii Manure management – Rabbits

Activity data for rabbits with which the graph was obtained are presented in table 5.4 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

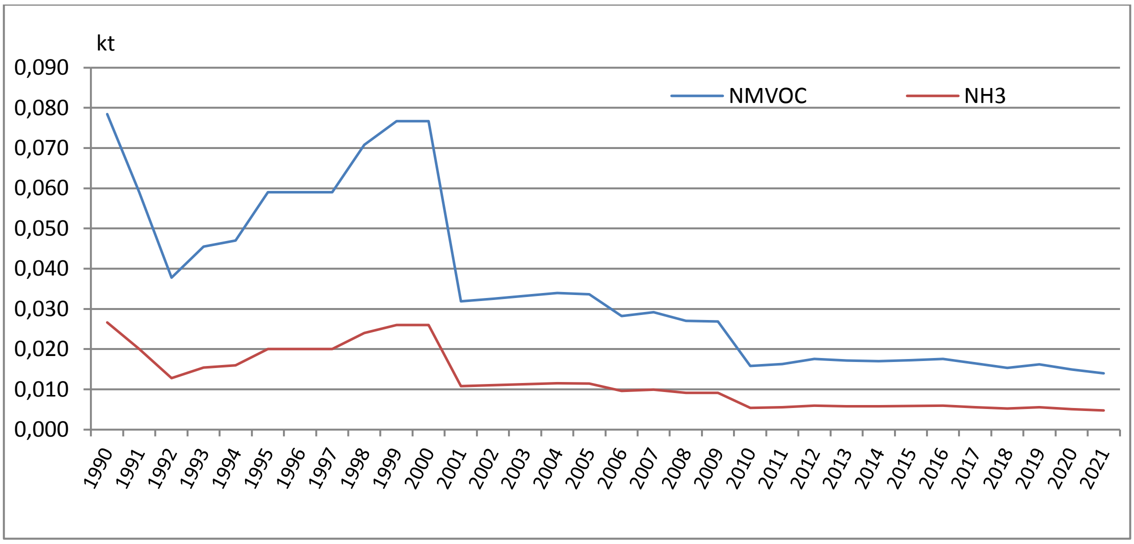

Figure 5.11.1 Emission trends (kt) for NFR 3.B.4.g.ii Manure management – Rabbits

The emissions of NMVOC and $NH_3$from manure management – rabbits, a new category in inventory, follow the activity data trends which varied from year to year due variations in livestock.

Recalculations and improvements:
- Recalculation of NMVOC emissions for the year 2020, the sheep category (NFR 3B2) due to a calculation error.
- Recalibration NH3 values for finishing pigs (NFR 3B3), using the version of "N-flow tool – Jan 2021", for the 1990-2004 time series.
- Recalculation of all pollutants for broilers (NFR 3B4gii) as a result of the change in activity data by subtracting the new values of turkeys and other poultry, for the entire time series.
- Recalculation of NH3 emissions with their redistribution in NFR 3B, 3Da2a, 3Da3 by subtracting the values created by anaerobic digestion of manure, which is returned to chapter 5B2 (as mentioned in the description of ammonia emissions). The time period for which manure values were reported in NFR categories 3B1a, 3B3, 3B4gi, used in anaerobic digestion is 2013-2021.
- Time series completion 1990-2018 and recalculation 2019-2020 for NFR 3B4giii (turkeys) and 3B4giv (other poultry).

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.

5.12 NFR 3.D.a.1 Inorganic N-fertilizers (also includes urea application)

The inorganic N-fertiliser sector represents a key category for agricultural sector for which the emission of NH_3 and NOx were estimated.

The emission of NH_3 from inorganic fertiliser contributes in 2021 with 21.22% of the emission for the agricultural sector and emission of NOx contributes in 2021 with 66.47% 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

N-ammonia fertilizers categories	Climate-Cool, Normal pH
Calcium ammonium nitrate (CAN)	8
Mixtures	15
NPK Mixtures	50
NP Mixtures	50
N solutions	98
Other straight N compounds	10
Urea	155

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} fertiliser 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**

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)
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**
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	147.22	8.75	61.28	14.63	1.21	90.80	50.10	3.45	43.96	47.48	**468.89**
2021	169.09	10.08	70.38	16.78	1.40	104.33	57.56	3.96	50.47	54.56	**538.61**

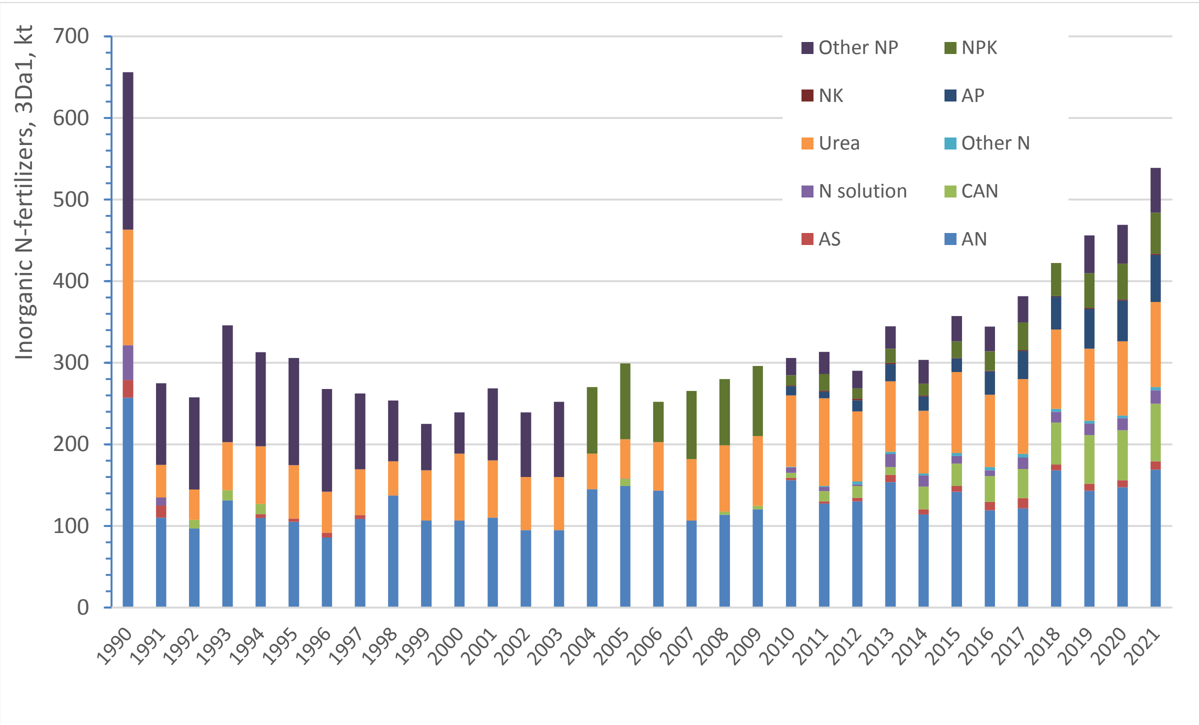

Figure 5.12.1 Trends of proportions of the categories of N-fertilizers (kt) for NFR 3Da1 Inorganic N-fertilizers

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	2019	2020	2021
Ammonia dir. applic. (N)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ammonium nitrate (N)	39.20%	34.33%	44.58%	49.75%	51.07%	39.72%	31.4%	31.4%	31.4%
Ammonium phosphate (N)	0.00%	0.00%	0.00%	0.00%	3.74%	4.74%	10.68%	10.68%	10.69%
Ammonium sulphate (N)	3.27%	1.29%	0.00%	0.00%	0.80%	1.98%	1.86%	1.87%	1.87%
Calc. amm. nitrate (N)	0.00%	0.00%	0.00%	2.90%	2.14%	7.65%	13.07%	13.07%	13.07%

N-Fertilizers	1990	1995	2000	2005	2010	2015	2019	2020	2021
N K compound (N)	0.00%	0.00%	0.00%	0.00%	0.27%	0.13%	0.26%	0.26%	0.26%
N P K compound (N)	0.00%	0.00%	0.00%	31.09%	4.01%	5.75%	9.38%	9.38%	9.37%
Nitrogen solutions (N)	6.53%	0.00%	0.00%	0.08%	2.14%	2.59%	3.13%	3.12%	3.12%
Other N straight (N)	0.00%	0.00%	0.00%	0.00%	0.27%	1.01%	0.74%	0.74%	0.73%
Other NP (N)	29.45%	42.92%	21.25%	0.00%	6.95%	8.66%	10.12%	10.13%	10.13%
Urea (N)	21.56%	21.46%	34.17%	16.17%	28.61%	27.75%	19.36%	19.36%	19.37%

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	25.666
2020	18.756	26.398
2021	21.544	30.012

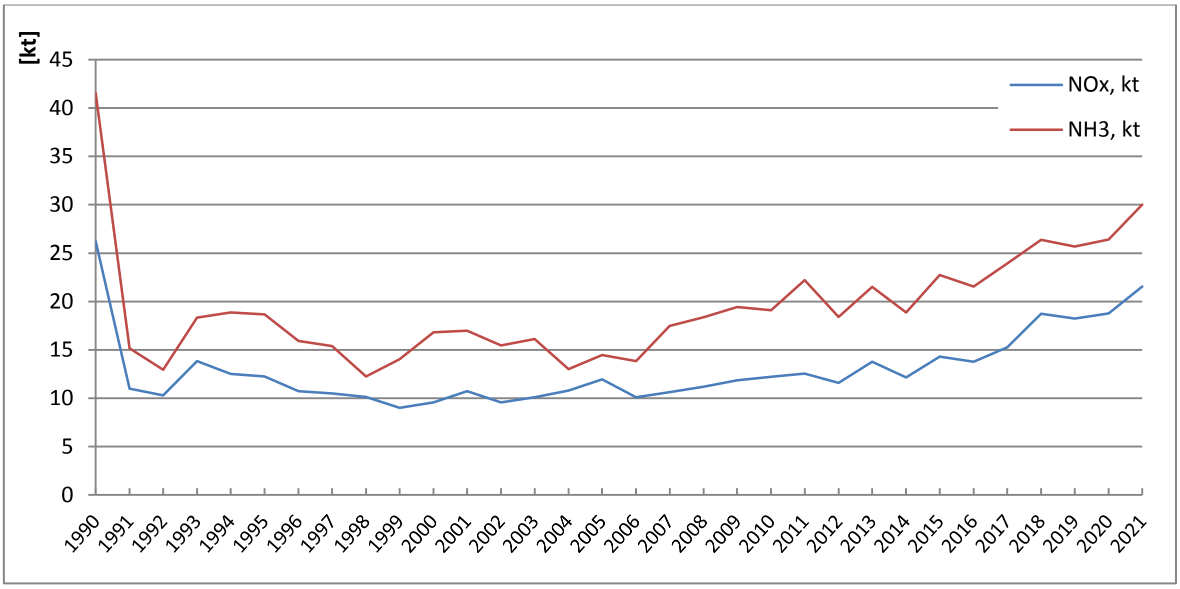

Figure 5.12.2 Emission trends (kt) for NFR 3Da1 Inorganic N-fertilizers

Recalculations and improvements:

- In RO-3Da1-2022-0001, the Romanian calculation method was explained step by step;
- Recalculation for the values of ammonia emissions due to changes in the quantities of fertilizer categories by IFA for 2018, 2019 and 2020 (petty differences).

5.13 NFR 3.D.a.2.a Animal manure applied to soils

For the sector animal manure applied to soils, the emission of NOx, NH_3 and NMVOC were estimated. The emissions of NH_3 from animal manure applied to soils contributes in 2021 with 27.68% from the ammonia emission of the agricultural sector and represent a key source, with 24.69% 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 instrument 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	478138096.2
1991	414358496.5
1992	362274497.2
1993	359393103.6
1994	336213928.3
1995	331292846.9
1996	327467769.3
1997	297879860.2
1998	291512626.5
1999	272871367.5
2000	251094374.3
2001	245466977.1
2002	255399990.3
2003	265685726.6
2004	276822750.9
2005	288468068.8
2006	290370960.7
2007	285282856.8
2008	273335099.5
2009	265618409.3
2010	230419389.4
2011	227153331.7
2012	226580070.3
2013	228034707.3
2014	230671798.9
2015	231245446.9
2016	231572353.6
2017	223742023.3
2018	217969485.0
2019	216848588.2
2020	212663150.7
2021	205749426.03

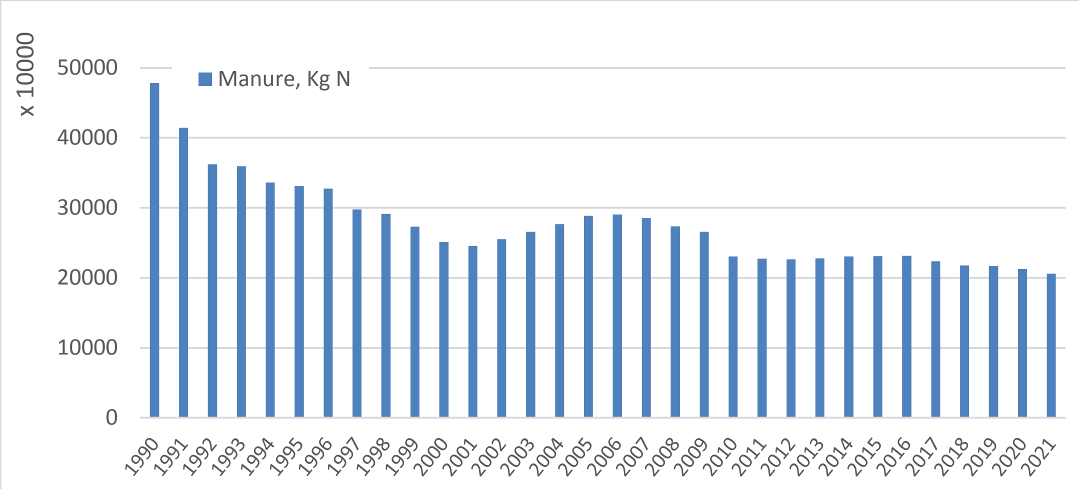

Figure 5.13.1 Activity data trends for NFR 3Da2a – pollutant NOx

Table 5.13.2 Emission trends (kt) for NFR 3Da2a Animal manure applied to soils

Year	NOx	NH_3
1990	19.1255	94.7030
1991	16.5743	82.8220
1992	14.4910	71.9930
1993	14.3757	68.5960
1994	13.4486	62.8840
1995	13.2517	64.0270
1996	13.0987	64.0240
1997	11.9152	58.0640
1998	11.6605	57.7840
1999	10.9149	53.2600
2000	10.0438	48.9160
2001	9.8187	47.3780
2002	10.2160	50.3320
2003	10.6274	50.7540
2004	11.0729	55.4320
2005	11.5387	56.8970
2006	11.6148	57.6580
2007	11.4113	55.5030
2008	10.9334	53.6120
2009	10.6247	50.8980
2010	9.2168	45.1160
2011	9.0861	44.0390
2012	9.0632	43.4000
2013	9.1214	42.9590
2014	9.2269	44.5330
2015	9.2498	44.9190
2016	9.2629	43.7010
2017	8.9497	42.0630
2018	8.7188	40.5540
2019	8.6739	40.4943
2020	8.5065	39.3409
2021	8.2300	39.1495

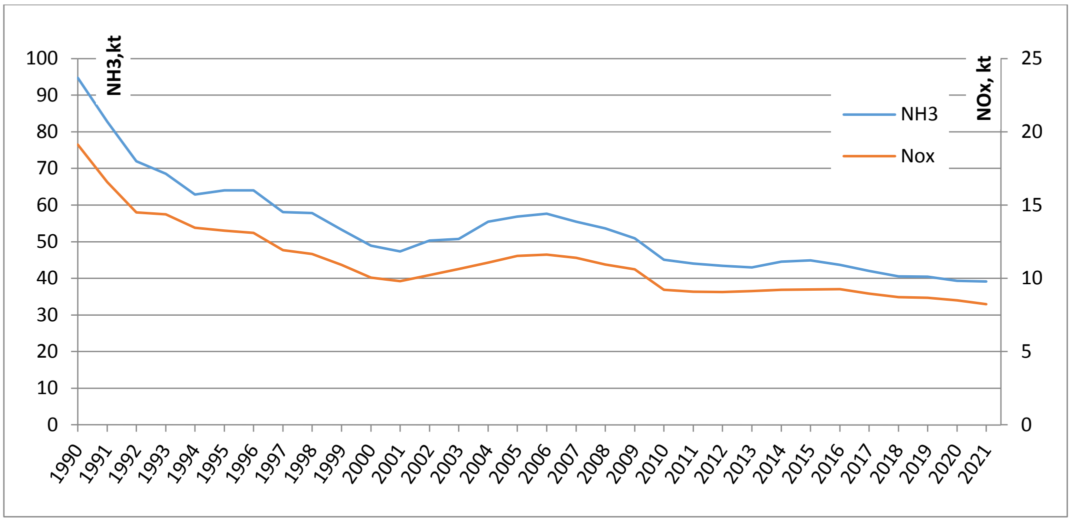

Figure 5.13.2 Emission trends (kt) for NFR 3Da2a Animal manure applied to soils

The emissions of NH_3 and NOx from animal manure applied to soils follow the activity data trend.

Recalculations and improvements:

- According to RO-3Da2a-2020-0001, non-methane volatile organic compounds (NMVOC) emissions, included in calculation of NFR 3B, was calculated with Agree Tool;
- Recalculation of ammonia emissions for the entire time series 1990-2019 in accordance with the TERT recommendation of RO-3Da2a-2021-0001.

5.14 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÷2021 period, completed with values for 1990÷2005 period from a Romania's Greenhouse Gas study[2].

[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".

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
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

Table 5.14.2 Emission trends (kt) for 3Da2b - Sewage sludge applied to soils

Year	NOx	NH_3
1990	0.00567	0.01929
1991	0.00565	0.01921
1992	0.00557	0.01892
1993	0.00558	0.01898
1994	0.00559	0.01901
1995	0.00349	0.01186
1996	0.00348	0.01182
1997	0.00347	0.01181
1998	0.00346	0.01176
1999	0.00344	0.01171
2000	0.00492	0.01673
2001	0.00651	0.02213
2002	0.00787	0.02676
2003	0.00958	0.03256
2004	0.01041	0.03539
2005	0.01148	0.03902
2006	0.01214	0.04127

Year	NOx	NH_3
2007	0.01226	0.04169
2008	0.01243	0.04226
2009	0.01247	0.04241
2010	0.01308	0.04448
2011	0.01714	0.05827
2012	0.01728	0.05876
2013	0.01777	0.06041
2014	0.01800	0.06119
2015	0.01818	0.06181
2016	0.01883	0.06403
2017	0.01942	0.06603
2018	0.02007	0.06824
2019	0.02053	0.06980
2020	0.02108	0.07167
2021	0.02159	0.07339

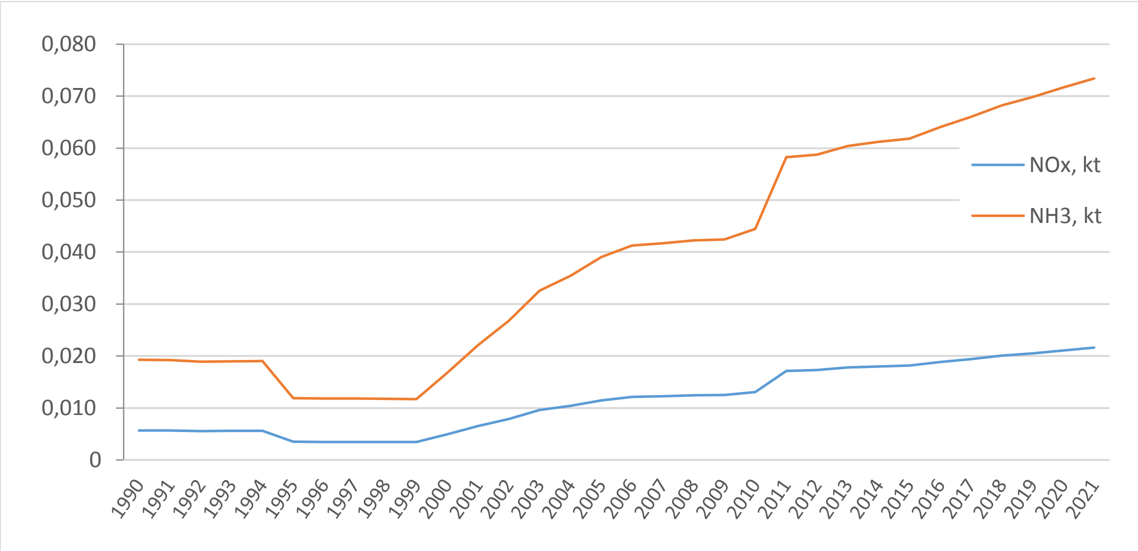

Figure 5.14.1 Emission trends (kt) for 3Da2b - Sewage sludge applied to soils

Recalculations and improvements:

- There were not recalculations since the previous submission.

5.15 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 2021 with 11.90% 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 instrument 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	35.0541
1991	32.1641
1992	28.0647
1993	27.3995
1994	26.6334
1995	26.2861
1996	25.4185
1997	24.1022
1998	23.3952
1999	22.9266
2000	21.9432
2001	21.2994
2002	21.8011
2003	22.1324
2004	21.4750
2005	21.8285
2006	21.9553
2007	22.8181
2008	22.5632
2009	21.9784
2010	19.0483
2011	19.0202
2012	19.2562
2013	19.4640
2014	19.7703
2015	20.1534
2016	20.2323
2017	19.9946
2018	19.9082
2019	19.7176
2020	19.5219
2021	18.8786

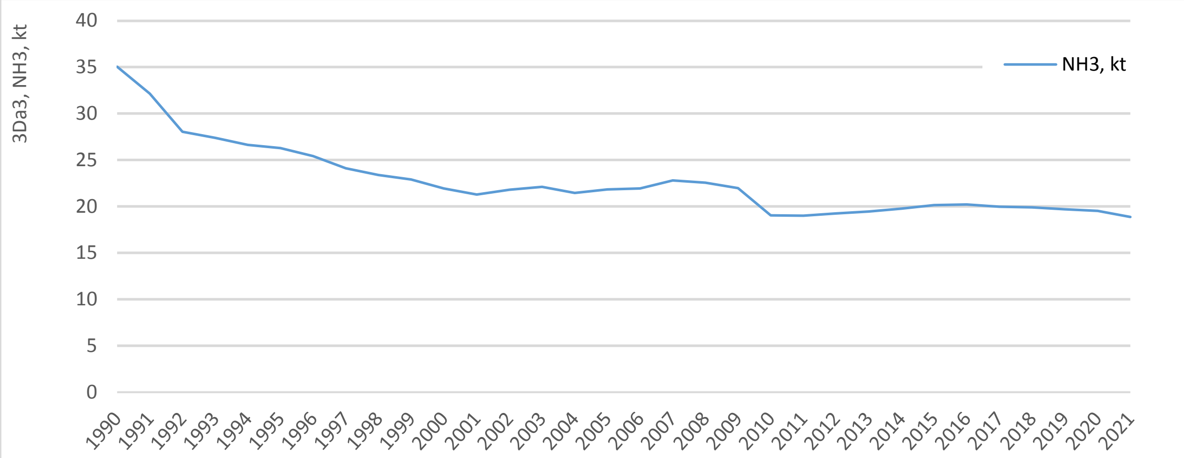

Figure 5.15.1 Emission trends (kt) for
NFR 3Da3 - Urine and dung deposited during grazing animals

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	127.57713	94.60682	35.05383
1991	111.98899	82.74225	32.16392
1992	97.95775	71.92223	28.06478
1993	93.03793	68.52830	27.39991
1994	84.64828	62.82139	26.63309
1995	86.85517	63.96410	26.28595
1996	86.85604	63.96153	25.41950
1997	78.34507	58.00494	24.10203
1998	78.12434	57.72757	23.39548
1999	71.38411	53.20594	22.92614
2000	65.09394	48.86558	21.94280
2001	62.92552	47.33112	21.29905
2002	67.17055	50.28429	21.80034
2003	67.76737	50.70356	22.13212
2004	74.30528	55.40639	21.47479
2005	76.77045	56.85789	21.82777
2006	77.38871	57.61947	21.95555
2007	75.15656	55.46354	22.81826
2008	72.54998	53.57410	22.56322
2009	68.97510	50.86418	21.97857
2010	61.46565	45.08813	19.04875
2011	59.72078	44.01737	19.02059
2012	58.72183	43.37657	19.25652
2013	58.37768	42.95732	19.46348
2014	60.56870	44.51395	19.77027
2015	61.08306	44.98965	20.15362

Year	3B-NH_3, kt	3Da2a-NH_3, kt	3Da3-NH_3, kt
2016	59.91288	43.89911	20.23219
2017	57.75168	42.26283	19.99516
2018	55.59836	40.78448	19.90788
2019	54.98139	40.58462	19.71774
2020	53.78682	39.40998	19.52153
2021	53.31519	39.14955	18.87865

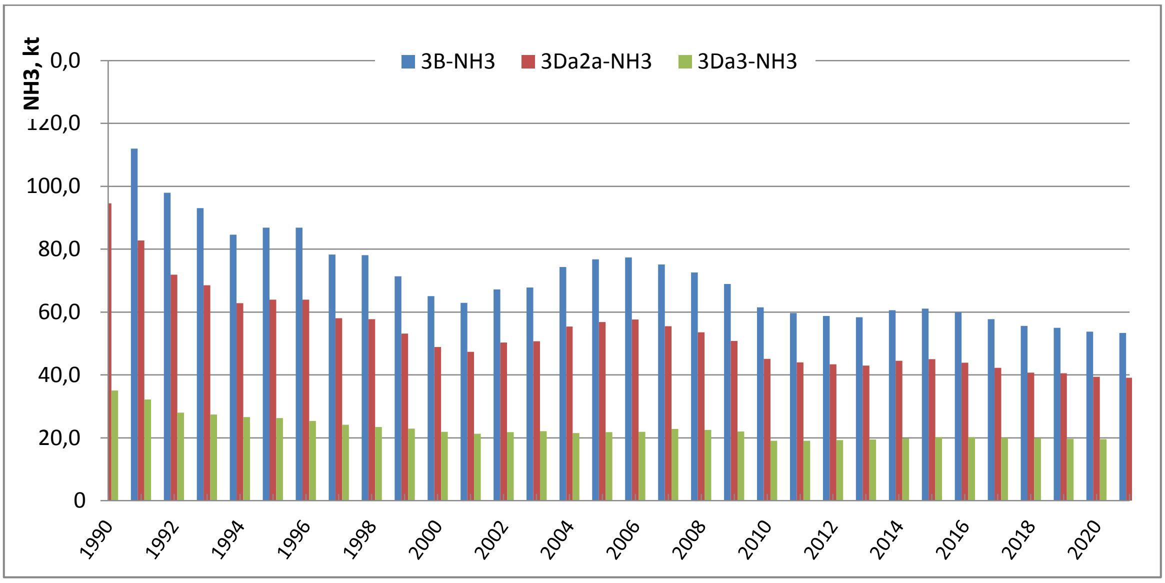

Figure 5.15.2 Comparison between the split of NH_3 [kt] for category 3B, 3Da2a, 3D3

Recalculations and improvements:

- According to RO-3Da2a-2020-0001, non-methane volatile organic compounds (NMVOC) emissions, included in calculation of NFR 3B, was calculated with Agree Tool.
- Recalculation of ammonia emissions for the entire time series 1990-2019 in accordance with the TERT recommendation of RO-3Da2a-2021-0001, as an effect for 3Da3.

5.16 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 with 13.11% of the total national emissions of PM_{10}, respectively with 8.87% of the total national emissions of TSP in 2021.

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	13214722

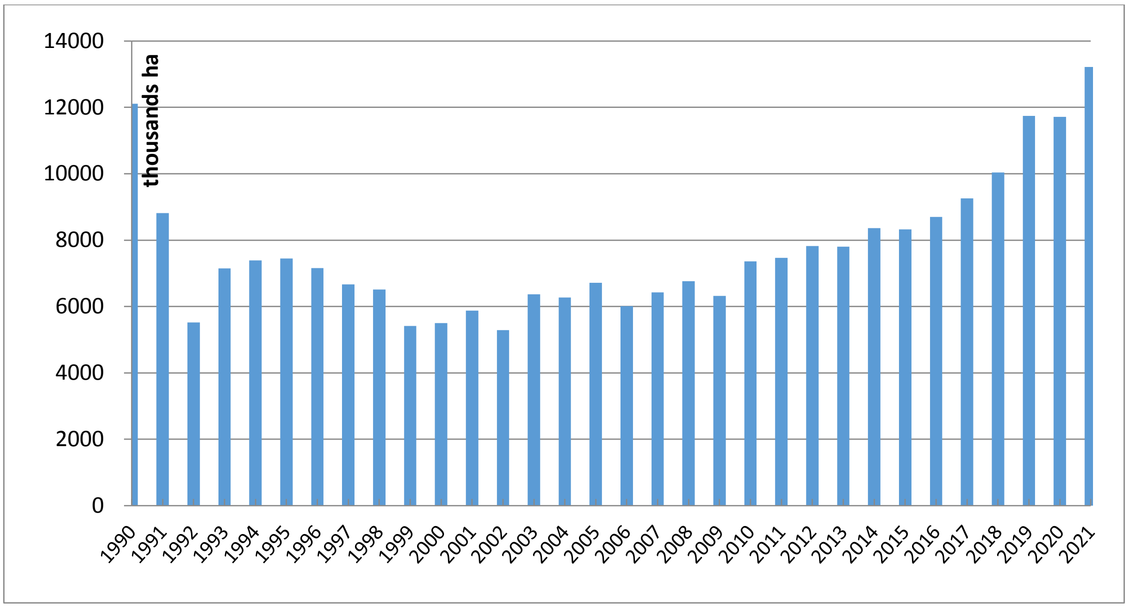

Figure 5.16.1 Activity data trends (ha) for NFR 3Dc Farm-level agricultural operations

The emissions represented here are from $PM_{2,5}$ and PM_{10}, the TSP having the same values (i.e. emission factor) as PM_{10}.

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	0.793	20.615

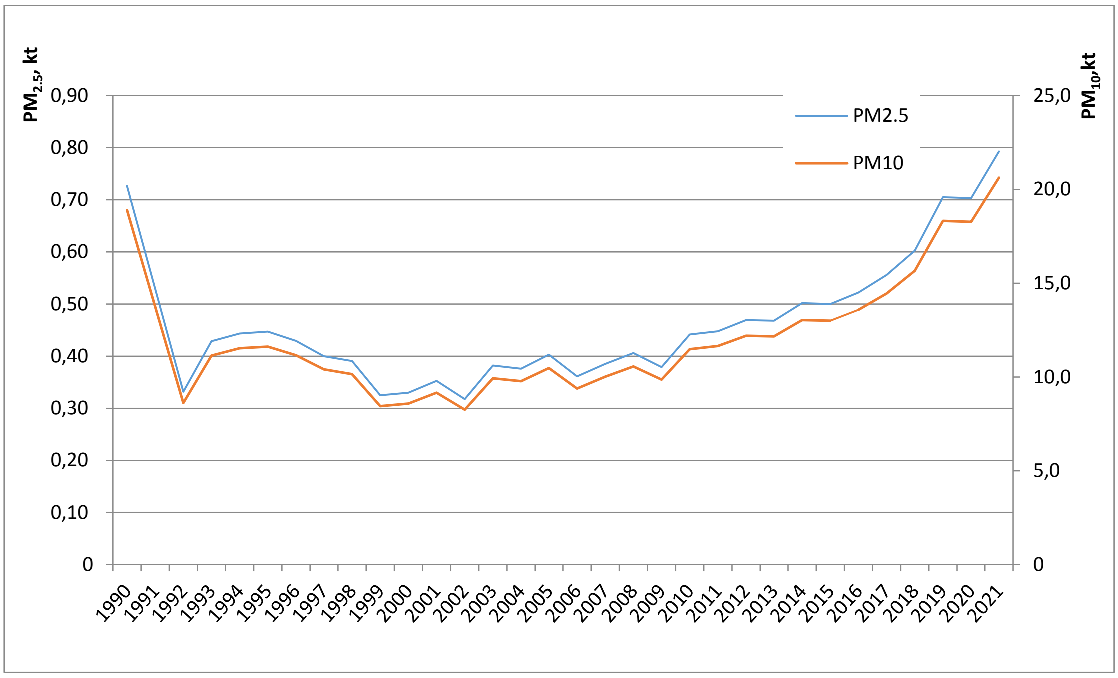

Figure 5.16.2 Emission trends (kt) for NFR 3Dc Farm-level agricultural operations

The emissions of particulate matter from farm-level agricultural operations follow the activity data trend.

5.17 NFR 3.D.e Cultivated crops

For the cultivated crops sector the emission of NMVOC were estimated, with a percent of 4.85% from the total national of NMVOC emissions.

The emission of non-methane volatile organic compounds from cultivated crops were calculated by area of cultivated crops multiplied with the emission factor.

For the activity data, the area of cultivated crops was provided by the N.I.S.

The emission factor used are based on 2019 EMEP/EEA Guidebook, table 3.1.

Table 5.17.1 Emission trends (kt) for NFR 3De - Cultivated crops

Year/Pollutant	NMVOC
1990	10.416
1991	7.584
1992	4.751
1993	6.145
1994	6.355
1995	6.405
1996	6.155
1997	5.735
1998	5.601
1999	4.660
2000	4.732
2001	5.052
2002	4.552
2003	5.479
2004	5.390
2005	5.772
2006	5.173
2007	5.524
2008	5.819
2009	5.433
2010	6.328
2011	6.422
2012	6.727
2013	6.708
2014	7.189
2015	7.162
2016	7.484
2017	7.966
2018	8.634
2019	10.102
2020	10.075
2021	11.365

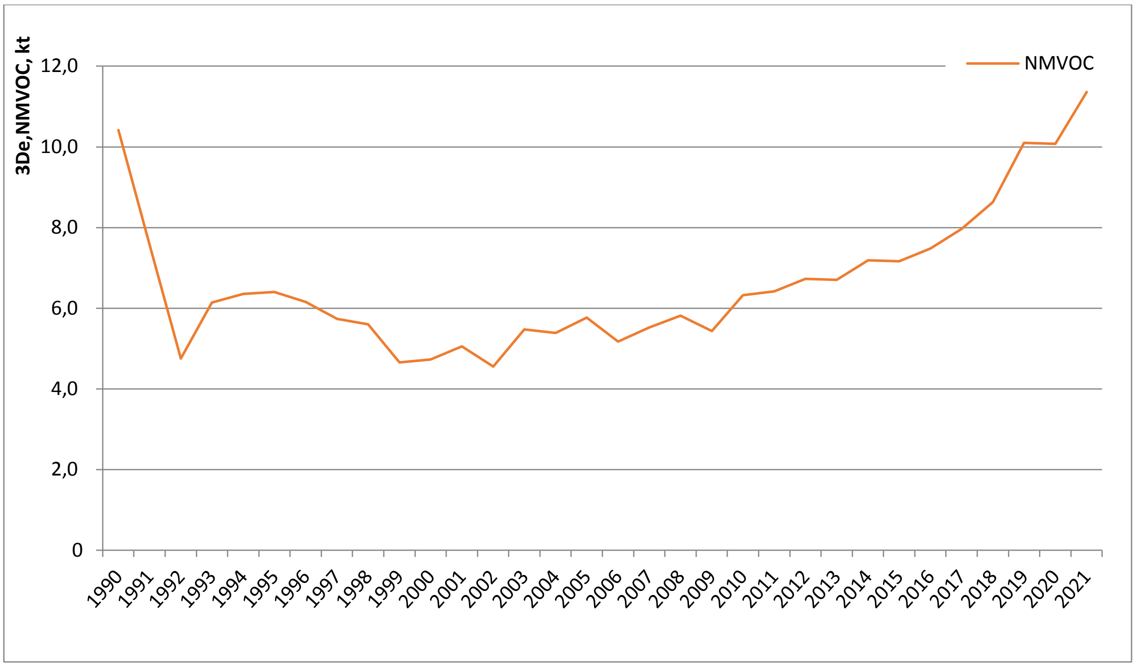

Figure 5.17.1 Emission trends (kt) for NFR 3De - Cultivated crops, NMVOC, kt

The emissions of NMVOC from cultivated crops follow the activity data trend.

5.18 NFR 3.F Field Burning of Agricultural Residues

This category includes emission for the open burning of crop residue on arable land after harvesting. This activity does not include the burning of crop products that are burnt after having been used on the farm, which is reported under NFR code 5.C.2 Open burning of waste. Emissions of NOx, NMVOC, SOx, NH_3, particulate matter, BC, CO, heavy metals and PAHs were included under this NFR. These emissions contribute with less than 1% from 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 to calculate the emissions 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 area of land on which the crops whose residues are burned are provided by from the Romania's Greenhouse Gas Inventory – N.I.R., improving 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

Year	Wheat	Maize	Barley	Rye	Other cereals
2010	383464	372115	91472	2581	2603
2011	315239	419291	67922	2000	2658
2012	549509	751012	116701	2386	7059
2013	338652	405334	79784	1729	4098
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	424764	497841	87760	2365	1697

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

Year	Wheat	Maize	Barley	Rye	Other cereals
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	1520739	3994674	290030	10419	6075

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

Year/Pollutant	benzo(a) pyrene	benzo(b) fluoranthene	benzo(k) fluoranthene	Indeno (1,2,3-cd) pyrene
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	0.010	0.006	0.006
2018	0.015	0.009	0.005	0.005
2019	0.019	0.010	0.006	0.006
2020	0.030	0.017	0.010	0.010
2021	0.029	0.016	0.009	0.010

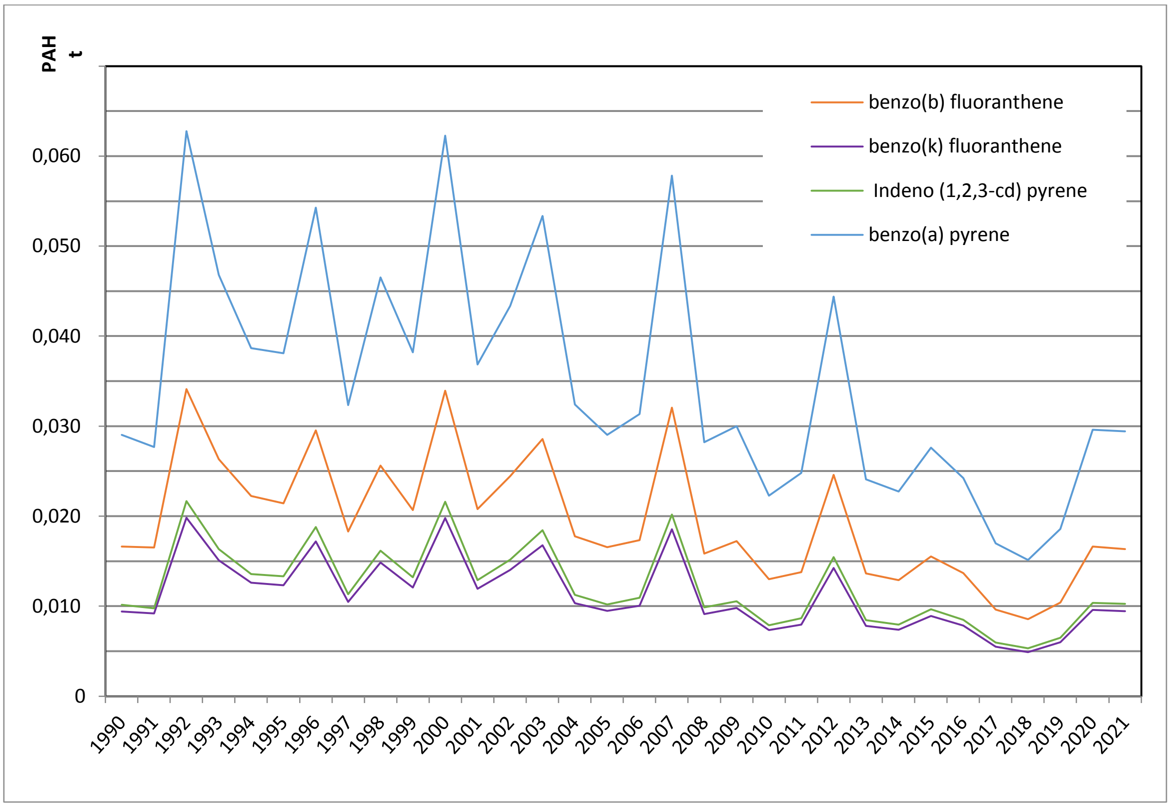

Figure 5.18.1 Emission trends (t) for NFR 3.F Field Burning of Agricultural Residues

The emissions of PAHs follow the activity data trend.

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

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 6.1.1. 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
5C1a Municipal waste incineration	-	
5C1bi Industrial waste incineration	All CLRTAP 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 CLRTAP pollutants (except NH3, PM2.5, PM10, Se, Zn, PAHs)	T2 - EMEP EEA guidebook (2019) factors
5C1biv Sewage sludge incineration	-	
5C1bv Cremation	All CLRTAP 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 CLRTAP 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

6.5 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× 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	4295.031	49.376
1991	4290.069	50.858
1992	4221.985	52.278
1993	4223.518	53.529
1994	4223.557	54.691
1995	5913.262	55.797
1996	5297.580	59.104
1997	3504.374	62.250
1998	4750.406	63.016
1999	5834.110	65.153
2000	6828.846	76.872
2001	6199.334	82.242
2002	7143.516	87.014
2003	6594.523	92.810
2004	7019.397	98.014
2005	7399.425	102.603
2006	7295.422	104.645
2007	7432.074	111.380
2008	8486.132	114.531
2009	7068.242	118.820
2010	5998.657	124.093
2011	5782.518	105.326
2012	4658.190	128.827
2013	4714.254	140.914

2014	5014.406	141.389
2015	5075.909	141.523
2016	5300.558	143.779
2017	4953.199	146.188
2018	5298.318	147.389
2019	5507.419	152.717
2020	5150.130	154.6998
2021	5521.267	155.4653

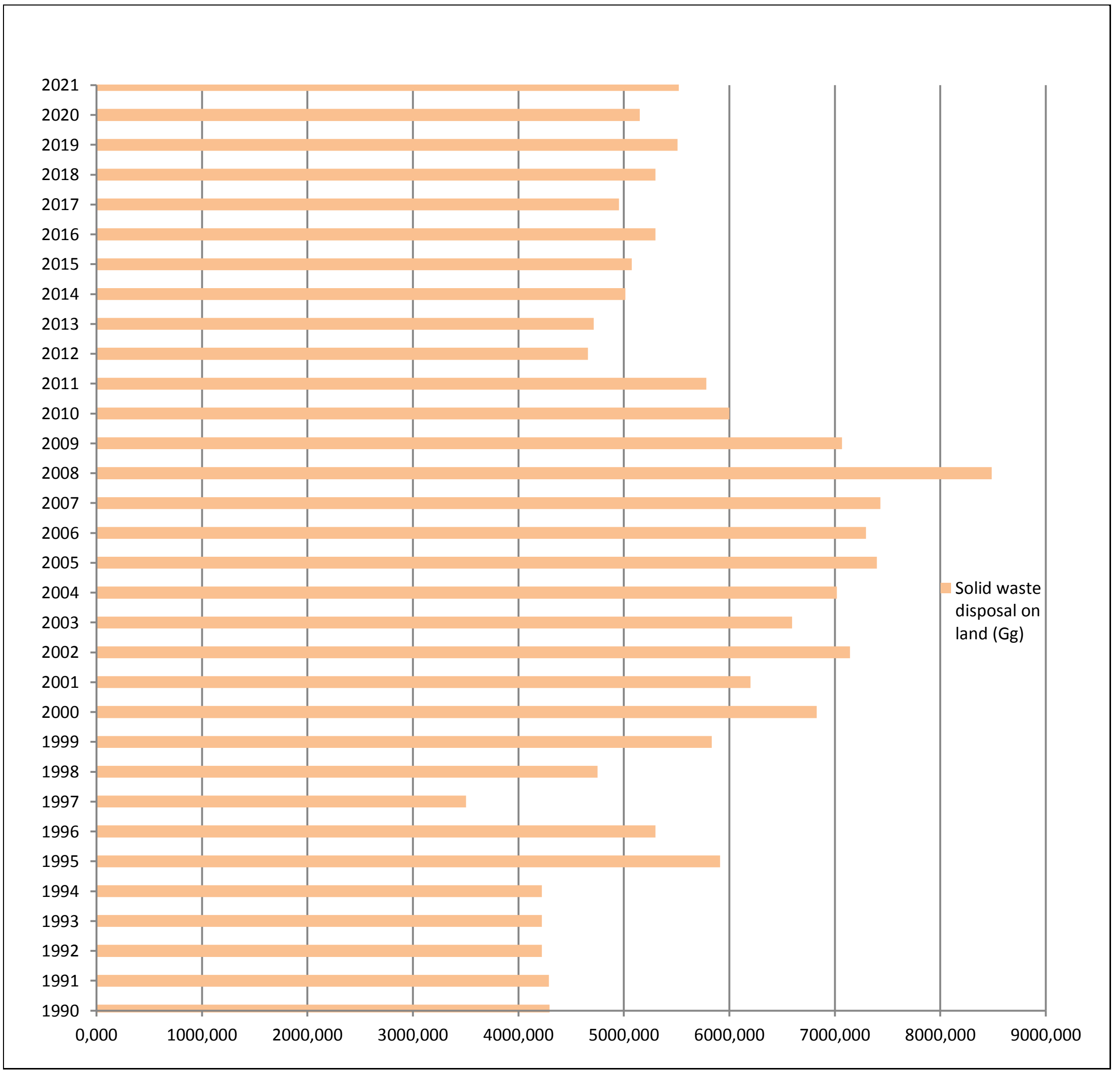

Figure 6.1.1 Activity data trends (*Solid waste disposal on land [Gg]*) for NFR 5.A

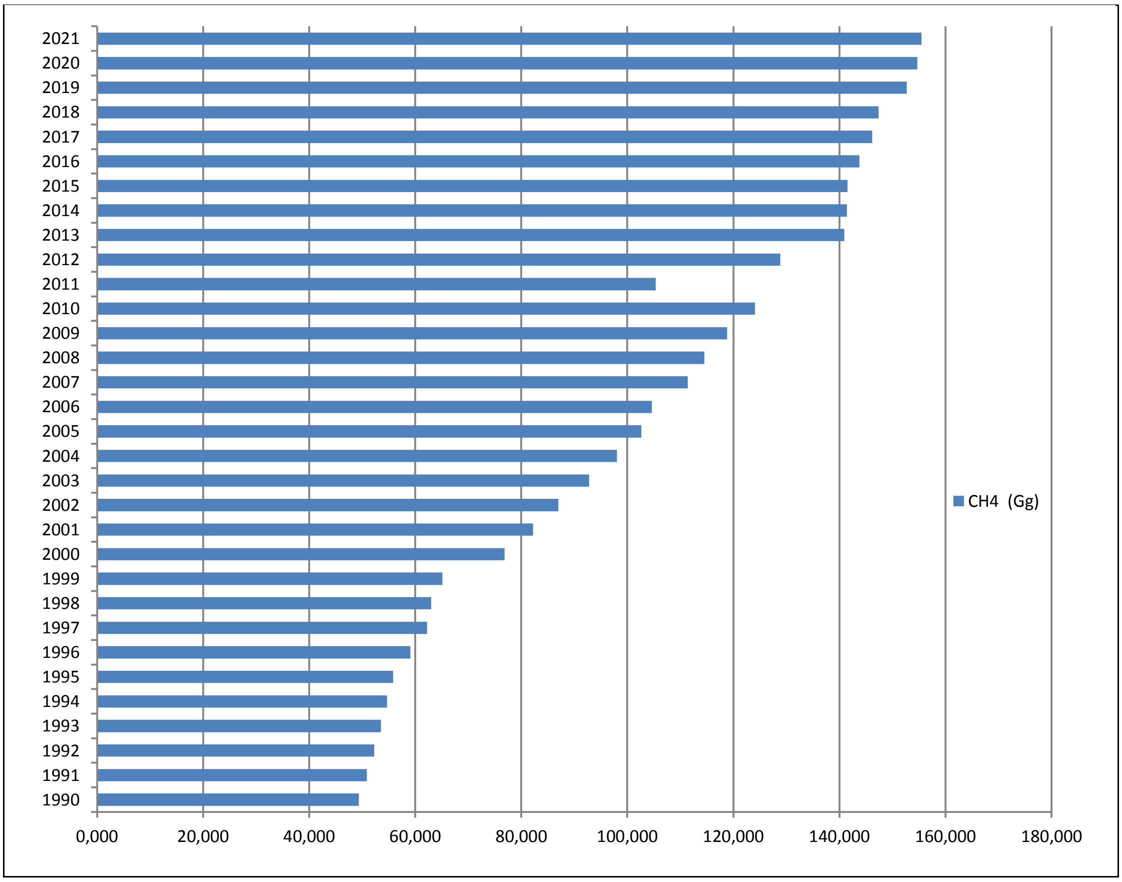

Figure 6.1.1" Activity data trends (CH_4 *from annual deposition of MSW at the SWDS [Gg]*) for NFR 5.A

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	0.6503
1991	0.6699
1992	0.6886
1993	0.7050
1994	0.7203
1995	0.7349
1996	0.7785
1997	0.8199
1998	0.8300
1999	0.8581
2000	1.0125
2001	1.0832
2002	1.1461
2003	1.2224
2004	1.2910
2005	1.3514
2006	1.3783
2007	1.4670
2008	1.5085
2009	1.5650
2010	1.6345
2011	1.3873
2012	1.6968
2013	1.8560
2014	1.8623
2015	1.8640

2016	1.8937
2017	1.9255
2018	1.9413
2019	2.0115
2020	2.0375
2021	2.0476

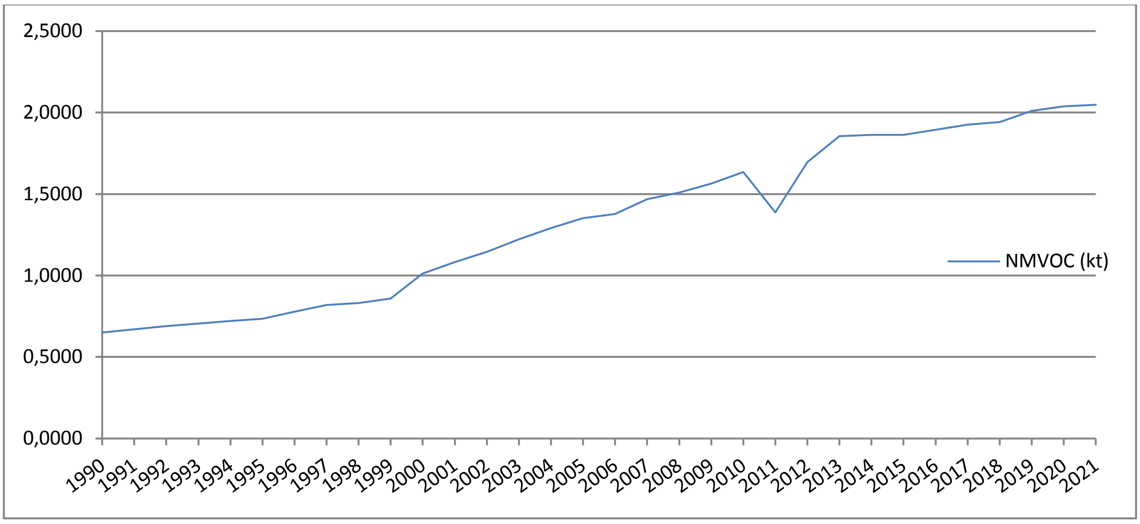

Figure 6.1.2 Emission trends (*kt for NMVOC*) for NFR 5.A Biological treatment of waste – Solid waste disposal on land

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	0.000142	0.000941	0.001989
1991	0.000142	0.000940	0.001986
1992	0.000139	0.000925	0.001955
1993	0.000139	0.000925	0.001955
1994	0.000139	0.000925	0.001956
1995	0.000195	0.001295	0.002738
1996	0.000175	0.001160	0.002453
1997	0.000116	0.000767	0.001623
1998	0.000157	0.001040	0.002199
1999	0.000193	0.001278	0.002701
2000	0.000225	0.001496	0.003162
2001	0.000205	0.001358	0.002870
2002	0.000236	0.001564	0.003307
2003	0.000218	0.001444	0.003053
2004	0.000232	0.001537	0.003250

2005	0.000244	0.001620	0.003426
2006	0.000241	0.001598	0.003378
2007	0.000245	0.001628	0.003441
2008	0.000280	0.001858	0.003929
2009	0.000233	0.001548	0.003273
2010	0.000198	0.001314	0.002777
2011	0.000191	0.001266	0.002677
2012	0.000154	0.001020	0.002157
2013	0.000156	0.001032	0.002183
2014	0.000165	0.001098	0.002322
2015	0.000168	0.001112	0.002350
2016	0.000175	0.001161	0.002454
2017	0.000163	0.001085	0.002293
2018	0.000175	0.001160	0.002453
2019	0.000182	0.001206	0.002550
2020	0.000170	0.001128	0.002385
2021	0.000182	0.001209	0.002556

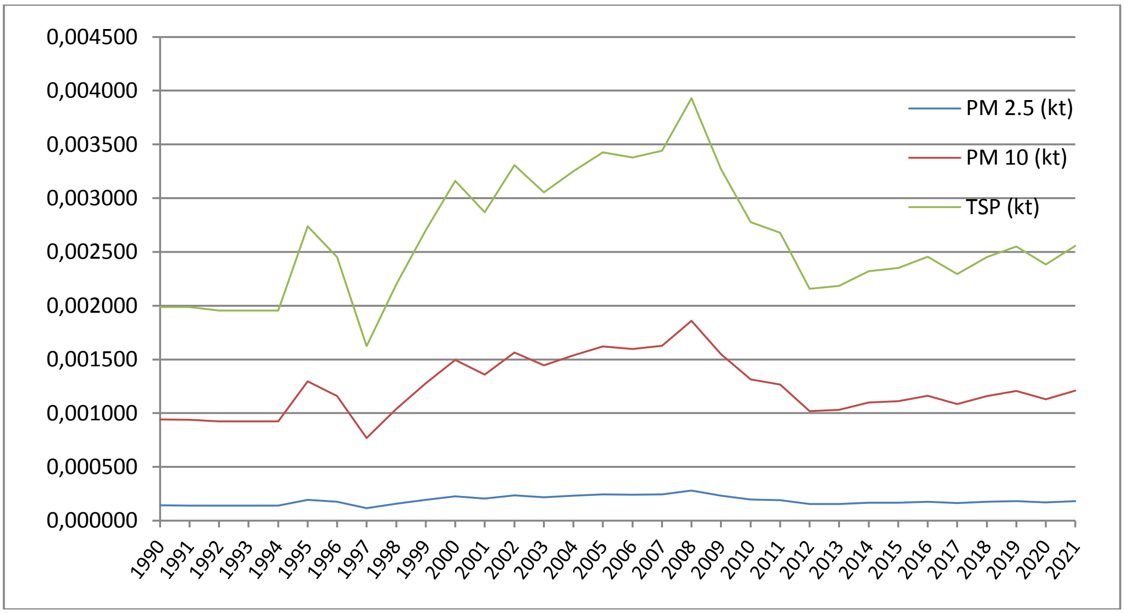

Figure 6.1.3 Emission trends (*kt for $PM_{2.5}$, PM_{10}. TSP*) for NFR 5.A Biological treatment of waste –solid waste disposal on land

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 2020 recalculation the emission of NMVOC (CH_4 emissions from the IPCC inventory update).

6.6 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:

$$E_{pollutant} = AR_{production} \times EF_{pollutant}$$

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	0.220
2006	0.325
2007	2.344
2008	2.360
2009	2.920
2010	1.214
2011	15.095
2012	20.553
2013	30.328
2014	17.150
2015	36.826
2016	50.841
2017	86.121
2018	64.989
2019	122.395
2020	139.782

2021	97.729

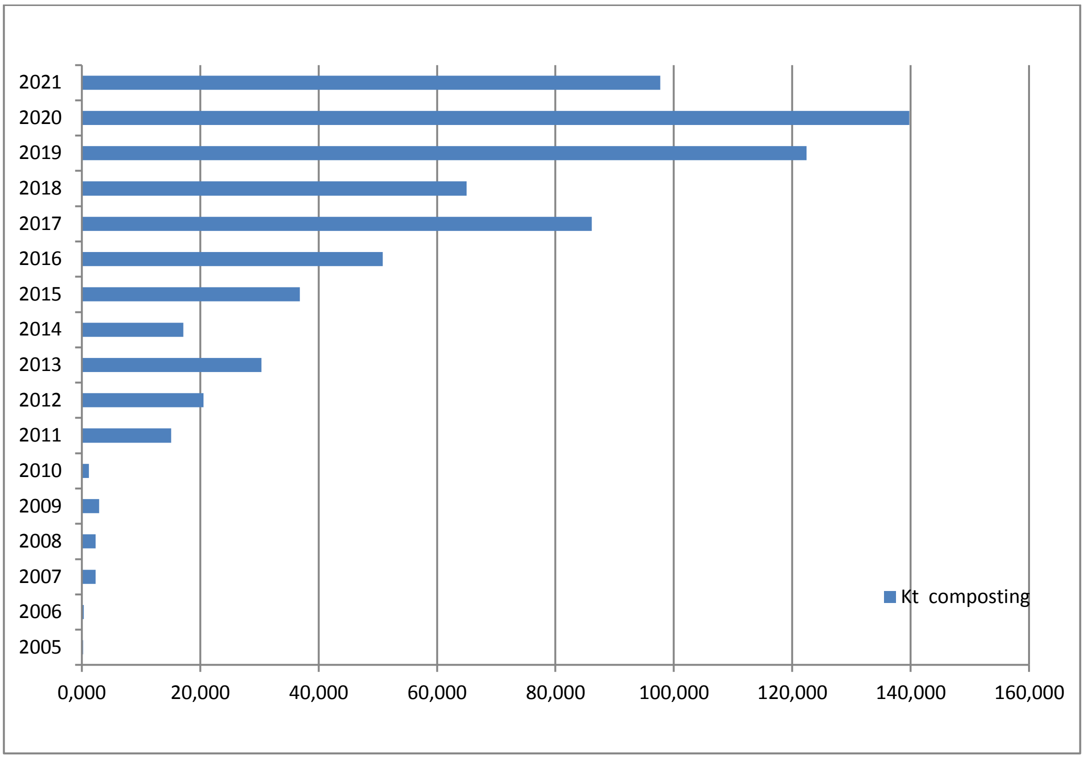

Figure 6.2.1 Activity data trends *(kt compost)* for NFR 5.B.1
Biological treatment of waste – Composting

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	0.0000528
2006	0.0000780
2007	0.0005626
2008	0.0005664
2009	0.0007008
2010	0.0002914
2011	0.0036228
2012	0.0049327
2013	0.0072787
2014	0.0041160
2015	0.0088382
2016	0.0122018
2017	0.0206690
2018	0.0155974
2019	0.0293748
2020	0.0335477

2021	0.0234550

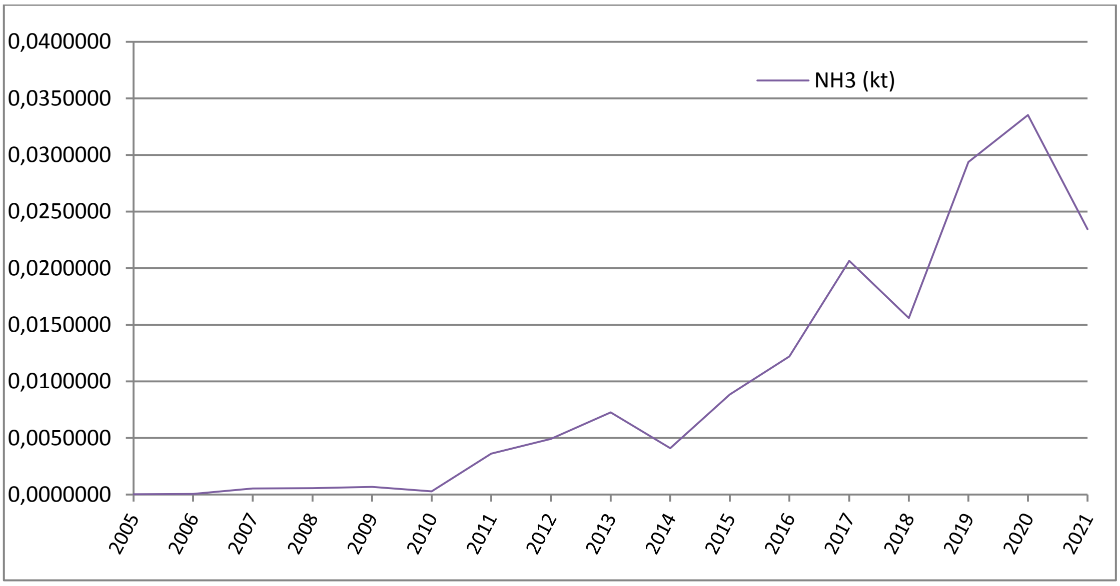

Figure 6.2.2 Emission trends (*kt for* NH_3) NFR 5.B.1
Biological treatment of waste – Composting

The NH_3 emissions from compost production follow the activity data trend.
There were no recalculations and improvements for this category.

6.7 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. Large biogas plants are fully automated

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:

ENH3 = ARfeedstock x ∑EFNH3-N, stage i x 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
Municipal organic waste (a)	kg									21000
Green waste (grass, etc.) (a)	kg					314287	39310	673505	1043360	616680
Food waste (food processing	kg		6415390	3999190	10760270	17208530	21962717.8	27090337	29842905.2	65428831
Cattle slurry (a)	kg		1762450	7184940	15975400	33612040	39897360	56623080	61039960	53407550
Pig slurry (a)	kg				1950000	9592369	3376000	642000	672000	1147000
Cattle solid manure (b)	kg			1093000	4616000	17917000	16129200	18640015	18767182	20354990
Pig solid manure (b)	kg					6658836	3951179	941000	182000	0
Poultry manure (b)	kg	9700000	7430000	1070000	5690000	4517000	3524000	3110000	1390500	1926000
Maize silage (a)	kg	11569056	43159570	58657710	58543000	80547094	79495412	61423769	45623576	40717800
Grass silage (a)	kg							2054000	90000	103738
Straw (a)	kg					144686	198404	84043	39608	25550
TOTAL feedstock	**kg**	**21269056**	**58767410**	**72004840**	**97534670**	**170511842**	**168573582.8**	**171281749**	**158691091.2**	**183749139**

Table 6.3.2 Calculation AR feedstock total in during storage of the digestate for NFR 5B2Biological 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		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
Municipal orga	0.4	0.0068	(kg a – 1)	0	0	0	0	0	0	0	0	57.12
Green waste (g	Not availab	0.0046	(kg a – 1)	0	0	0	0	1445.7202	180.826	3098.123	4799.456	2836.728
Food waste (fo	Not availab	0.0051	(kg a – 1)	0	32718.489	20395.869	54877.377	87763.503	112009.86	138160.72	152198.82	333687.04
Cattle slurry (a)	0.1	0.0052	(kg a – 1)	0	916.474	3736.1688	8307.208	17478.261	20746.627	29444.002	31740.779	27771.926
Pig slurry (a)	0.06	0.0048	(kg a – 1)	0	0	0	561.6	2762.6023	972.288	184.896	193.536	330.336
Cattle solid ma	0.25	0.0052	(kg a – 1)	0	0	1420.9	6000.8	23292.1	20967.96	24232.02	24397.337	26461.487
Pig solid manu	0.25	0.006	(kg a – 1)	0	0	0	0	9988.254	5926.7685	1411.5	273	0
Poultry manure	0.5	0.0175	(kg a – 1)	84875	65012.5	9362.5	49787.5	39523.75	30835	27212.5	12166.875	16852.5
Maize silage (a	0.35	0.0046	(kg a – 1)	18626.18	69486.908	94438.913	94254.23	129680.82	127987.61	98892.268	73453.957	65555.658
Grass silage (a	0.35	0.0094	(kg a – 1)	0	0	0	0	0	0	6757.66	296.1	341.29802
Straw (a)	0.86	0.0051	(kg a – 1)	0	0	0	0	634.5928	870.19994	368.6126	173.72069	112.0623
AR.feedstock total			**(kg a – 1)**	**103501.18**	**168134.37**	**129354.35**	**213788.72**	**312569.6**	**320497.14**	**329762.3**	**299693.58**	**474006.15**

Table 6.3.3 Calculation NH3 emissions for NFR 5B2Biological 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
NH3	0.0266	kg NH3-N per kg N in feedstock	kg	3343.088	5430.74	4178.146	6905.375	10096	10352.06	10651.32	9680.103	15310.4
			kt	0.003343	0.005431	0.004178	0.006905	0.010096	0.010352	0.010651	0.00968	0.01531

Recalculations and improvements:

- The emissions for the NFR 5B2Biological treatment of waste – anaerobic digestion at biogas facilities have been recalculated for 2019 year and for 2020 year.

6.8 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	0.264
1991	3.451
1992	6.639
1993	9.876
1994	13.112
1995	16.349
1996	19.585
1997	0.530
1998	26.058
1999	29.294
2000	32.531
2001	35.627
2002	38.058
2003	41.704
2004	55.328
2005	99.536

2006	20.058
2007	0.454
2008	0.745
2009	0.530
2010	0.564
2011	1.499
2012	2.353
2013	2.337
2014	1.633
2015	1.189
2016	3.195
2017	1.405
2018	4.177
2019	3.964
2020	2.628
2021	2.642

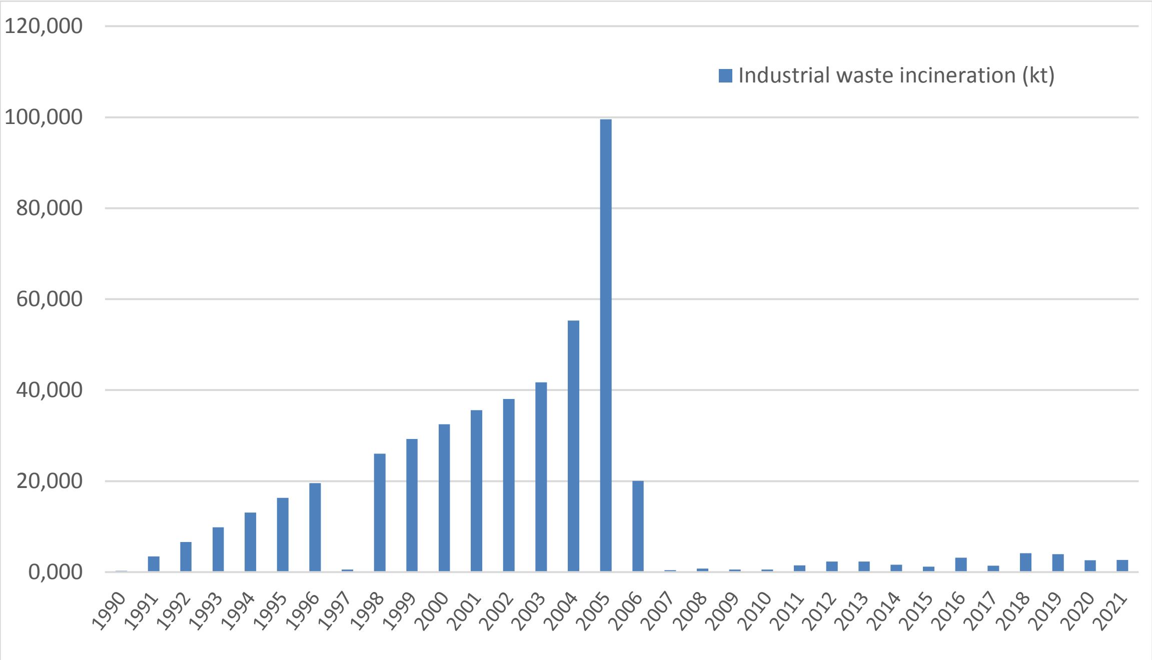

Figure 6.4.1 Activity data trends (*kt waste*) for NFR 5.C.1.b.i Industrial waste incineration

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	0.00023	0.00195	0.00034	0.09230
1991	0.00300	0.02554	0.00449	1.20800
1992	0.00578	0.04913	0.00863	2.32369
1993	0.00859	0.07308	0.01284	3.45645
1994	0.01141	0.09703	0.01705	4.58922

Year	NOx (kt)	NMVOC (kt)	Pb (t)	PCDD/F (g I-TEQ)
1995	0.01422	0.12098	0.02125	5.72198
1996	0.01704	0.14493	0.02546	6.85475
1997	0.01985	0.16888	0.02967	7.98751
1998	0.02267	0.19283	0.03388	9.12028
1999	0.02549	0.21678	0.03808	10.25304
2000	0.02830	0.24073	0.04229	11.38580
2001	0.03100	0.26364	0.04632	12.46961
2002	0.03311	0.28163	0.04948	13.32037
2003	0.03628	0.30861	0.05421	14.59631
2004	0.04814	0.40943	0.07193	19.36475
2005	0.08660	0.73656	0.12940	34.83743
2006	0.01745	0.14843	0.02608	7.02034
2007	0.00040	0.00336	0.00059	0.15905
2008	0.00065	0.00551	0.00097	0.26082
2009	0.00046	0.00392	0.00069	0.18550
2010	0.00049	0.00418	0.00073	0.19756
2011	0.00130	0.01110	0.00195	0.52477
2012	0.00205	0.01741	0.00306	0.82355
2013	0.00203	0.01729	0.00304	0.81795
2014	0.00142	0.01208	0.00212	0.57155
2015	0.00103	0.00880	0.00155	0.41615
2016	0.00278	0.02364	0.00415	1.11825
2017	0.00122	0.01040	0.00183	0.49175
2018	0.00363	0.03091	0.00543	1.46195
2019	0.00345	0.02933	0.00515	1.38740
2020	0.00228	0.01944	0.00341	0.91980
2021	0.00229	0.01955	0.00343	0.92470

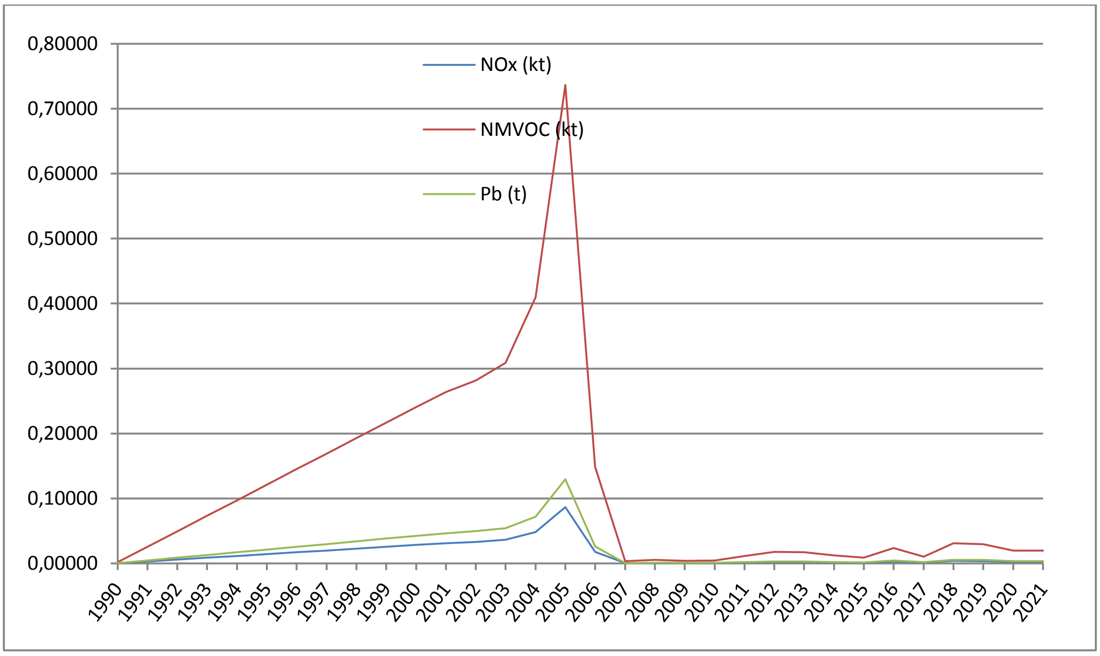

Figure 6.4.2.a. Emission trends (*Kt for NOx and NMVOC, t for Pb*)
for NFR 5.C.1.b.i Industrial waste incineration

Emission trends for NOx, NMVOC and Pb follow the waste incineration activity data trend.

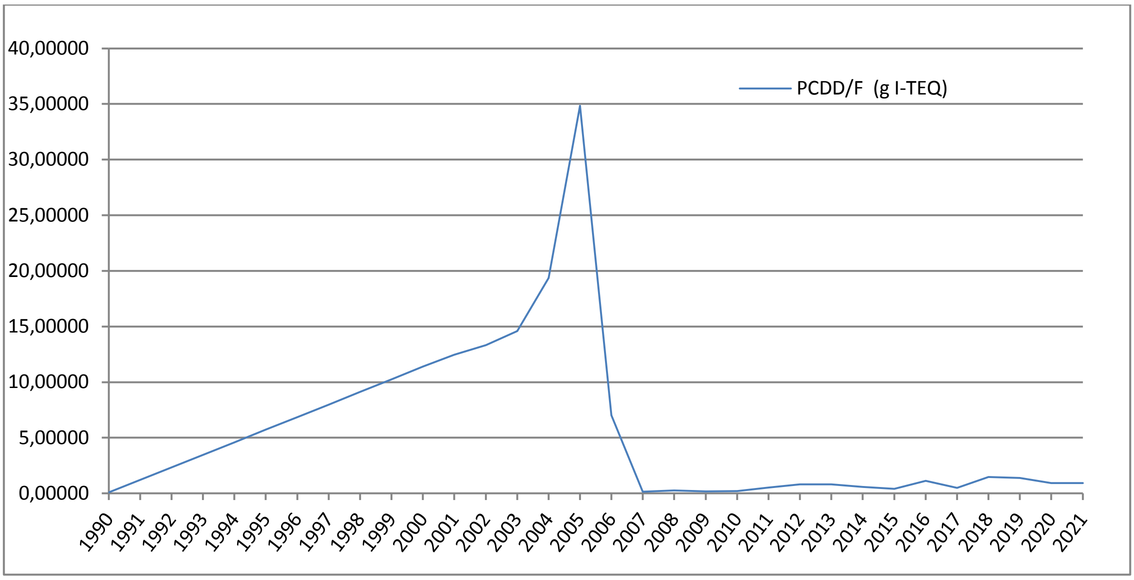

Figure 6.4.2.b. Emission trends (*g I-TEQ for PCDD/F)*
for NFR 5.C.1.b.i Industrial waste incineration

Emission trends for PCDD/F follow the waste incineration activity data trend.

Recalculations and improvements:

- For the 2020 year were revised the activity data and recalculated all the pollutants.

6.9 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: 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 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	2.1963
1991	2.2224
1992	2.2373
1993	2.2688
1994	2.3082
1995	2.3228
1996	2.3510
1997	2.6330
1998	3.6300
1999	10.1491
2000	15.0310
2001	19.0590
2002	17.0266
2003	18.7922
2004	17.0264
2005	13.5511
2006	12.6115
2007	9.9968
2008	6.4420
2009	4.7900
2010	5.4616
2011	5.1318
2012	5.8110
2013	5.9410
2014	6.5250
2015	7.3520
2016	8.0200
2017	9.3300
2018	9.8727
2019	10.7289
2020	13.3750
2021	17.779

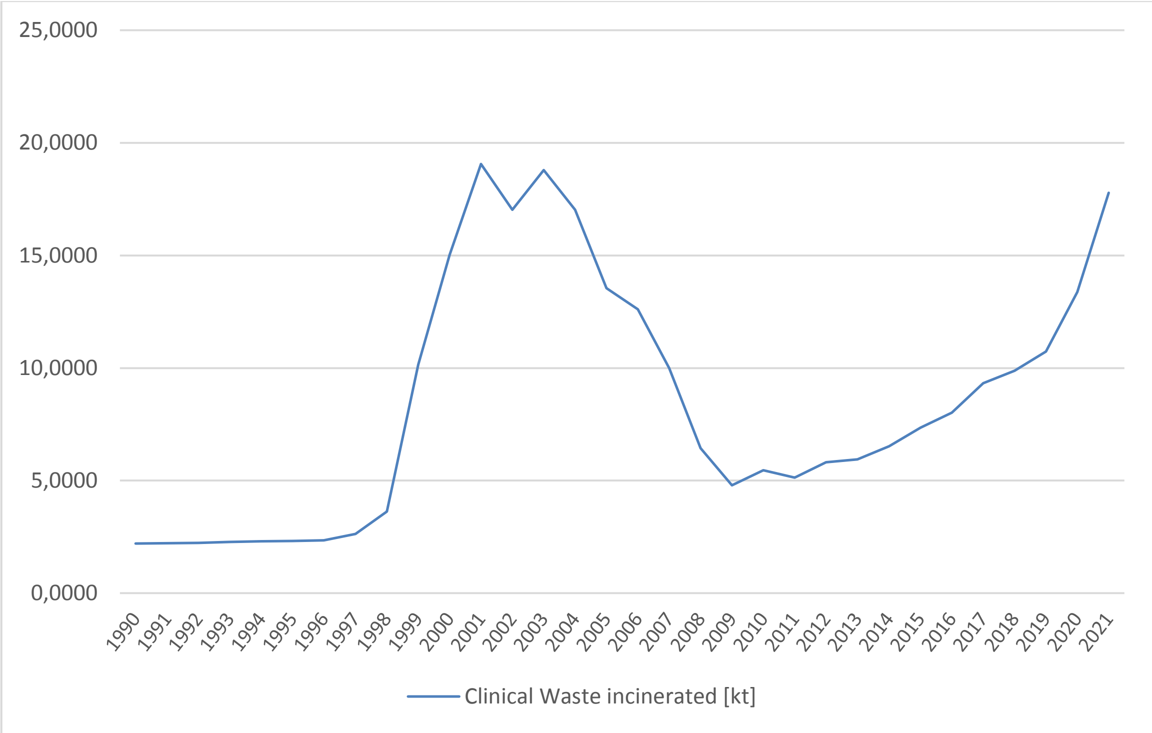

Figure 6.5.1 Trend data activity for 5.C.1.b.iii Clinical waste incineration (kt)

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
2016	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

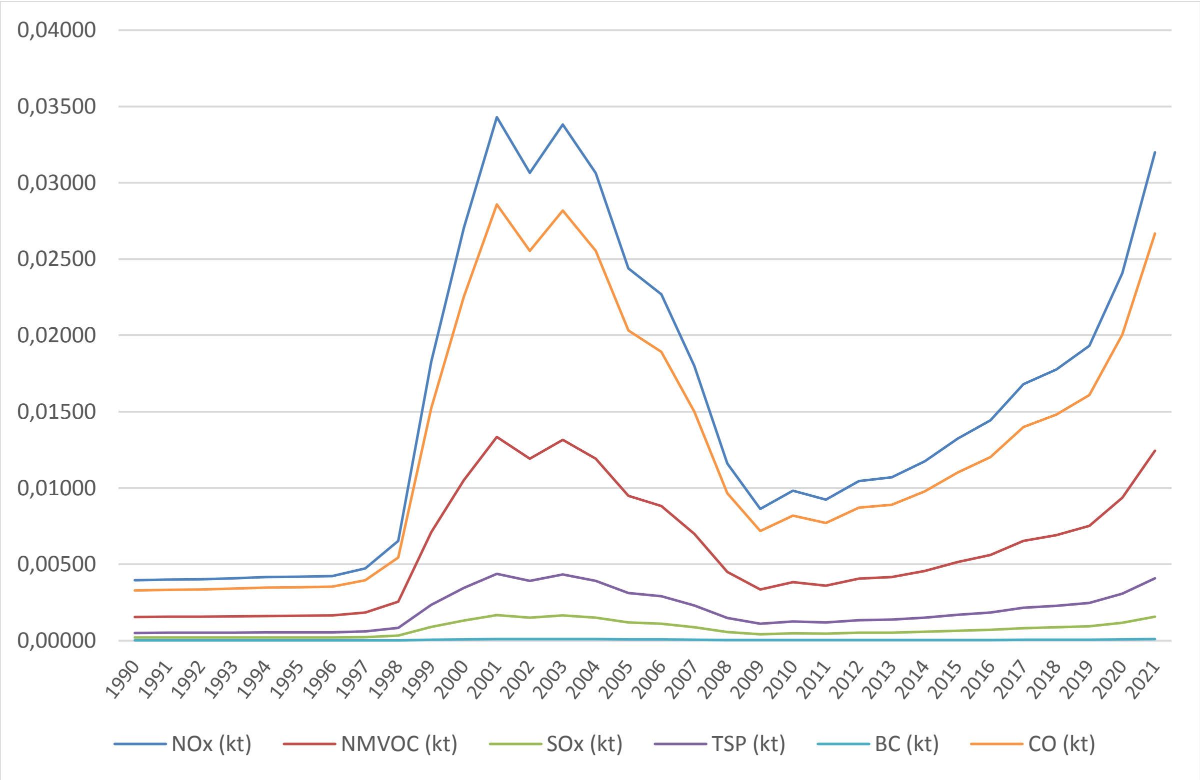

Figure 6.5.2 Trend Main Pollutants for 5.C.1.b.iii Clinical waste incineration (kt)

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

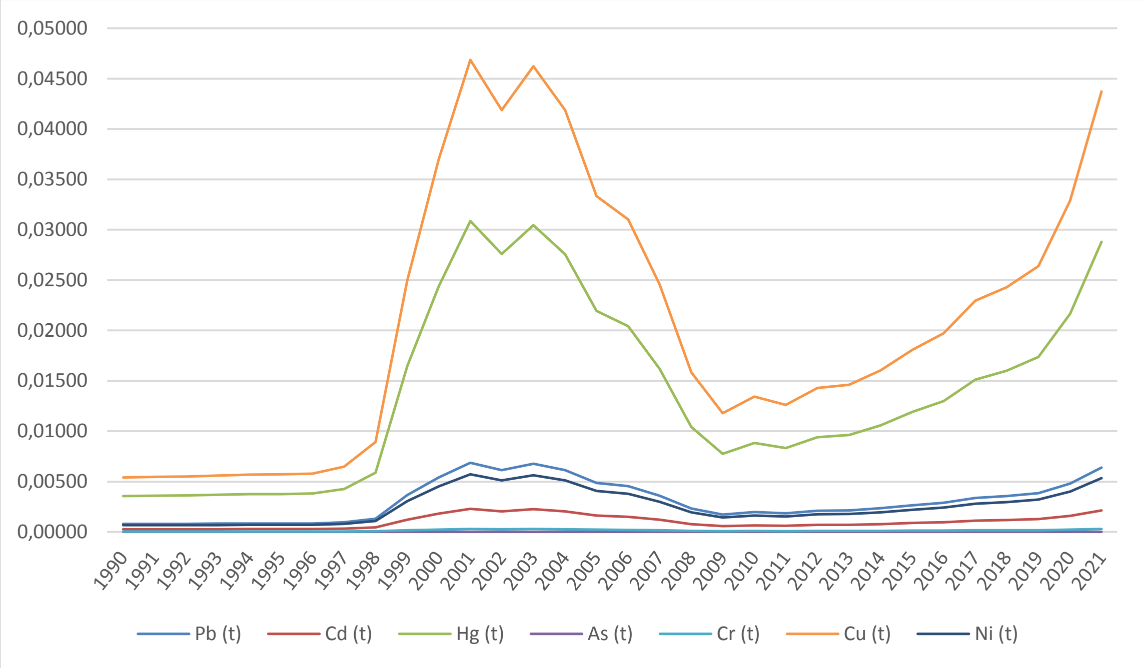

Figure 6.5.3 Trend Heavy Metals for 5.C.1.b.iii Clinical waste incineration (t)

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
2012	16.2708	0.000000232	0.5811
2013	16.6348	0.000000238	0.5941
2014	18.2700	0.000000261	0.6525

Year	PCDD/PCDF (g I-TEQ)	PAHs (t)	HCB (kg)
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

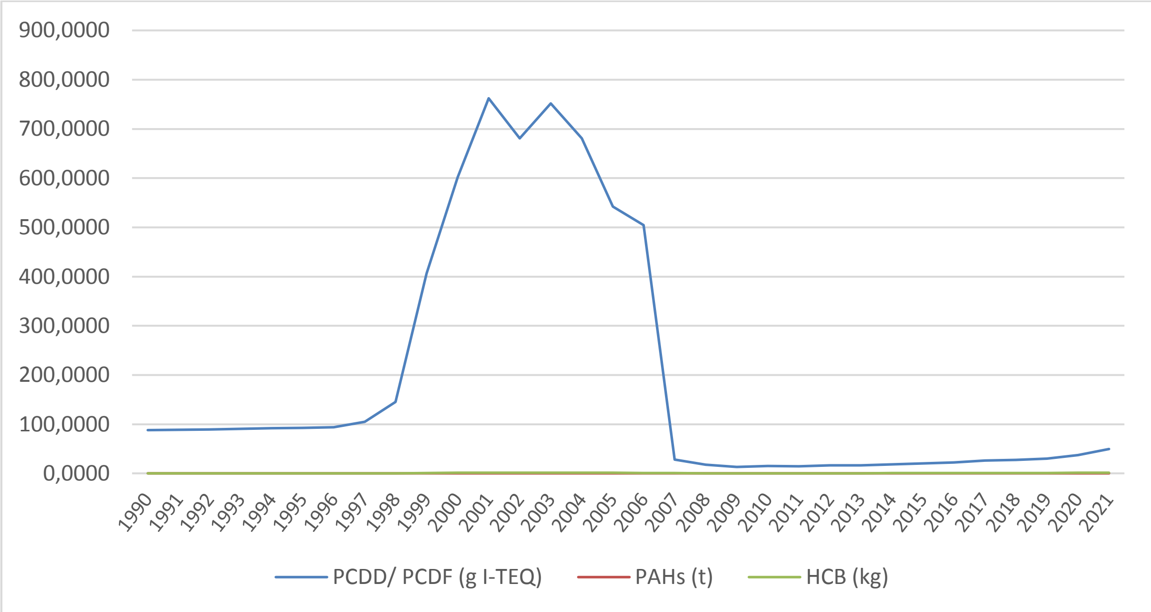

Figure 6.5.4 Trend POPs for 5.C.1.b.iii Clinical waste incineration

Emission trends for POPs follow the clinical waste incineration activity data trend.

PCDD/F emissions from this category are the key source, representing 23.63% of the total national emissions of PCDD/Fs in 2021.

HCB emissions from this category are the key source, representing 49.48% of the total national emissions of HCBs in 2021.

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

6.10 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 for the 1990-2020 period 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 (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
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

Year/Activity data	Corpses (number)
2020	2644
2021	2791

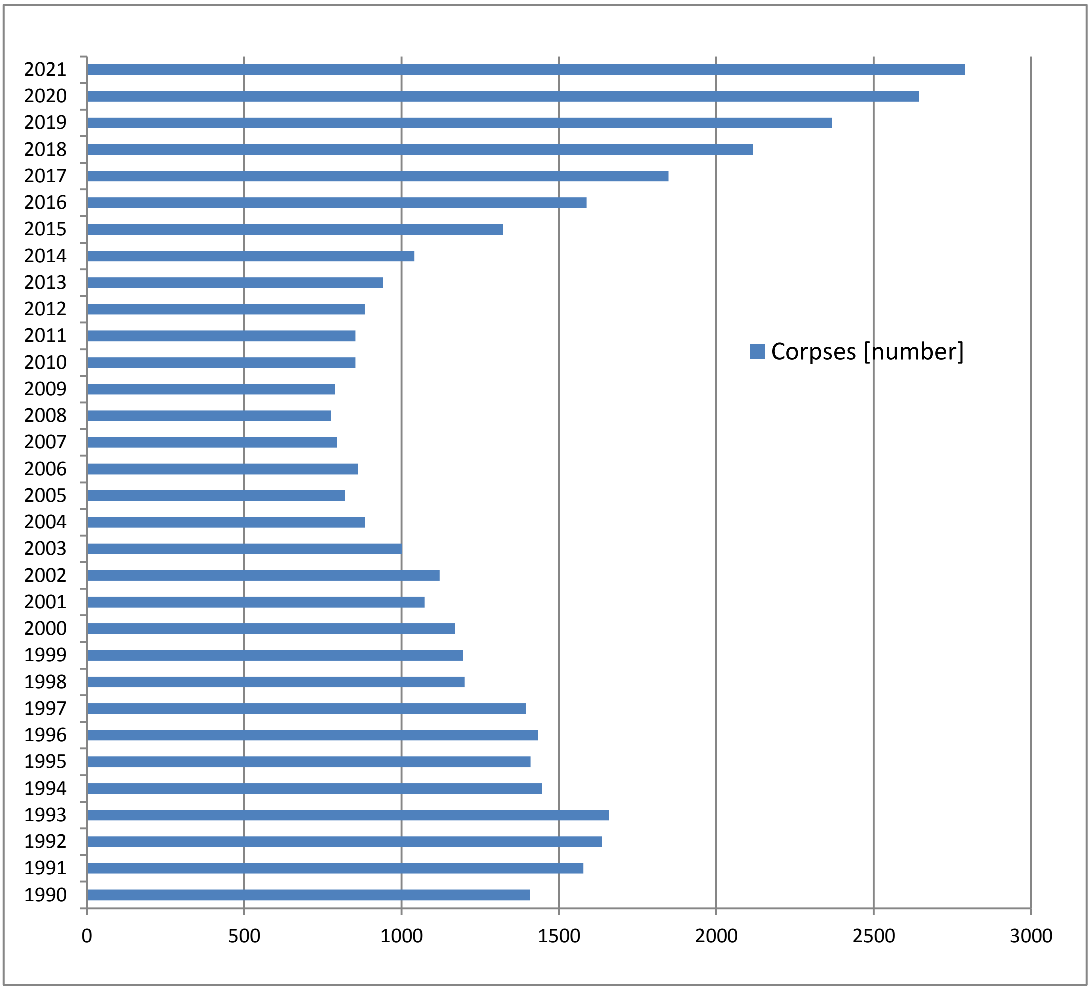

Figure 6.6.1 Activity data trends (*number corpses*) for NFR 5.C.1.b.v Cremation

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

Year	NOx (kt)	NMVOC (kt)	SOx_5 (kt)	$PM_{2.5}$ (kt)	Hg (t)
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

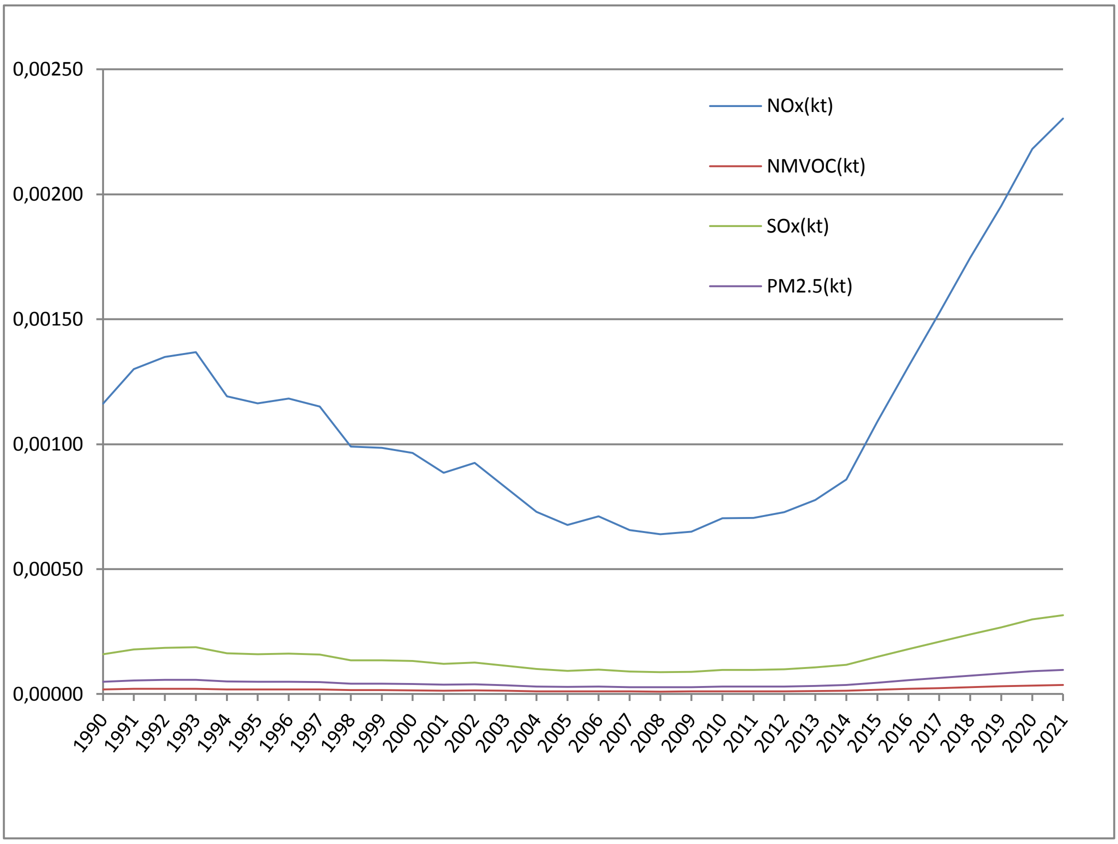

Figure 6.6.2.a. Emission trends (*Kt for NOx, NMVOC, $PM_{2.5}$ and SOx*)
for NFR 5.C.1.b.v Cremation

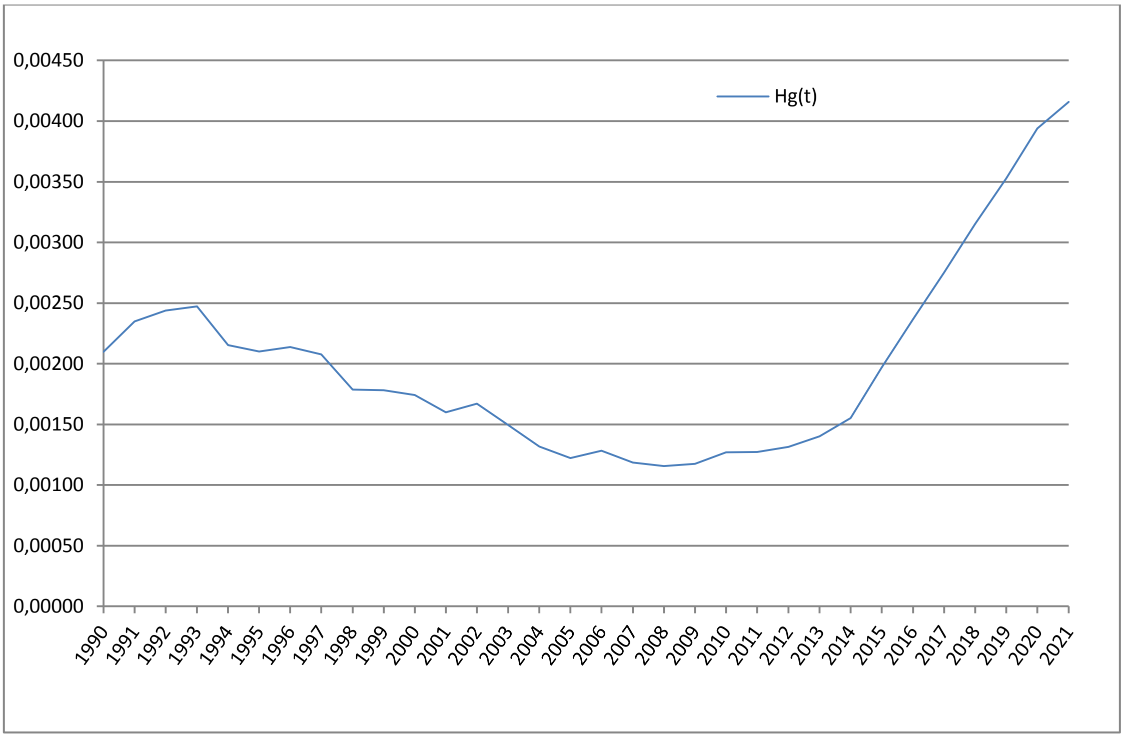

Figure 6.6.2.b. Emission trends (*t for Hg,*)
for NFR 5.C.1.b.v Cremation

The contribution of crematoria to national emissions is comparatively small for all pollutants.

There were no recalculations and improvements for this category.

6.11 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	142.600
1991	151.224
1992	144.347
1993	159.874
1994	163.939
1995	161.121
1996	146.070
1997	157.994
1998	148.015
1999	134.269
2000	141.380
2001	157.373
2002	150.952
2003	138.545
2004	156.635
2005	146.642
2006	127.860
2007	128.230
2008	130.268
2009	132.061
2010	126.016
2011	130.618
2012	136.007
2013	135.530
2014	136.080

Year	Amount of waste burned (kt)
2015	136.707
2016	137.174
2017	129.809
2018	131.429
2019	139.227
2020	133.451
2021	133.788

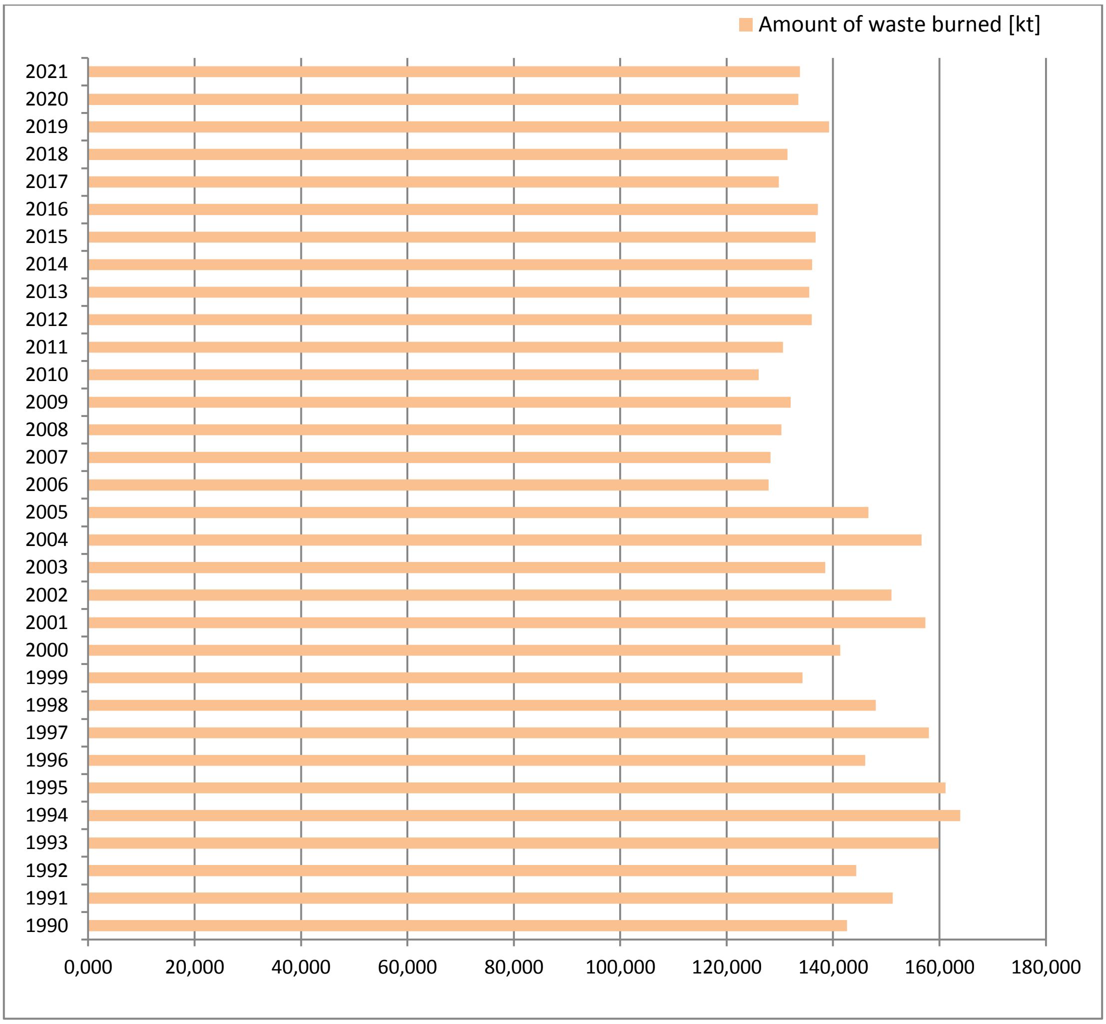

Figure 6.7.1 Activity data trends (*kt product*) for NFR 5.C.2 Small scale waste burning

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	0.4535	0.1754	0.5975	0.6431	1.4260	0.0087
1991	0.4809	0.1860	0.6336	0.6820	1.5122	0.0092
1992	0.4590	0.1775	0.6048	0.6510	1.4435	0.0088
1993	0.5084	0.1966	0.6699	0.7210	1.5987	0.0098
1994	0.5213	0.2016	0.6869	0.7394	1.6394	0.0100
1995	0.5124	0.1982	0.6751	0.7267	1.6112	0.0098
1996	0.4645	0.1797	0.6120	0.6588	1.4607	0.0089
1997	0.5024	0.1943	0.6620	0.7126	1.5799	0.0096
1998	0.4707	0.1821	0.6202	0.6675	1.4801	0.0090

Year	NOx (kt)	NMVOC (kt)	$PM_{2.5}$ (kt)	PM_{10} (kt)	PCDD/F (g I-TEQ)	Total PAHs (t)
1999	0.4270	0.1652	0.5626	0.6056	1.3427	0.0082
2000	0.4496	0.1739	0.5924	0.6376	1.4138	0.0086
2001	0.5004	0.1936	0.6594	0.7098	1.5737	0.0096
2002	0.4800	0.1857	0.6325	0.6808	1.5095	0.0092
2003	0.4406	0.1704	0.5805	0.6248	1.3855	0.0085
2004	0.4981	0.1927	0.6563	0.7064	1.5663	0.0096
2005	0.4663	0.1804	0.6144	0.6614	1.4664	0.0089
2006	0.4066	0.1573	0.5357	0.5767	1.2786	0.0078
2007	0.4078	0.1577	0.5373	0.5783	1.2823	0.0078
2008	0.4143	0.1602	0.5458	0.5875	1.3027	0.0079
2009	0.4200	0.1624	0.5533	0.5956	1.3206	0.0081
2010	0.4007	0.1550	0.5280	0.5683	1.2602	0.0077
2011	0.4154	0.1607	0.5473	0.5891	1.3062	0.0080
2012	0.4325	0.1673	0.5699	0.6134	1.3601	0.0083
2013	0.4310	0.1667	0.5679	0.6112	1.3553	0.0083
2014	0.4327	0.1674	0.5702	0.6137	1.3608	0.0083
2015	0.4347	0.1681	0.5728	0.6165	1.3671	0.0083
2016	0.4362	0.1687	0.5748	0.6187	1.3717	0.0084
2017	0.4128	0.1597	0.5439	0.5854	1.2981	0.0079
2018	0.4179	0.1617	0.5507	0.5927	1.3143	0.0080
2019	0.4427	0.1712	0.5834	0.6279	1.3923	0.0085
2020	0.4243	0.1641	0.5591	0.6018	1.3345	0.0081
2021	0.4254	0.1645	0.5605	0.6033	1.3378	0.0081

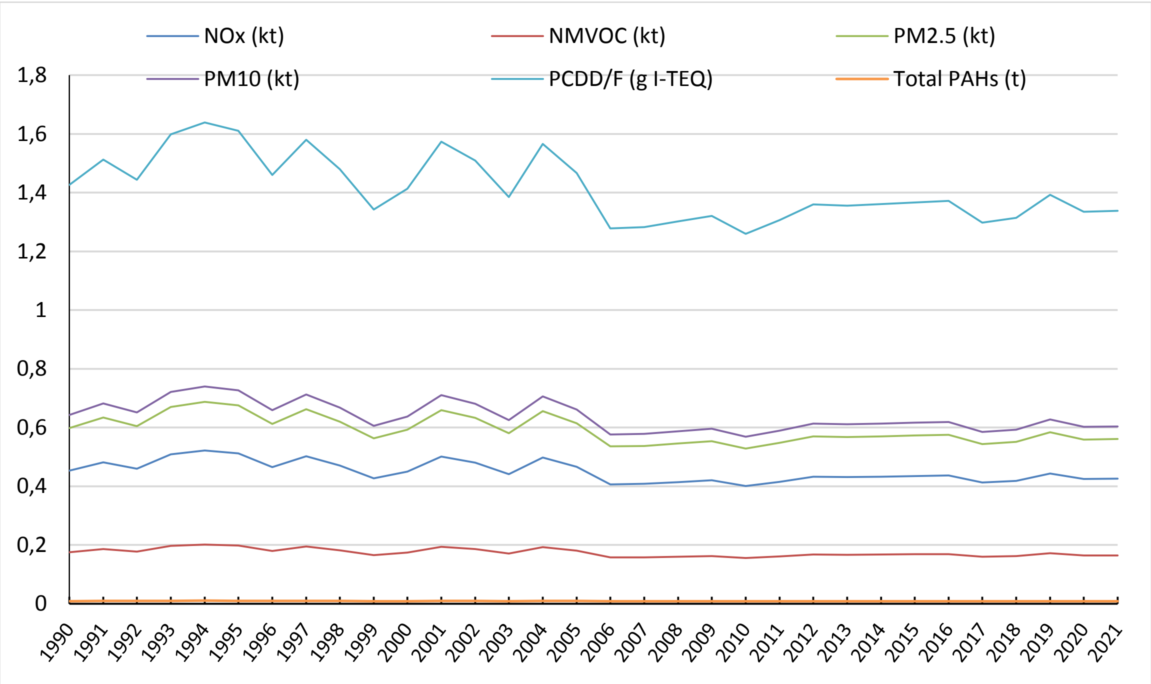

Figure 6.7.2 Emission trends (*kt for NOx, NMVOC, $PM_{2.5}$ and PM_{10}, g I-TEQ for PCDD/F and t for Total PAHs*) for NFR 5.C.2 Small scale waste burning

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:

For the 2020 year were revised the activity data and recalculated all the pollutants.

6.12 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.

New calculation algorithm for latrines (NH3 emissions) – review RO-5D3-2022-0001

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
1994	2094070
1995	1976470
1996	1996000
1997	3137220
1998	2050930
1999	2092970
2000	2020840
2001	1679670
2002	2031810
2003	1559910
2004	1484200
2005	1432288
2006	1230988
2007	1417751
2008	1249768
2009	1394457
2010	1291500
2011	1471220
2012	1577620
2013	1977613
2014	1581360.13
2015	1578513.36
2016	1619318.61
2017	2146200
2018	2151350
2019	2188540
2020	1553760
2021	1673350

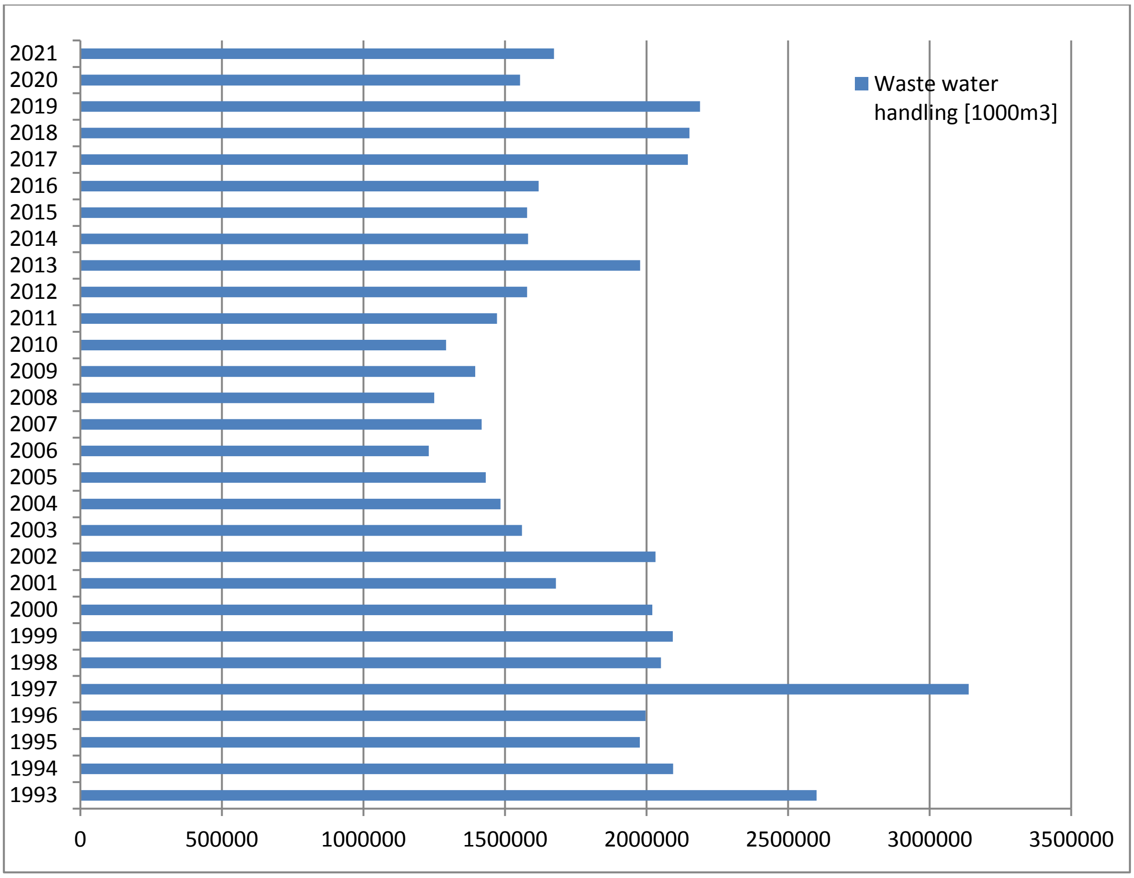

Figure 6.8.1 Activity data trends (*water handling 1000 m^3*) for NFR 5.D.3 Wastewater handling

Table 6.8.2 Emission trends *(kt for NMVOC)* for NFR 5.D.3 Wastewater handling

Year	NMVOC (kt)
1993	0.03900
1994	0.03141
1995	0.02965
1996	0.02994
1997	0.04706
1998	0.03076
1999	0.03139
2000	0.03031
2001	0.02520
2002	0.03048
2003	0.02340
2004	0.02226
2005	0.02148
2006	0.01846
2007	0.02127
2008	0.01875
2009	0.02092
2010	0.01937
2011	0.02207
2012	0.02366
2013	0.02966
2014	0.02372
2015	0.02368

Year	NMVOC (kt)
2016	0.02429
2017	0.03219
2018	0.03227
2019	0.03283
2020	0.02331
2021	0.02510

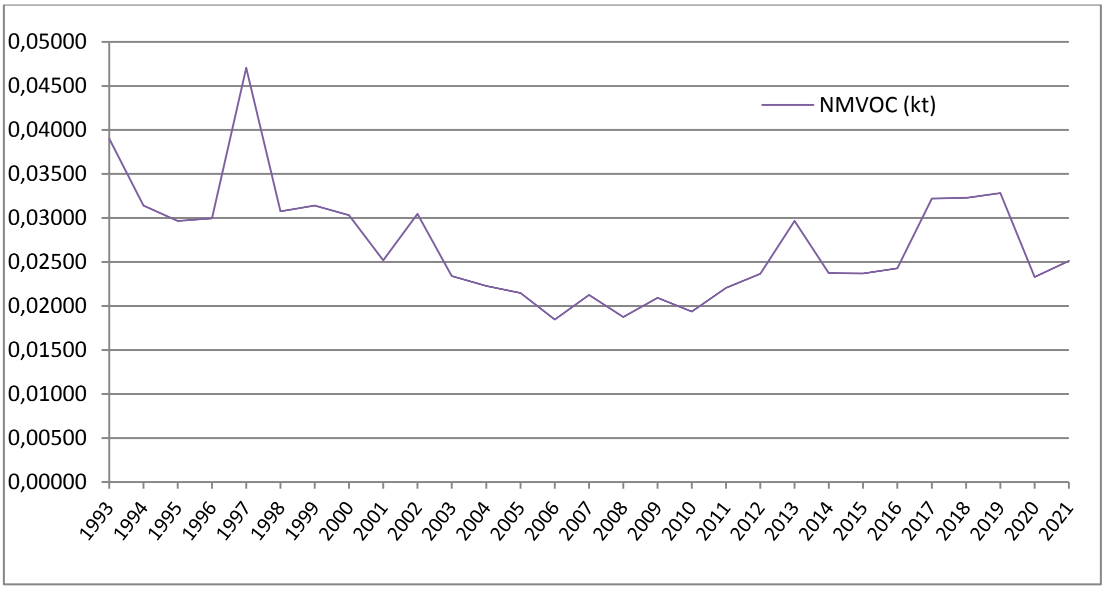

Figure 6.8.2 Emission trends (*kt for NMVOC*) for NFR 5.D.3 Wastewater handling

The NMVOC emissions from NFR 5.D.3 - wastewater handling follow the activity data trend.

Table 6.7.3 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

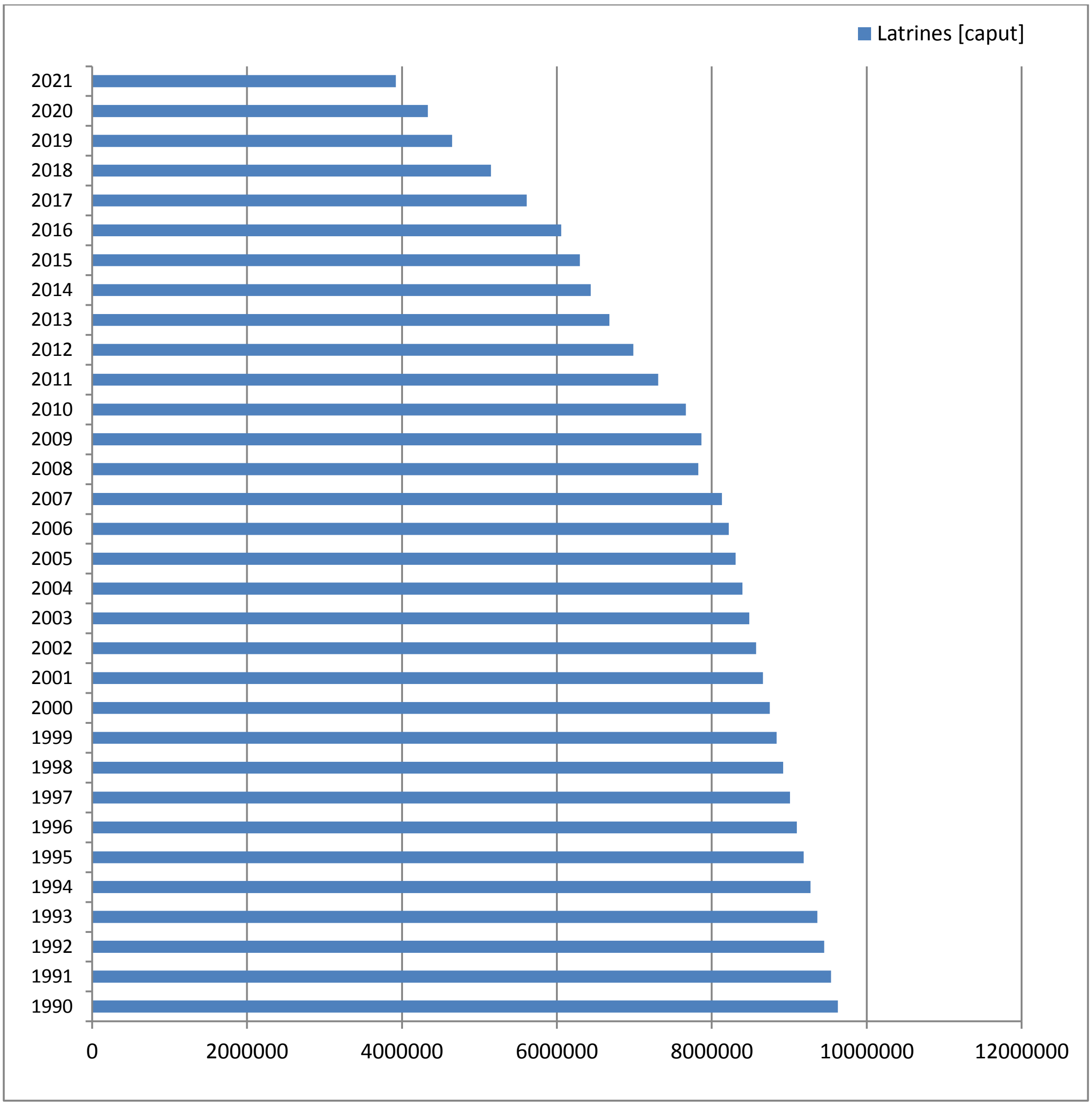

Figure 6.8.3 Activity data trends (*caput*) for NFR 5.D.3 Wastewater handling-Latrines

Table 6.8.4 Emission trends (*kt for NH_3*) for NFR 5.D.3
Wastewater handling-Latrines

Year/Pollutant	NH_3 (kt)
1990	15.40276
1991	15.26208
1992	15.12139
1993	14.98070
1994	14.84002
1995	14.69933
1996	14.55864
1997	14.41796
1998	14.27727
1999	14.13658
2000	13.99590
2001	13.85521
2002	13.71452
2003	13.57384
2004	13.43315
2005	13.29247
2006	13.15178
2007	13.01109
2008	12.52171
2009	12.58591
2010	12.26217
2011	11.69467
2012	11.18195
2013	10.68746
2014	10.29926
2015	10.07499
2016	9.69191
2017	8.97839
2018	8.23728
2019	7.43517
2020	6.93596
2021	6.27510

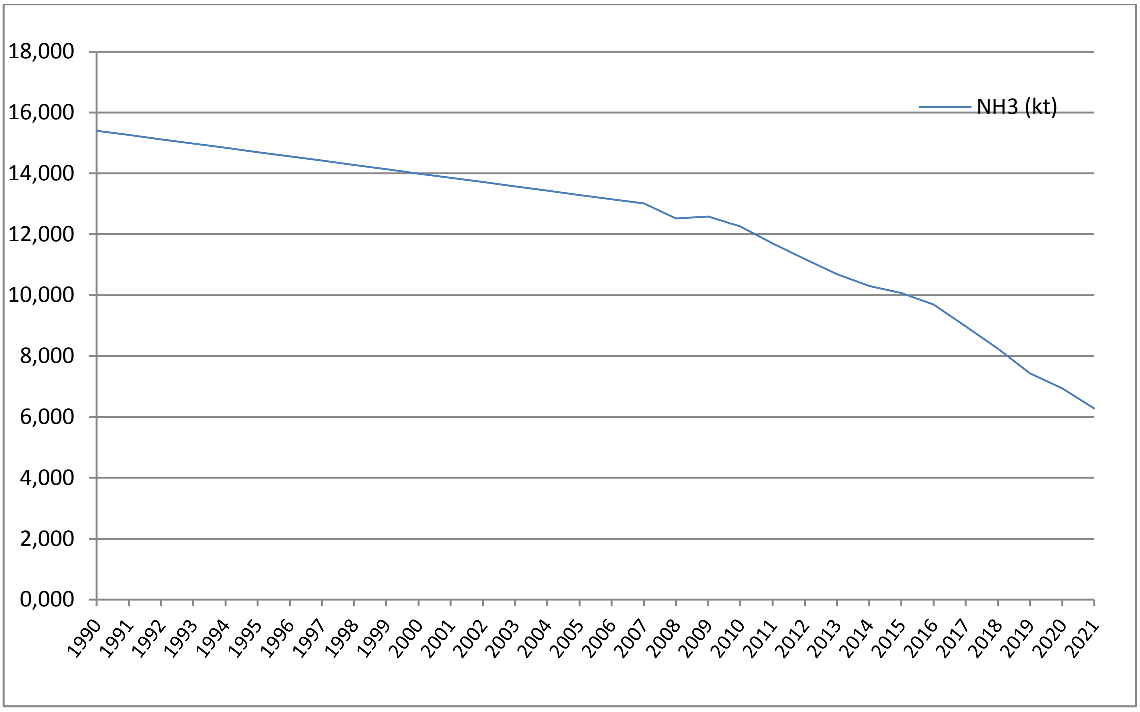

Figure 6.8.4 Emission trends (*kt for NH_3*) for NFR 5.D.3
Wastewater handling-Latrines

The NH_3 emissions from NFR 5.D.3. – latrines, decreased compared to 1990 emission data and follow the activity data trend.
NH3 emissions from this category are the key source, representing 3.96% of the total national emissions of NH_3 in 2021.
Recalculations and improvements:

- New calculation algorithm for the NFR 5.D.3. Wastewater handling- Latrines for SNAP 091007
- latrines (NH3 emissions) for 1990-2021 time period– review RO-5D3-2022-0001

6.13 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 (car fire and house fire)

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

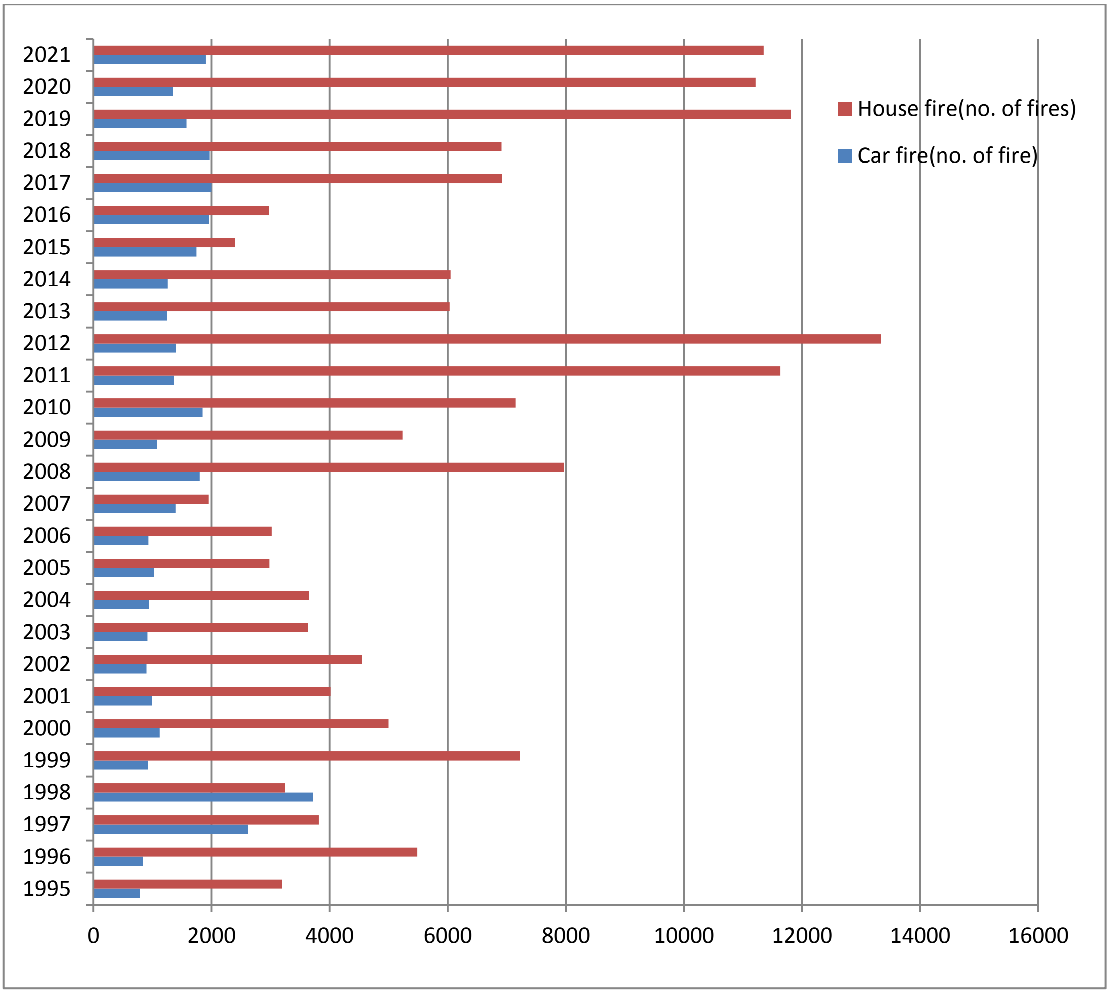

Figure 6.9.1 Activity data trends (*no. of fire*) for NFR 5.E. Other waste (car fire and house fire)

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

Emission trends for $PM_{2.5}$ follow the activity data (car fires and house fires) trend.

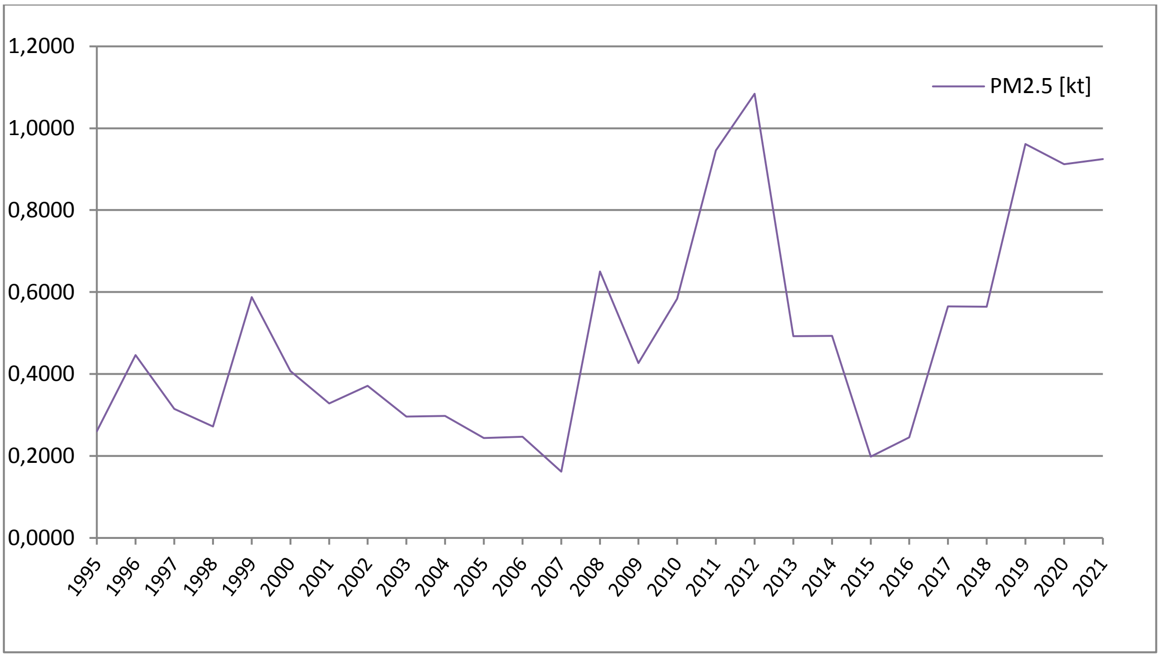

Figure 6.9.2 Emission trends (*kt for $PM_{2.5}$*) for NFR 5.E. Other waste (car fire and house fire)

Emission trends for heavy metals follow the activity data (car fires and house fires) trend.

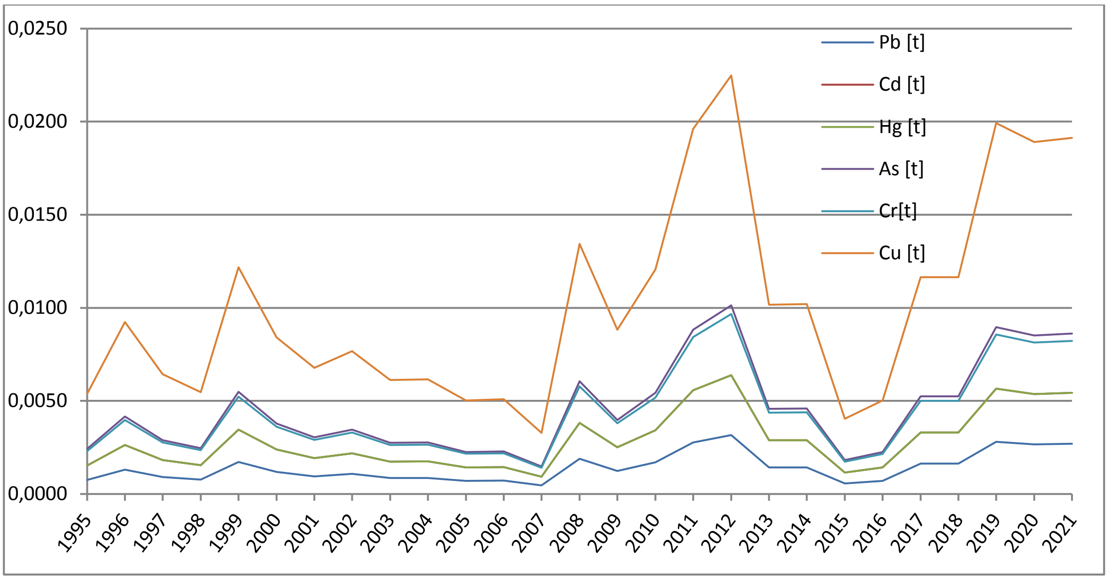

Figure 6.9.3 Emission trends (*t for heavy metals)* for NFR 5.E.
Other waste (car fire and house fire)

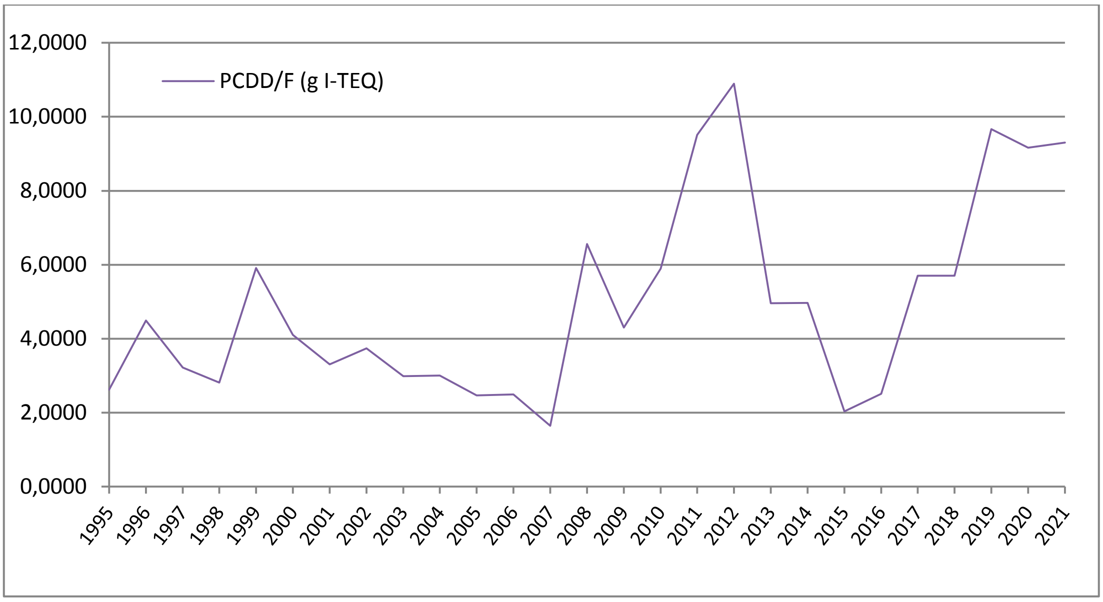

Figure 6.9.4 Emission trends (g I-TEQ for PCDD/F) for NFR 5.E.
Other waste (car fire and house fire)

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.

There were no recalculations and improvements for this category.

Recalculations and improvements:

For the 2020 year were revised the activity data and recalculated all the pollutants

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 Review in 2017-2021, large part of recommendations from TERT were assessed and implemented.
Significant recalculations and improvements were developed on the following categories:

NFR	Timeseries	Pollutants	Reason
1A1c	1990-2020	PM10, TSP, BC	Correction of emission factors.
1A2f	2005-2020	All	Recalculation with Tier 2 approach (Review RO-1A2f-2022-0001
1A3a	2017-2020	NOx, NMVOC, SOx, PM, CO	Data update by Eurocontrol for 2017-2020.
1A3bi-1A3biv	1991-2004	NOx, NMVOC, NH3, PM2.5, PM10, TSP, BC, CO, Pb, PAHs	Changed EFs for 1990-2004 applying a linear regression between maxim Tier 1 EFs (the year 1990) and the COPERT 5.6.1 EFs (the year 2005).
1A3bi-1A3biv	2000-2004	SO2	Correction of error in SO2 emission estimation based on sulphur content in fuels.
1A3bi-1A3bvii	2005-2020	All	Recalculated using COPERT 5.6.1 and national NCV, changed fuel consumption for 2009-2011 and 2013.
1A4cii	1992-2020	SOx	Slight correction of emissions from gasoline.
1B2aiv	1990-2020	Benzo(a), benzo(b), benzo(k), indeno, Total PAH	Error in the calculation unit of measure.

2D3a	1990-2020	NMVOC	Recalculated using AD=population EUROSTAT and EF from ESIG.
2D3b	1990-2020	NMVOC, PM2.5, PM10, TSP	Recalculation with Tier 2 approach (Review RO-2D3b-2022-0002)
2D3g	1990-2020	NMVOC	Activity data update (new SNAP 060301) / recalculation.
2D3h	2018; 2020	NMVOC	Correction of activity data (total solvents).
2D3i	1990-2020	NMVOC	Activity data update by EUROSTAT (total population for 1991-2001 and 2013, 2014, 2018, 2020). Correction of activity data (total solvents) for 2019 and 2020. New calculation algorithm for time 1990-2007 for SNAP 060404 (activity data - total edible oils) by N.I.S. / recalculation.
2G	2008-2020	NMVOC	Activity data update for SNAP 060603, “Use of shoes” activity.
2H2	1990-2020	NMVOC	Correction of the activity data with new SNAP, recalculation the NMVOC emissions.
3B2	2020	NMVOC	Error in the calculation.
3B3	1990-2004	NH3	Recalibration with new version of “N-flow tool –Jan 2021” values.
3B4gii	1990-2020	NOx, NMVOC, NH3, PM2.5, PM10, TSP	Activity data changed by decreasing the number of poultry corresponding to NFR 3B4giii, 3B4giv.
3B4giii	1990-2020	NOx, NMVOC, NH3, PM2.5, PM10, TSP	New activity data calculation for 1990-2018 and recalculation for 2019- 2020.
3B4giv	1990-2020	NOx, NMVOC, NH3, PM2.5, PM10, TSP	New activity data calculation for 1990-2018 and recalculation for 2019-2020.
3Da1	2019, 2020	NH_3	Activity data update by IFA.
3Da2a	1990-2020	NMVOC, NH_3	Activity data changed by decreasing the number of poultry corresponding to NFR 3B4giii, 3B4giv.
3Da3	1990-2020	NMVOC, NH_3	Activity data changed by decreasing the number of poultry corresponding to NFR 3B4giii, 3B4giv.

5A	2020	NMVOC	Correction of activity data (total CH4).
5B2	2019-2020	NH_3	Correction of activity data.
5C1bi	2020	All	Correcting of activity data/recalculating of all pollutant emissions.
5C2	2020	All	Activity data update by N.I.S./recalculation all pollutant emissions.
5D3	1990-2020	NH_3	New calculation algorithm for latrines (NH3 emissions) – review RO-5D3-2022-0001.
5E	2020	All	Activity data update by IGSU (General Inspectorate for Emergency Situations of Romania).

8.2 Planned improvements

Improvements, for the next submission, will include:

- studying the possibility of obtaining activity data for historical time series for the calculation of pollutant emissions using the Tier 2 methodology for solvents sector;
- 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 2022 and the comments of Romania on the recommendations are presented below:

8.3 NECD Recommendations

All recommendations, revised estimates, technical corrections and unquantified potential technical corrections including those additionally made during the NECD Review 2022 and those not implemented from previous reviews.

Table 8.3.1 Recommendations from the NECD Review 2022

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
RO-1A1-2022 - 0001	No	1A1 Energy Production, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, PM_{10}, BC, TSP, 1990-2020	For 1A1 Energy Production and all pollutants and all years, the TERT noted that there is a lack of transparency as the NFR does not provide information on where the 'Other fuels' (in the NFR 'IE' is used) are included, for what reasons this is done and how this relates to the emission factors used. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Romania explained that no other fuel is used for these sources and rather than leaving a blank cell the notation key 'IE' was used and that this will be corrected to 'NO'. The TERT recommends that the use of the notation key 'NA' is more appropriate in this case as the process does exist (there are emissions for the source category) but only the specific fuel is not used, and to correct this in the next submission.	Yes	1.8. General Assessment of Completeness
RO-1A1a-2022 - 0001	Yes	1A1a Public Electricity and Heat Production, SO_2, 1990-2020	For 1A1a Public Electricity and Heat Production and all pollutants for all years, the TERT noted that there is a lack of transparency as the NFR does not provide information on where the 'Other fuels' (in the NFR 'IE' is used) are included in, for what reasons this is done and how this relates to the emission factors used. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Romania explained that no other fuel is used for these sources and rather than leaving a blank cell the notation key 'IE' was used and that this will be corrected to 'NO'. The TERT recommends that the use of the notation key 'NA' is more appropriate in this case as the process does exist (there are emissions for the source category) but only the specific fuel isn’t used, and to correct this in the next submission.	Yes	1.8. General Assessment of Completeness
RO-1A1-2022 - 0002	No	1A1 Energy Production, SO2, NOX, NH3,	For 1A1 Energy production, 1A2 Stationary Combustion in Manufacturing Industries and Construction, 1A4ai Commercial/institutional: Stationary, 1A4bi	Yes	1.8. General Assessment of

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
		NMVOC, PM2.5, 1990-2020	Residential: Stationary and 1A5a Other, Stationary (Including Military) for all years, the TERT noted that there are “zeros” reported for several activity data. This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Romania explained that this was mistakenly done to highlight that no fuels were reported in the Energy Balance and that no guidance on reporting “zero” was found in the 2019 EMEP/EEA Guidebook and that this will be corrected by using 'NO'. The TERT recommends that the use of the notation key 'NA' is more appropriate in these cases as the process does exist (there are emissions for the source category), but the specific fuel is not reported, and to correct this in the next submission**.**		Completeness
RO-1A2f-2022 - 0001	Yes	1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-Metallic Minerals, SO_2, NO_X, 1990-2020	For 1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-Metallic Minerals, all fuels used and SO_2 and NO_X (but also Pb and Hg) and years 1990-2020 the TERT noted that a Tier 1 methodology is used for a Key Category. In response to a question raised during the review, Romania explained that there is a lack of information on activity data and that in 2022 research will be done to see if information is available about the facilities/technologies used in this activity. Based on this study, Romania will assess whether the available data are relevant and sufficient for a higher-level estimate. Romania submitted a revised estimate for the years 2005, 2018-2020 for this source, based only on natural gas and Tier 2 EFs from non-residential 1-50 MWth boilers. However, the TERT notes that the shares in the use of liquid, solid and gaseous fuels are in the same order of magnitude in 2020 and that the impact on NO_X and SO_X from liquid and solid fuels will probably exceed by far those from natural gas and thus the TERT notes that this revised estimate is insufficient as continuing with the use of Tier 1 emission factors could be related to an over-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 issue is flagged as a recommendation only, however the TERT strongly recommends that Romania develop a higher Tier method for NO_X and SO_X (and not limited to these two pollutants), and emissions from 1A2f Stationary Combustion in Manufacturing Industries and Construction: Non-Metallic Minerals are included in next year's inventory submission.	Yes	3.5.2 NFR 1.A.2.f. Non-metallic minerals. Stationary combustion

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
RO-1A3bi -2022 - 0001	No	1A3bi Road Transport: Passenger Cars, SO_2, 2005	For category 1A3bi Road Transport: Passenger Cars, liquid fuel and SO_2 for 2005, the TERT noted that there is a lack of transparency regarding the SO_2 emission, which is statistically greater than emissions between 2000 -2010. The TERT also suspected a potential error in reported fuel consumption, NCV or in sulphur content for the 2005-2010 time series. In response to a question raised during the review, Romania explained that it has not identified any errors in the reported fuel consumption and/or in the used NCV for this category. Romania stated that the observation will take into account and the input data will be checked and, if any errors found, it will correct them in the 2023 submission. The TERT recommends that Romania to check reported apparent sulphur content, NCV and fuel consumption for its next submission.	Yes	3.13 NFR 1.A.3.b Road transport
RO-1A3bii -2022 - 0001	No	1A3bii Road Transport: Light Duty Vehicles, NMVOC, 2005	For category 1A3bii Road Transport: Light Duty Vehicles, liquid fuel and NMVOC for 2005, the TERT noted that there is a lack of transparency regarding the NMVOC emission, which is statistically greater than emissions between 2000 -2010. The TERT also suspected a potential error in reported fuel consumption or NCV for the 2005-2010 time series. In response to a question raised during the review, Romania explained that it has not identified any errors in the reported fuel consumption and/or in the used NCV for this category. Romania stated that the observation will be taken into account and the input data will be checked and, if any errors found, it will correct them in the 2023 submission. The TERT recommends that Romania to check reported NCV and fuel consumption for its next submission.	Yes	3.13 NFR 1.A.3.b Road transport
RO-1A3bii -2022 - 0002	No	1A3bii Road Transport: Light Duty Vehicles, SO_2, 2005	For category 1A3bii Road Transport: Light Duty Vehicles, liquid fuel and SO_2 for 2005, the TERT noted that there is a lack of transparency regarding the SO_2 emission, which is statistically greater than emissions between 2000 -2010. The TERT also suspected a potential error in reported fuel consumption, NCV or in sulphur content for the 2005-2010 time series. In response to a question raised during the review, Romania explained that it has not identified any errors in the reported fuel consumption and/or in the used NCV for this category. Romania stated that the observation will be taken into account and the input data will be checked and, if any errors found, it will correct them in the 2023 submission. The TERT recommends that Romania to check reported apparent sulphur content, NCV and fuel consumption for its next submission.	Yes	3.13 NFR 1.A.3.b Road transport

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
RO-2-2022-0001	No	2 Industry, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, CO, 1990-2022	The TERT noted with reference to NFR categories 2B1 Ammonia Production, 2B2 Nitric Acid Production, 2B10a Chemical Industry: Other, 2C3 Aluminium Production, 2C5 Lead Production, 2C6 Zinc Production, pollutants SO_X, NO_X, NH_3, NMVOC, $PM_{2.5}$, CO and IIR pages 54-55 as well as 2019 EMEP/EEA Guidebook chapters for these NFR categories that these pollutants are reported using the notation key 'NE' (not estimated) and that in the IIR it is stated that the reason is related to lack of emission factors in the 2019 EMEP/EEA Guidebook. The TERT notes that in case no default methods are provided in the 2019 EMEP/EEA Guidebook, no process related emissions are expected, and such pollutants can be reported as 'NA' (not applicable) if no country-specific information is available. To the question on the issue Romania responded that they will change the notation key to 'NA'. The TERT recommend Romania to change the notation keys and to add the related documentation in the IIR, to improve the transparency of reporting in the next submission.	Yes	1.8. General Assessment of Completeness
RO-2-2022 -0002	No	2 Industry, NA, 1990-2022	The TERT noted with reference to NFR tables and related documentation in IIR 2022 that it is not clear if the following sources exist or not in Romania: 2J Production of POPs, 2K Consumption of POPs and heavy metals (e.g. electrical and scientific equipment) and 2L Other production, consumption, storage, transportation or handling of bulk products. The lack of transparency is related to not reporting the notation key 'NO' (not occurring) but instead 'NA' (not applicable) and 'NE' (not estimated). To the question on the issue Romania responded that they will replace the notation keys ‘NA’ and ‘NE’ from NFR 2J and 2L with ‘NO’ for 1990-2020 in the 2023 submission. For NFR 2K they will start an analysis and will report according to the research results in the next submission. The TERT recommend Romania to change the notation keys to follow the definitions in Reporting Guidelines paragraph 12 and to include the related explanation in the IIR. The TERT also recommends Romania to identify any missing activities under category 2K and to estimate and report the possibly missing emissions, or to use the proper notation key and in both cases to document the cases in the IIR in the next submission.	Yes	1.8. General Assessment of Completeness
RO-2C7b -2022-0001	No	2C7b Nickel production, NA, 1990-2022	For 2C7b Nickel Production for all years, the TERT noted with reference to the IIR that there is a lack of transparency regarding if the activity exists in Romania as the IIR does not provide any information on category 2C7b. In response to a question raised during the review, Romania confirmed that the activity does not occur in Romania, and that the notation key will be changed to 'NO' (not occurring). The TERT recommends Romania to change the notation keys and to include the related	Yes	1.8. General Assessment of Completeness

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
			explanations in the IIR in the next submission.		
RO-2C7c-2022 - 0001	No	2C7c Other Metal Production, NA, 1990-2022	The TERT noted with reference to category 2C7c Other Metal Production and the IIR that there is a lack of transparency regarding if the activity exists in Romania. The IIR does not provide any information on category 2C7c. The TERT is unable to determine whether there is an under-estimate that may be above the threshold of significance for a technical correction. In response to a question raised during the review, Romania clarified that they study the possibility to identify the activity data related to the other metal production and will report in accordance with the research results. The TERT recommends Romania to carry out the study and to quantify and report emissions of possibly occurring activities in the next submission or report on the progress.	Yes	1.8. General Assessment of Completeness
RO-2D-2022 - 0001	Yes	2D Non-Energy Products From Fuels and Solvent Uses, NMVOC, 1990, 2020	For categories of 2D Non-Energy Products from Fuels and Solvent Uses and NMVOC, the TERT noted that there is a lack of transparency regarding the methods used for the assessment of the uncertainty, which is provided in Romania's IIR 2022, Table Uncertainty estimation of NMVOC emissions 1990 and 2020 (pages 37-40). This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review, Romania explained that the uncertainty assessment of 2D category NMVOC emissions is based on default values provided by the 2019 EMEP/EEA Guidebook, Chapter 5 Uncertainties, Table 2-1. 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. The uncertainty associated with the emission factors was calculated based on the average of the upper and lower estimates of the 95% confidence interval provided for each EF (2019 EMEP/EEA Guidebook, Chapter 2.D-2L Other solvent and product use, several Tables). Furthermore, Romania informed that the results of the uncertainty assessment were gained in the NECD Capacity Building Project - Uncertainty workshop. The TERT recommends Romania include more information on uncertainties in line with the information provided to the TERT in the next IIR submission.	Yes	NFR 2D-recalculations and improvement
RO-2D3a -2017-0001	Yes	2D3a Domestic Solvent Use Including Fungicides, NMVOC, 1990-2020	For category 2D3a Domestic Solvent Use Including Fungicides, NMVOC, 1990-2020, the TERT noted that the increased domestic use of hand sanitiser due to the COVID-19 pandemic has not been taken into consideration. In response to a question raised during the review Romania explained that due to lack of detailed activity the Tier 2 methodology could not be applied and did not provide a revised estimate. Romania recalculated the entire time series using a Tier 1 methodology	Yes	4.19 NFR 2D3a Domestic Solvent Use Including Fungicides

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
			for the 2022 submission, because a trial of using Tier 2 led to inconsistencies. The Tier 1 methodology uses population as activity data which does not take into account the increased use of hand sanitiser in 2020. The TERT decided to calculate a technical correction for the years 2005, 2018-2020 which was accepted by Romania. The estimates demonstrate that the issue is above the threshold of significance. The TERT recommends that Romania include a revised estimate in its next submission.		
RO-2D3b -2022-0002	Yes	2D3b Road Paving with Asphalt, PM_{10}, TSP, 1990-2020	For category 2D3b Road Paving with Asphalt, pollutants PM_{10} and $PM_{2.5}$ and for the years 1990-2020, the TERT noted that a Tier 1 method was used for a key category (IIR 2022, Table 1.3.23 and chapter 4.19). In response to a question raised during the review, Romania explained that detailed activity data were missing. However, Romania provided an emission calculation with Tier 2 emission factors (technology specific to batch mix /hot mix asphalt plant), following the methodology given in the 2019 EMEP/EEA Guidebook, Chapter 2D3b Road Paving with Asphalt. The TERT noted that the issue is below the threshold of significance for $PM_{2.5}$ but above the threshold for PM_{10}. The TERT recommends that Romania include the Tier 2 emission calculation in its 2023 NFR and IIR submission and continues to seek detailed activity data.	Yes	4.20 NFR 2.D.3.b Road Paving with Asphalt
RO-2D3d -2020-0001	No	2D3d Coating Applications, NMVOC, 1990-2007	For 2D3d Coating Applications, NMVOC, and for years 1990-2007, the TERT noted that there is a lack of activity data of coating applications for Boat Building and Wood. Romania's IIR includes this issue in the list of improvements. This was raised during the 2020 and 2021 NECD review. In response to a question raised during the review Romania explained that they will explore methods for completing the activity data for years 1990-2007 using methods described in Chapter 4 of the 2019 EMEP/EEA Guidebook on 'Time series consistency'. Romania stated that they will include information on this in the 2023 submission of their IIR. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Romania use methods described in the 2019 EMEP/EEA Guidebook to obtain activity data on Boat Building and Wood for the years 1990-2007, and describe the methods used in their next IIR submission.	No	
RO-2D3i -2020-0001	Yes	2D3i Other Solvent Use, NMVOC, 1990-2007	For category 2D3i Other solvent use and NMVOC for 1990-2007 the TERT noted that there may be an under-estimate of emissions (Romania's 2022IIR, section 4.26). This was raised during the 2020 and 2021 NECD review. In response to a question raised during the review Romania explained that it is very difficult to obtain historical data from economic operators for the time series 1990-2007. The	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
			TERT noted that the issue is related to a non-mandatory category or year. The TERT recommends that Romania provide detailed information on planned actions and activities such as meeting with operators, association, and governmental institution in charge, but also studies implemented by subcontractors and/or universities etc. in its next submission.		
RO-2D3g -2019-0001	Yes	2D3g Chemical Products, NMVOC, 1990-2020	For category 2D3g Chemical Products and NMVOC for 1990-2007, the TERT noted that the emissions are estimated based on Tier 1 for the time series 1990-2007 and based on Tier 2 for the time series 2008-2020 (IIR 2022, Chapter 4.24). This was raised during 2019, 2020 and 2021 NECD review. In response to a question raised during the review, Romania explained that it is difficult to collect appropriate activity data for the historical time series. Romania provided revised estimates for year 2005, 2018, 2019 and 2020. The TERT agreed with the revised estimate provided by Romania. However, the TERT strongly recommends undertaking further efforts to improve estimates for this sector in future submissions. The TERT recommends that Romania include the revised estimate in its 2023 NFR and IIR submission.	Yes	4.25 NFR 2D3g Chemical Products
RO-2H2-2022 - 0001	No	2H2 Food and Beverages Industry, PM_{10}, 1990-2020	For 2H2 Food and Beverages Industry and particulate matter, for all years, the TERT noted that there may be an under-estimate of emissions caused by not estimating PM_{10} emissions from handling of agricultural products while the 2019 EMEP/EEA Guidebook provides the EF (Table 3-10). In response to a question raised during the review Romania explained that they will study the possibility of identifying the activity data and to report according to the research results. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Romania collect the activity data and includes the missing emissions in the next submission.	No	
RO-2H2-2022 - 0002	Yes	2H2 Food and Beverages Industry, NMVOC, 1990-2020	For 2H2 Food and Beverages Industry and NMVOC for all years, the TERT noted that there is a lack of transparency regarding the AD and EFs that are confidential as well as the following sources not included in the inventory while there are methods in the 2019 EMEP/EEA Guidebook: animal rendering and manufacture of animal and pet feed, meat, fish and poultry meals, cakes and biscuits. In response to the question on the issue Romania provided revised estimates for NMVOC emissions from the production of meat and canned meat as well as of pastry and confectionery products for the years 1990-2020 and stated that it will be included in the next submission. To the question on if Romania intended to use the provided NMVOC estimates as a revised estimate Romania responded that they will include	Yes	4.30 NFR 2H2 Food and beverages industry

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
			these in the future submissions and that they will study the possibility of identifying activity data to the productions requested by the TERT and will report accordingly. The TERT notes that the emissions from animal rendering, manufacture of animal and pet feed, meat, fish and poultry meals, cakes and biscuits, which are currently missing from the inventory are below the threshold of significance for a technical correction. The TERT recommend that Romania collect the activity data and include the missing emissions in the next submission. The TERT also recommends Romania to explore options for reporting more activity data information in the IIR.		
RO-2I-2022 -0001	No	2I Wood Processing, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, PM_{10}, CO, BC, 1990-2020	For 2I Wood Processing and NO_X, NMVOCs, SO_X, NH_3, $PM_{2.5}$, PM_{10} and CO for all years, the TERT noted that the emissions have not been estimated due to 'lack of emission factors in the 2019 EMEP/EEA Guidebook.' The TERT noted that the above-mentioned pollutants are not expected as process emissions from this source and as such would expect 'NA' (not applicable) to be reported. In response to a question raised during the review, Romania stated that they will change the notation key to 'NA'. The TERT recommends Romania to change the notation key in the next submission.	Yes	4.31 NFR 2I Wood processing
RO-3B-2022 -0001	Yes	3B Manure Management, NO_X, NH_3, NMVOC, 1990-2020	For 3B1a Manure Management - Dairy Cattle, 3B1b Manure Management - Non-Dairy Cattle and 3B3 Manure Management - Swine, NH_3, NO_X and NMVOC for all years, the TERT noted that there is a lack of transparency regarding the estimate for allocation of manure between management systems. The implied emission factor for NH_3 (Dairy cattle and Non-Dairy cattle), NO_2 (Dairy cattle, Non-dairy cattle, Swine) and NMVOC (Non-dairy cattle) shows a significant change from 2013 to 2014, which probably is due to changes in allocation of manure between management systems as mentioned in the IIR page 251. Furthermore, the TERT noted that the manure management system distribution did not match the one reported in the greenhouse gas inventory. In response to a question raised during the review, Romania provided further information and explained that they took the data from a 2018 study, which was the basis of the 'Romanian projections on pollutant emissions until 2030', while the reporting of greenhouse gases was based on an older study. Both studies were developed by ISPE Design and Consulting. This does not relate to an over- or under-estimate of emissions. The TERT recommends that Romania include detailed information in the IIR on the trend in manure management systems and the references. Furthermore, the TERT recommends that Romania explain any differences between the manure management systems distribution used in the NECD submission with the one used in the greenhouse gas	Yes	Cap. 5 3B MM Description Annex A, Table 1-4

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
			inventory.		
RO-3B1a -2022-0001	Yes	3B Manure Management, NH_3, 1990-2020	For NFR category 3B1a Manure Management - Dairy Cattle and 3B1b Manure Management - Non-Dairy Cattle and NH_3 for all years, the TERT noted that there is a lack of transparency related to the calculation of the NH_3 emission. In response to a question raised during the review, Romania provided an Excel sheet which includes all the variables used for NH_3 calculation for cattle. The TERT notes that default data is used for all variables except animal weight, AR Feedstock and AWMS. Likewise, all variables are the same for all years except from AWMS, which change from year 2013 to 2014. The TERT recommends that Romania include more documentation in the IIR on the variables used in estimating the NH_3 emission including information on which values are country-specific and which are defaults and to explain changes over time, e.g., as it relates to manure management systems. Furthermore, the TERT recommends that Romania continue to work on improving the inventory by implementing more national data for the cattle production, e.g., N-excretion (depending on changes in feed intake and milk yield) and number of grazing days.	No	
RO-3B3-2022 - 0001	Yes	3B3 Manure Management - Swine, NH_3, 1990-2020	For NFR category 3B3 Manure Management - Swine and NH3 for all years, the TERT noted that there is a lack of transparency related to the calculation of NH3 emissions. In response to a question raised during the review, Romania provided an Excel sheet, which includes all the variables used for NH3 calculation for fattening pigs and sows. The TERT notes that default data is used for all variable except from animal weight, AR Feedstock and AWMS. Animal weight is estimated annually based on the allocation of subcategories. The values for AR feedstock were obtained directly from the farmers by questionnaires at national level, for the years 2019 and 2020. For the allocation of manure types, it estimated a change from year 2013 to 2014. The TERT recommends that Romania include more documentation in the IIR on the variables used in estimating the NH3 emission including information on which values are country-specific and which are defaults and to explain changes over time, e.g. as it relates to manure management systems. Furthermore, the TERT recommends that Romania continue to work on improving the inventory by implementing more national data for the swine production, e.g. N-excretion	Yes	Cap. 5 3B MM Description Annex A, Table 1-3
RO-3Da1 -2022-0001	Yes	3Da1 Inorganic N-Fertilizers, NH_3, 2018, 2019	For category 3Da1 Inorganic N-fertilizers and NH_3 for 2018-2019, the TERT noted that a significant recalculation has been applied (14% reduction) for years 2018 and 2019. The total amount of N used in inorganic fertilizer is unchanged, but the	Yes	5.12 NFR 3.D.a.1 Inorganic N-fertilizers (also includes urea

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
			allocation on fertilizer types is changed. No information is given in the IIR in the section describing the recalculations (IIR page 271). In response to a question raised during the review, Romania explained that the quantity of inorganic N-fertilizers applied on agricultural land is based on data from the national statistics, N.I.S. For the allocation on fertilizer types, no national information is available, and thus estimate is based on data for the IFA organization (https://www.fastat.org/databases/plant-nutrition), as recommended in previous NECD review. The TERT checked the data and agrees with the calculation. The TERT recommends that Romania include information on the source of the data for types of mineral fertiliser and provides explanations on all recalculations in the IIR.		application)
RO-3Dc-2022 - 0001	No	3Dc Farm-Level Agricultural Operations Including Storage, Handling and Transport of Agricultural Products, NMVOC, 1990-2020	For category 3Dc Farm-Level Agricultural Operations Including Storage, Handling and Transport of Agricultural Products and NMVOC for all years, the TERT noted that notation key ‘IE’ (included elsewhere) is used. However, no NMVOC emissions from this pollutant and NFR category would be expected. In response to a question raised during the review Romania confirm that the correct notation key should be ‘NA’ (not applicable) for the entire time series, and that they plan to correct this for next submission 2023. The TERT recommends that Romania correct the notation key in the next submission.	Yes	5.16 NFR 3.D.c Farm-level agricultural operations including storage, handling and transport of agricultural products
RO-5B2-2022 - 0001	No	5B2 Biological Treatment of Waste - Anaerobic Digestion at Biogas Facilities, NH_3, 2002-2020	For 5B2 Biological Treatment of Waste - Anaerobic Digestion at Biogas Facilities and NH_3 for 2002-2018, the TERT noted that NH_3 emissions are only estimated for 2019 and 2020, while according to the 2022 NIR of Romania (p 651), Biogas facilities worked since 2002 in Romania. In response to a question raised during the review, Romania explained that investigations will be made to identify the activity data during these years. The TERT noted that the issue is below the threshold of significance for a technical correction. The TERT recommends that Romania collect the activity data and estimates and report emissions in the NFR and IIR in the next submission.	Yes	6.3 NFR 5B2 Biological Treatment of Waste - Anaerobic Digestion at Biogas Facilities
RO-5C2-2022 - 0001	No	5C2 Open Burning of Waste, SO_2, NO_X, NH_3, NMVOC, $PM_{2.5}$, PM_{10}, 1990-2020	For 5C2 Open Burning of Waste and all pollutants for all years, the TERT noted that there is a lack of transparency because in the IIR (p318) Romania only mentioned use 'agricultural' waste burning. However, 2019 EMEP/EEA Guidebook also identifies orchards residues and forest residues. In the IIR, Romania notes that it is forbidden to burn forest waste but not provide the date of the legislation. In	Yes	6.7 NFR 5.C.2 Open Burning of Waste

Observation	Key Category	NFR, Pollutant(s), Year(s)	Recommendation	Implemented	Section in IIR covered in
			response to a question raised during the review, Romania explained that investigations will be made about this issue. The TERT recommends that Romania include justification in its 2023IIR, including the legislation reference of the prohibition of burn forest waste and the perimeter covered by 'agricultural waste' taking into account in the calculation of the Romania's emissions		
RO-5D3-2022 - 0001	Yes	5D3 Other Wastewater Handling, NH_3, 1990-2020	For 5D3 Other Wastewater Handling and NH_3 for all years, the TERT noted that there is a lack of transparency regarding the number of latrines used. Indeed, in the IIR (p322) Romania notes that number of latrines have been calculated using as a work algorithm. This algorithm uses the difference between the total population and the population served by the public water supply system, which decreases by 10% percent (the population using septic tanks). The TERT notes that there is no information in the IIR about percentages of population connected to sewage and unconnected wastewater treated but information is available in the 2022 NIR of Romania (p 671). In this table, TERT noted that population unconnected to sewage with treatment system increase (for example from 61% in 2005 to 98% in 2020 for urban population). This does not relate to an over- or under-estimate of emissions. In response to a question raised during the review Romania responded that investigations will be made concerning activity data and the algorithm used. The TERT recommends that Romania improve the transparency by providing the percentage of population connected and unconnected (rural/urban) and more details about the assumptions made in the algorithm used.	Yes	6.8. NFR 5.D.3 Wastewater handling Latrines

9 PROJECTIONS

ROMANIAN PROJECTIONS FOR POLLUTANTS EMISSIONS TO 2030

CONTENTS

1. EMISSION PROJECTION METHODOLOGY. GENERAL CONSIDERATIONS

Emission projections of air pollutants covered by the **NEC Directive** – nitrogen oxides (NOx), sulphur dioxide (SO_2), non-methane volatile organic compounds (NMVOCs), ammonia (NH_3) and particulate matter ($PM_{2.5}$) have been developed for the following scenarios:

- **The scenario with measures (WM)** which includes all policies and measures implemented and adopted.

The implemented policies and measures are represented by:

- ✓ National legislation in force;
- ✓ OR one or more voluntary agreements already established;
- ✓ OR for which financial resources are allocated;
- ✓ OR for which human resources are mobilized,

Policies and measures adopted: an official government decision has been taken and there is a firm commitment to further implementation.

The starting point of the forecasts for this scenario is recommended to be the last historical year of the air pollutant inventory.

- **The scenario with additional measures (WAM)** includes the planned policies and measures, which are under debate and which have a real chance of being adopted and implemented in the future.

The methods of estimating emissions recommended by the EMEP/EEA Guide 2019 were used to develop forecasts of atmospheric pollutant emissions.

To ensure consistency between historical emissions and forecast emissions, the methods used to estimate air pollutant emissions projections were generally similar to those used to estimate historical emissions. Emissions projections were estimated for each activity category, based on the forecasted evolution of activity data (e.g. productions, consumptions) and emission factors reflecting technological and legislative evolution at activity sector/category level.

1.1 Socio economic indicators

For defining the scenarios, it was taken into account that Romania's economic development for the period 2018÷2030 is closely linked to both the global economic development and that of the European Union, taking place in a particularly complex international environment.

In order to define the assumptions regarding the economic-social, technological and demographic evolution of Romania in the period 2018÷2030, the SWOT analysis of the period 1989÷2018 was carried out by analysing:

- The economic growth;
- The demographic development;
- The social development;
- The structural adjustment of the economy;
- The structural adjustment of the industry;
- The technological innovation and reduction of energy intensity in industry, agriculture, construction;
- The development and modernization in transport sector;

- The development and modernization of the services sector;
- The development and upgrading of living conditions.

In making the forecasts for the period 2022 - 2030, the average annual growth rate of GDP during this period indicated by the National Commission for Strategy and Prognosis is taken into account, and the average annual growth rate of GDP during the period 2005-2021 is indicated by the National Institute of Statistics (**Table 1**).

Table 1. The average annual growth rate of GDP in the period 2005 - 2030 (%)

Year	2005	2016	2017	2018	2019	2020	2021-2025	2026-2030
	Achievements						Projections	
Average annual GDP growth rate	4.7	4.8	7.1	4.4	4.1	-3.8	5.2	4.0

Table 2 shows the forecast of GDP evolution in Euro$_{2020}$ in the period 2022-2030, provided by the National Commission for Strategy and Prognosis, which was taken into account when making forecasts of atmospheric pollutant emissions.

Table 2. GDP evolution, in bln. Euro$_{2020}$, during the period 2019-2030

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	Achievements			Projections								
GDP	227.4	218.9	231.8	240.0	248.8	260.4	272.2	283.2	294.1	304.5	313.9	323.2

The positive evolution of the Romanian economy between 2000 and 2018 led to a 2.32 - fold increase in the gross domestic product per inhabitant (9814 Euros$_{2016}$/inhabitant at the level of 2018). During period 2007-2018, the gross domestic product per inhabitant increased by almost 20% compared to the European Union average. So, if in 2007 the GDP/inhabitant was at 40% of the EU average, in 2018, the value of this indicator reached 60% of the EU average. That means that Romania must make important progress in economic development.

Table 3 presents the gross value added structure by branches during the period 2022 - 2030, provided by the National Commission for Strategy and Prognosis.

Table 3. GVA structure by branches (%)

Year	2018	2019	2020	2022	2025	2030
	Achievements			Projections		
TOTAL GVA (%), of which:	**100**	**100**	**100**	**100**	**100**	**100**
Industry	27.2	22.67	22.42	21.66	21.90	20.64
Agriculture	5.2	4.96	4.38	4.38	4.26	3.79

Year	2018	2019	2020	2022	2025	2030
	Achievements			Projections		
Constructions	5.5	6.37	7.25	6.82	7.64	8.17
Services	62.1	66.0	65.95	67.14	66.91	67.40

Table 4 shows the forecast of GDP evolution during the period 2022÷2030, in $Euro_{2020}$ prices. Also taking into account the forecast of population evolution in the period 2022-2030, the increase of the GDP/inhabitant indicator from the value of 12386 $Euro_{2020}$ in 2022, to the value of 17994 $Euro_{2020}$ in 2030 is observed, with an average annual growth rate of 4.24%. In the same table, the evolution of gross value added (GVA) is presented as total and by activity sector (industry, agriculture, construction, services), which reflects a continuous trend of structural adjustment of the economy, by increasing the share of services sector activities in the formation GVA to the detriment of other economy branches.

Table 4. Forecast of GDP evolution during the period 2022÷2030

Indicator	U.M	2022	2023	2024	2025	2026	2027	2028	2029	2030
Population	Thou. persons	19376	19270	18772	18662	18521	18378	18239	18101	17962
GDP	Billion $Euro_{2020}$	240.0	248.8	260.4	272.2	283.2	294.1	304.5	313.9	323.2
GDP/inh.	$Euro_{2020}$/ inhabitant.	12386	12911	13872	14485	15290	16003	16694	17342	17994
GVA	Billion $Euro_{2020}$	217.0	225.1	235.6	246.3	256.2	266.2	275.7	284.1	292.6
GVA Industry	Billion $Euro_{2020}$	47.0	48.1	50.2	52.2	54.0	55.7	57.4	58.9	60.4
	%	21.66	21.37	21.31	21.19	21.07	20.92	20.82	20.73	20.64
GVA Services	Billion $Euro_{2020}$	145.7	151.1	157.7	164.8	171.5	178.4	185.0	191.0	197.2
	%	67.14	67.13	66.93	66.91	66.94	67.02	67.10	67.23	66.40
GVA Agriculture	Billion $Euro_{2020}$	9.5	10.0	10.3	10.5	10.6	10.8	10.9	11.0	11.1
	%	4.38	4.44	4.37	4.26	4.14	4.06	3.95	3.87	3.79
GVA Construction	Billion $Euro_{2020}$	14.8	15.9	17.4	18.8	20.1	21.3	22.4	23.2	23.9
	%	6.82	7.06	7.39	7.64	7.85	8.00	8.133	8.17	8.17

2. PROJECTIONS METHODOLOGY BY SOURCE CATEGORY

This section provides details of the approach used to forecast emissions in WM scenario and WaM scenario.

2.1 NFR 1 Energy sector

The methodology for forecasting the emissions of sulphur dioxide, nitrogen oxides, volatile organic compounds, ammonia and dust is different depending on the activities that produce these emissions, by combustion, in industrial processes, agriculture, waste management, etc.

Methodology for energy sector

The National Commission for Strategy and Prognosis presented in October 2022, the Energy Balance for the period 2019-2030, in correlation with the projection of macroeconomic indicators and Romania's national targets regarding energy efficiency, greenhouse gas emissions, the use of renewable energy resources, etc.

In **Table 5**, both the achievements of 2019, 2020, 2021 and the forecasts for the other years are presented. It results that, in 2020, Romania's domestic primary energy consumption was about 32.171 million toe, representing about 75% of the national target of 42.99 million toe indicated in NEEAP IV.

Table 5. Forecast of domestic primary energy consumption and final energy consumption [thou. toe]

Specification/ Year	2019	2020	2021	2025	2030
	Achieved			Forecasted	
Domestic primary energy consumption	**33015**	**32171**	**32909**	**33693**	**35637**
Consumption in the energy sector	3023	3050	2926	2810	2782
Loss	895	870	872	844	810
Available for final consumption	**25102**	**25127**	**25795**	**26784**	**28388**
Non-energy consumption	1135	1295	1286	1326	1346
Final energy consumption, of which:	**23874**	**23513**	**24509**	**25458**	**27042**
- Population consumption	7754	8008	8089	7482	7512
- Consumption in economy Of which:	**16120**	**15505**	**16410**	**18363**	**19530**
- Industry	6281	6009	6412	6621	6808
- Construction	378	416	398	484	525
- Transport and telecommunications	537	531	571	554	562
- Agriculture, forestry and fishing	6713	6514	6907	8346	9177
- Other economy branches	2191	2035	2131	2357	2458

Source: National Commission for Strategy and Prognosis for the period 2019-2030, The National Institute of Statistics for the period 2019-2021

Romania's final energy consumption in 2020 was about 25.127 million toe, representing about 82.8% of the national target of 30.32 toe.

2.1.1 NFR 1.A.1.a Electricity and heat production

Activity data

For NFR Category 1.A.1.a Electricity and heat production, the evolution of domestic electricity consumption and production of the power plant park during the period 2022-2030 is considered, which is presented in **Table 6**.

Table 6. Evolution of domestic consumption and electricity production during the period 2018÷2030

Indicators	UM	2018	2019	2020	2022	2025	2030
		Achievements			Projections		
Gross domestic electricity consumption	TWh	57.40	56.63	54.68	56.02	58.25	60.79
Total net electricity production	TWh	60.18	55.18	51.92	55.81	56.85	58.49
Total gross electricity production	TWh	64.88	59.62	55.94	59.67	61.25	63.16

In 2020, the power installed in power plants in Romania was 20584 MW, as shown in **Table 7**.

Table 7. Power installed in power plants in 2020

Type of plant	Installed power, MW
Power plants:	
- on coal	4786.969
- on liquid hydrocarbons	87.494
- on gaseous hydrocarbons	3340.142
Nuclear power plant	1414.000
Hydro power plants	6560.797
Wind plants	3012.527
Photovoltaic plants	1382.539
TOTAL INSTALLED POWER	20584.468

The development program of the NPS power plants during the period 2018 - 2030 is presented taking into account the provisions of the integrated National Energy and Climate Plan (NECP) 2021-2030.

This Plan is considered in the scenario with measures (WM). In the scenario with additional measures (WAM), it is expected that the power installed in wind and photovoltaic plants will be supplemented and will cover the electricity produced in coal-fired power plants. In this scenario, it is projected to increase the quality of renewable energy in district heating, with geothermal energy as source, from 31 ktoe in 2016 to 45 ktoe in 2030.

Table 8 shows the structure of electricity production during the period 2018 - 2030 for the scenario with measures and the scenario with additional measures.

Table 8. Structure of electricity production during the period 2005 - 2030

Specification/Scenario/Year	Scenario	2005	2018	2020	2025	2030
		Achievements			Projections	
Total electricity production in GWh, of which based on:	WM	**59412**	**64877**	**55935**	**61252**	**63163**
Liquid fuels		1816	28	17	0	0
Solid fuels		21915	15646	9814	5530	3519
Gaseous fuels		9612	10538	9468	9545	9054
Renewables		20207	26190	24380	34076	38428
Uranium		5555	11377	11354	11400	11400
Biomass		307	1098	902	701	762
Total electricity production in GWh, of which based on:	WAM	**59412**	**64877**	**55935**	**61252**	**63163**
Liquid fuels		1816	28	17	0	0
Solid fuels		21915	15646	9814	5530	0
Gaseous fuels		9612	10538	9468	9545	9054
Renewables		20207	26190	24380	34076	41947
Uranium		5555	11377	11354	11400	11400
Biomass		307	1098	902	701	762

Corresponding to the structure of electricity production, the total demand for energy resources is shown in **Table 9**.

Table 9. Total demand for energy resources in the period 2005 - 2030

Specification/Scenario/Year	Scenario	2005	2018	2020	2025	2030
		Achievements			Projections	
The total demand for energy resources in PJ, of which based on:	WM	532.91	475.22	**383.71**	**255.89**	**229.91**
Liquid fuels		35.99	7.00	4.43	0	0
Solid fuels		174.51	149.63	131.46	63.16	40.19
Gaseous fuels		255.43	184.52	114.10	62.92	59.68
Renewables		1.08	7.17	7.82	2.61	2.84
Uranium		65.9	126.9	125.9	127.2	127.2
The total demand for energy resources in PJ, of which based on:	WAM	532.91	475.22	**324.44**	**255.89**	**189.72**
Liquid fuels		35.99	7.00	6.14	0	0
Solid fuels		174.51	149.63	125.69	63.16	0
Gaseous fuels		255.43	184.52	63.66	62.92	59.68
Renewables		1.08	7.17	3.05	2.61	2.84
Uranium		65.9	126.9	125.9	127.2	127.2

Emission factors

The emission factors used for the forecasts, presented in **Table 10**, were determined based on the data reported by the operators of large combustion plants (IMA Inventory 2020).

Table 10. Emission factors

Fuels	EF calculated IMA 2020, g/GJ		
	SO_2	NO_x	$PM_{2,5}$
Natural gas	0.281	38.72	0.53
Liquid fuel	301.8	66.2	3.3
Hard coal	106.6	161.5	3.4
Lignite	149.1	108.5	1.8
Biomass	6.1	83.7	13.3

2.1.2 NFR 1.A.1.b Petroleum refining

A. Scenario with measures

Activity data

The forecasted Energy Balance developed by the National Commission for Strategy and Prognosis, show the quantities of crude oil that will be extracted in Romania and of crude oil that will be imported for processing in refineries during the period 2022-2030. **Table 11** shows the forecast of the quantities of crude oil that will be processed in the 4 operational refineries.

Table 11. Evolution of the quantities of crude oil processed in Romania (thousands of toe)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Extracted crude oil	3382	3243	3045	2975	2907	2840	2783	2727	2673	2619	2567
Imported crude oil	7071	6909	7634	8131	8643	9136	9702	10216	10686	11103	11158
TOTAL	10453	10152	10679	11106	11550	11976	12485	12943	13359	13722	13725

For the refining of the crude oil quantities to be processed in Romania, the quantities of fuels presented in **Table 12** are consumed.

Table 12. Evolution of the fuels quantities used in the refining process in the period 2020 ÷ 2030

Fuel demand, în TJ	Years		
	Achievements	Projections	
	2020	2025	2030
Liquid fuels	722	0	0
Gas	18745	26320	30164
TOTAL, în TJ	19467	26320	30164

Forecasted emission factors

For the elaboration of NOx, NMVOC, SO_2, NH_3, particulate matters ($PM_{2.5}$) forecasts, historical emission factors related to year 2020 will be used.

B. Scenario with additional measures

Activity data

Considering that there is no information on the measures undertaken by economic agents regarding the increase in energy efficiency, the same activity data as those used in the scenario with measures are considered.

Forecasted emission factors

For the elaboration of NOx, NMVOC, SO_2, NH_3, particulate matters ($PM_{2.5}$) forecasts, historical emission factors related to year 2020 will be used.

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

A. Scenario with measures

Activity data

According to Romania's Energy Balance, electricity, solid, liquid and gaseous fuels are required for the extraction and handling of coal, crude oil and natural gas. The forecast of the energy demand evolution for the period 2020-2030, in the scenario with measures and the scenario with additional measures, was made by extrapolating the values achieved in the period 2018-2020.

Table 13 presents the evolution of the fuel demand in the period 2020-2030.

Table 13. Evolution of fuel demand in the period 2020 - 2030

Fuel demand, TJ	Years		
	Achieved	Forecasted	
	2020	2025	2030
Liquid fuels	10836.94	10900	10960
Gaseous fuels	6358.76	6400	6450
Solid fuels	0	0	0
Biomass	0.67	0	0
TOTAL	17196.76	17300	17400

Forecasted emission factors

For the elaboration of NOx, NMVOC, SO_2, NH_3, particulate matters ($PM_{2.5}$) forecasts, historical emission factors related to year 2020 were used.

B. Scenario with additional measures

Activity data

Considering that there is no information on the measures undertaken by economic agents regarding the increase in energy efficiency and the improvements of the technologies used, the same activity data and the same emission factors as those used in the scenario with measures are considered.

2.1.4 NFR 1.A.2 Manufacturing industries and constructions (combustion)

A. Scenario with measures

Activity data

The evolution of the energy demand during the period 2020÷2030 in the *Industry and Construction* sector was estimated considering the assumptions regarding the development of various industrial branches and the increase in energy efficiency as a result of the application of the Energy Efficiency Action Plan (NEEAP IV). **Table 14** presents the forecasts of the National Commission for Strategy and Prognosis regarding the evolution of energy consumption in the *Industry and Construction* sector in the period 2020-2025-2030 for the scenario with measures considering that fuel consumption represents 69% of the sector's final consumption.

Table 14. Evolution of energy demand in the period 2020÷2030, for the industry and construction sector

Energy demand	Years		
	Achieved	Forecasted	
	2020	2025	2030
Total în Mtep	6.425	7.017	7.333

In **Tables 15, 16**, the evolution of the fuels quantities and their structure in the period 2020-2030 is presented for the determination of emissions for the inventory sectors 1A2a, b, c, d, e, f and 1A2.gvii, viii.

Table 15. Evolution of the fuel demand in the period 2020÷2030, in TJ, for the NFR category 1.A.2.a, b, c, d, e

Fuel demand	Years		
	Achieved	Forecasted	
	2020	2025	2030
Total în TJ, of which:	**189327**	**202718**	**211862**
Liquid fuels	27424	36578	44782
Solid fuels	35839	31460	22958
Gaseous fuels	117858	134680	144122
Biomass	8206	0	0

Table 16. Evolution of the fuel demand in the period 2020÷2030, in TJ, for the NFR category 1.A.2.a g.vii, viii

Fuel demand	Years		
	Achieved	Forecasted	
	2020	2025	2030
Total în TJ, of which:	**44317**	**46737**	**48006**
Liquid fuels	13984	14654	15491
Solid fuels	21	0	0
Gaseous fuels	23593	25782	26620
Biomass	6720	6301	5895

B. Scenario with additional measures

Activity data

In the scenario with additional measures, it is taken into account that the structure of the industry does not change, but important actions to increase energy efficiency in accordance with technological development are considered.

In **Tables 17, 18**, the fuel consumption forecast for the period 2022-2030 is presented for the category NFR 1.A.2.a Manufacture of cast iron and steel and for the category NFR1a.2gviii Others.

Table 17. Evolution of fuel demands in the period 2020÷2030, in TJ, for NFR category 1.A.2.a, b, c, d, e

Fuel demand	Years		
	Achieved	Forecasted	
	2020	2025	2030
Total în TJ, of which:	**189327**	**200550**	**209960**
Liquid fuels	27424	35843	40523
Solid fuels	35839	30460	20537
Gaseous fuels	117858	134247	148900
Biomass	8206	0	0

Table 18. Evolution of the fuel demand in the period 2020÷2030, in TJ, for the NFR category 1.A.2.a g.vii, viii

Fuel demand	Years		
	Achieved	Forecasted	
	2020	2025	2030
Total în TJ, of which:	**44317**	**46103**	**46606**
Liquid fuels	13984	14854	15091
Solid fuels	21	0	0
Gaseous fuels	23593	25782	27620
Biomass	6720	5467	3895

Forecasted emission factors

For NFR category 1.A.2.a, historical emission factors will be used to develop NOx, NMVOC, SO_2, NH_3, particulate matters ($PM_{2.5}$) forecasts.

For category 1.A.2.g.viii, starting from 2025, the forecasted emission factors for NOx, SO_2 and particulate matters ($PM_{2.5}$) are determined based on the reduction of historical emission factors by 2%, as a result of the publication of BAT conclusions for those sectors whose BREFs have not been updated.

2.1.5 NFR 1.A.3 Transport

According to the National Inventory of atmospheric pollutant emissions and the data from the LRTAP reporting formats, the data related to the transport sub-sector are divided into data for the **category NRF 1.A.3.b Road transport** and data for the **categories NRF 1.A.3. a,c,d,e Non-road transport**.

For the period 2020-2030, the evolution of the goods and passengers transport, according to the data transmitted by the National Commission for Strategy and Prognosis, is presented in **Tables 19, 20**.

Table 19. Evolution of passenger transport, in million passenger-km, in the period 2021-2030

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
TOTAL	**18939.4**	**19325.3**	**19788.7**	**20349.4**	**20892.9**	**21442.5**	**21978.5**	**22498.6**	**22942.6**	**23382.1**
Railway transport	4271.4	4305.6	4378.8	4462.0	4528.9	4587.8	4652.0	4721.8	4792.6	4869.3
Road transport	14660.7	15012.5	15402.8	15880.3	16356.8	16847.5	17310.2	17769.5	18142.7	18505.5
International inland waterways	7.4	7.2	7.1	7.1	7.2	7.2	7.3	7.3	7.3	7.3

Table 20. Evolution of goods transport in million ton-km in the period 2021-2030

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
TOTAL	**80092.4**	**91762.7**	**93832.2**	**95923.3**	**98456.5**	**100739.0**	**102884.0**	**104723.6**	**106325.2**	**107507.0**
Railway transport	13625.0	13693.1	13788.9	13926.8	14038.3	14150.6	14277.9	14420.7	14593.7	14783.5
Road transport	61848.3	63332.7	65106.0	67059.2	69003.9	70867.0	72567.8	74019.2	75277.5	76180.8
International inland waterways	13521.7	13629.9	13807.1	14028.0	14238.4	14523.2	14813.7	15035.9	15186.2	15262.2
Pipeline transport	1087.4	1107.0	1130.2	1155.1	1175.9	1198.2	1224.6	1247.8	1267.8	1280.5

In accordance with NEEAP IV and NECP for the period 2020 – 2040 the following measures are taken in the transport sector:

- Renewing the fleet of vehicles for all means of transport;
- Development and promotion of alternative mobility;
- Limiting the circulation of vehicles with conventional fuelling in city centres;
- Promotion of electromobility in road transport;
- Promoting the use of biofuels in transport;
- Promoting the use of renewable energy in railway transport;
- The priority development of railway transport and its intermodal integration with other transport modes;
- Electrification and modernization of railway lines;
- Modernization of urban and interurban passenger transport in large cities.

The evolution of energy consumption in the period 2020-2030, in the scenario with measures, corresponds to the data of the National Commission for Strategy and Prognosis is presented in **Table 21**.

Table 21. Evolution of final energy consumption, in thousands of toe, in the scenario with measures for the period 2020-2030

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Energy consumption	6514	6907	7149	7478	7799	8103	8346	8580	8786	8979	9177

Table 22 presents the energy consumption in the period 2020-2030, in the scenario with measures, by types of transport means.

Table 22. Energy consumption during the period 2020-2030 in the scenario with measures

Energy demand	Years			
	Achieved	Forecasted		
	2020	2022	2025	2030
Total k tep	**6514.2**	**7149.0**	**8103.0**	**9177.0**
Liquid fuels	6420.2	7040.4	7975.8	9010.8
Solid fuels	0.006	0	0	0
Gaseous fuels	0.28	0.1	3.2	4.4
Electricity	93.5	108.2	123.0	160.3
Heat	0.3	0.3	1.0	1.5
a. Aviation	**85.9**	**93.3**	**108.2**	**141.2**
Liquid fuels	85.9	93.3	108.2	141.2
b. Road transport	**6182.1**	**6739.4**	**7614.4**	**8564.4**
Liquid fuels	6178.7	6732.7	7598.9	8533.9
Electricity	3.4	6.7	15.5	30.5
c. Railways	**199.2**	**259.1**	**308.9**	**383.8**
Liquid fuels	112.9	161.9	207.6	261.5

Energy demand	Years			
	Achieved	Forecasted		
	2020	2022	2025	2030
Electricity	86.3	97.2	101.3	122.3
Solid fuels	0.006	0.000	0.000	0.000
d. Navigation	**42.7**	**52.5**	**61.1**	**74.2**
Liquid fuels	42.7	52.5	61.1	74.2
e. Pipeline transport	**4.2**	**4.7**	**10.4**	**13.4**
Gaseous fuels	0.28	0.1	3.2	4.4
Electricity	3.62	4.3	6.2	7.5
Heat	0.3	0.3	1.0	1.5

NFR 1.A.3.b Road transport

Activity data

Tables 23 and **24** show the evolution of energy consumption in the period 2020-2030 in the transport sector, in the scenario with measures and in the scenario with additional measures for all types of transport means.

Table 23. Energy demand in the period 2020-2030 in scenario with measures

Energy demand	2020	2025	2030
	Achieved	Forecasted	
Total k tep	272.679	339.195	384.153
Liquid fuels	251.465	344.549	387.049
Solid fuels	0	0	0
Gaseous fuels	0.012	0.128	0.188
Electricity	3.907	5.288	6.887
Heat	0.012	0.042	0.063
a. Aviation	1.232	4.530	5.912
Liquid fuels	1.232	4.530	5.912
b. Road transport	243.888	329.417	368.359
Liquid fuels	243.746	328.7682	367.082
Electricity	0.141	0649	1.277
c. Railways	8.295	13.071	16.203
Liquid fuels	4.681	8.692	10.948
Electricity	3.614	4.379	5.254
d. Navigation	1.805	2.558	3.107
Liquid fuels	1.805	2.558	3.107
e. Pipeline transport	0.176	0.440	0.607
Gaseous fuels	0.012	0.138	0.188
Electricity	0.152	0.260	0.356
Heat	0.012	0.042	0.0.63

Table 24. Energy demand in the period 2020-2030 in scenario with additional measures

Energy demand	2020	2025	2030
	Achieved	Forecasted	
Total k tep	272.679	339.195	384.153
Liquid fuels	251.465	340.808	381.137
Solid fuels	0	0	0
Gaseous fuels	0.012	0.138	0.188
Electricity	3.907	9.028	12.8
Heat	0.012	0.042	0.063
a. Aviation	1.232	4.530	5.912
Liquid fuels	1.232	4.530	5.912
b. Road transport	243.888	329.417	368.359
Liquid fuels	243.746	326.428	362.469
Electricity	0.141	2.989	5.89
c. Railways	8.295	13.071	16.203
Liquid fuels	4.681	7.292	9.649
Electricity	3.614	5.779	6.554
d. Navigation	1.805	2.558	3.107
Liquid fuels	1.805	2.558	3.107
e. Pipeline transport	0.176	0.440	0.607
Gaseous fuels	0.012	0.138	0.188
Electricity	0.152	0.260	0.356
Heat	0.012	0.042	0.63

In terms of required amounts of energy, the two scenarios differ by the amount of electricity used for road and railway transport and by the degree of renewal of the vehicles fleet.

Forecasted emission factors

For the evaluation of pollutant emission projections in the scenario with measures, the following were taken into account:

- the introduction of EURO 2 (1998), EURO 3 (2002), EURO 4 (2008) and EURO 5 (2012) standards and unleaded petrol led to a decrease in polluting emissions produced by motor vehicles (especially SO2, volatile organic compounds, benzene, lead, carbon monoxide);
- the historical emission factors took into account the renewal of the fleet of vehicles with EURO 2, EURO 3, EURO 4 and EURO 5 equipment until year 2020.

For the evaluation of pollutant emission projections in the scenario with additional measures, the following were taken into account:

- the gradual introduction of EURO 6 provisions, as follows:
  - ✓ in 2025, only 60% of the amount of fuel is used in vehicles with historical emission factors;
  - ✓ in 2030, only 40% of the amount of fuel is used in vehicles with historical emission factors.

NFR 1.A.3.a,c,d,e Non-road transport

Scenario with measures

Activity data

In **Table 25**, the evolution of energy quantities in the period 2020 ÷ 2030 is presented in the scenario with measures for railways, navigation and pipeline transport, taking into account the assumptions considered for the transport of passengers and goods.

Table 25. Evolution of the energy amount (in PJ) in the period 2020÷2030 in scenario with measures

Energy demand	2020	2025	2030
	Achieved	Forecasted	
Railways	**8.295**	**13.071**	**16.203**
Liquid fuels	4.681	8.692	10.948
Electricity	3.614	4.379	5.254
Navigation	**1.805**	**2.558**	**3.107**
Liquid fuels	1.805	2.558	3.107
Pipeline transport	**0.176**	**0.440**	**0.607**
Gaseous fuels	0.012	0.138	0.188
Electricity	0.152	0.260	0.356
Heat	0.012	0.042	0.063

Forecasted emission factors

For the evaluation of pollutant emission projections in scenario with measures, the historical emission factors were taken into account.

Table 26 shows the evolution of energy quantities in the period 2020 ÷ 2030, in scenario with additional measures.

Table 26. Evolution of the energy amount (in PJ) in the period 2020÷2030 in scenario with additional measures

Energy demand	2020	2025	2030
	Achieved	Forecasted	
Railways	**8.295**	**13.071**	**16.203**
Liquid fuels	4.681	7.292	9.649
Electricity	3.614	5.779	6.554
Navigation	**1.805**	**2.558**	**3.107**
Liquid fuels	1.805	2.558	3.107
Pipeline transport	**0.176**	**0.440**	**0.607**
Gaseous fuels	0.012	0.138	0.188
Electricity	0.152	0.260	0.356
Heat	0.012	0.042	0.063

Forecasted emission factors

For the assessment of pollutant emission projections in the scenario with additional measures, the improved historical emission factors were considered taking into account the renewal of the vehicle fleet more than in the scenario with measures.

2.1.6 NFR 1.A.4 Small combustion, non-road mobile sources and machinery

NFR 1.A.4.a.i, ii Commercial/Institutional sector

Scenario with measures

Activity data

Table 27 shows the forecast of the final energy consumption of energy in the service sector provided by the National Commission for Strategy and Prognosis for the period 2020-2030.

Table 27. Evolution of the energy demand in the period 2020÷2030, for the service sector

Energy demand	**Years**		
	Achieved	**Forecasted**	
	2020	**2025**	**2030**
Total in thou. tep	2035	2320	2458

Table 28 shows the evolution of the quantities of fuels and their structure in the period 2020-2030 for determining the emissions resulting from the commercial/institutional sector in the scenario with measures (1A4) on the assumption that fuels represent 50% of the final energy consumption forecasted for this sector and in the scenario with additional measures, fuels represent 48%.

Table 28. Evolution of fuel demands in the period 2020÷2030, in TJ, for NFR 1.A.4.ai,aii

Scenario		**Years**		
		Achieved	**Forecasted**	
		2020	**2025**	**2030**
WM	**Total, of which:**	**42907.17**	***48916.28***	**51825.95**
	Liquid fuel	2616.87	3978.2	4949.7
	Solid fuel	104.95	0	0
	Gaseous fuel	36696.65	44938.08	46876.25
	Biomass	3488.7	0	0
WAM	**Total, of which:**	**42907.17**	**46578.5**	**49.321.5**
	Liquid fuel	2616.87	3141.2	3995.2
	Solid fuel	104.95	0	0
	Gaseous fuel	36696.65	43438.6	45326.3
	Biomass	3488.7	0	0

Forecasted emission factors

For the development of atmospheric pollutant emissions projections for this category the implementation of the Ecodesign Directive was taken into account, which represents the framework for establishing the minimum ecological design requirements applicable to products with energy impact, implemented through specific regulations, such as Regulation (EU) 2015/1188, Regulation (EU) 2013/813, Regulation (EU) 2013/814, Regulation (EU) 2015/1189, Regulation (EU) 2015/1185.

Thus, for the preparation of the forecasts, the reduction of NOx emissions from the combustion of gaseous and liquid fuels (starting with 2018) and, respectively, the emissions of NOx, particulate matter and NMVOC from the combustion of solid fuels (starting with 2020, and, respectively the year 2022) were considered.

Also, for this category, the implementation of the provisions of Law no. 188/2018 regarding the limitation of air emissions of certain pollutants from medium combustion installations was taken into account, which provides for limit values for emissions applicable based on the type of installations (existing or new) and nominal thermal power.

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

Activity data

Table 29 presents the evolution of energy consumption in the residential sector forecasted by the National Commission for Strategy and Prognosis.

Table 29. Forecast of energy consumption in ktoe, in the residential sector, in the period 2020-2030

	Years										
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Energy consumption	8008	8089	7385	7422	7444	7467	7482	7489	7497	7504	7512

The energy demand in the period 2020-2030 in the Residential sector, for the two analysed scenarios, is presented in **Table 30**.

Table 30. Evolution of energy demand in the period 2020÷2030 for NFR 1.4 bi,bii

Scenario	Energy demand	Years		
		Achieved	Forecasted	
		2020	2025	2030
	Total in TJ, of which:	**335308.0**	**312655.4**	**314539.7**
WM	Electricity	42084.3	40165.9	41298.4
	Heat	25298.8	23978.2	24813.0
	Liquid fuel	957.32	800.0	645.0
	Solid fuel	1879.48	1120.0	820.0
	Gaseous fuel	136941.7	136227.5	149510.0
	Biomass	128146.5	110363.8	97453.3
WAM	**Total in TJ, of which:**	**335308.0**	**312655.4**	**314539.7**
	Electricity	42084.3	44700.0	48540.0
	Heat	25298.8	31450.0	32999.7
	Liquid fuel	957.32	300.4	0
	Solid fuel	1879.48	0	0
	Gaseous fuel	136941.7	135705.0	146.000.0
	Biomass	128146.5	100500.0	87000.0

Forecasted emission factors

For the preparation of atmospheric pollutant emissions forecasts for this category, similar to the approach used for category 1A4 a.i, the implementation of the Ecodesign Directive and of the specific regulations that assume the reduction of NOx emissions from the combustion of gaseous and liquid fuels (starting with the year 2018) and, respectively, of NOx, particulate matters and NMVOC emissions from the burning of solid fuels (starting with 2020 and, respectively, 2022) was considered. Thus, for this category, the gradual reduction of the EMEP/EEA 2019 emission factors associated with approach level 1 was estimated, with the following weights:

- liquid and gaseous fuels: reduction of emission factors for NOx by 1% in 2020, 3% in 2025 and 5% in 2030;
- solid fuels: reduction of emission factors for NOx, particulate matters and NMVOC by 2% in 2025 and 5% in 2030.

EMEP/EEA 2019 emission factors were used to estimate emissions related to biomass burning in the Residential sector.

NFR 1.A.4.c.i, ii Agriculture/Forestry sector

Activity data

For the period 2020÷2030, the reduction of energy intensity is estimated. The specific consumption of fuels for agricultural work will have a downward trend as a result of the concentration of agricultural land, but also an increasing effect as a result of the replacement of animals for agricultural work with machines. Action will be taken to modernize irrigation installations.

In **Table 31**, the evolution of energy consumption in the agricultural sector forecasted by the National Commission for Strategy and Prognosis is presented.

Table 31. Forecast of energy consumption in ktoe, in the agriculture sector in the period 2020-2030

	Years										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Energy consumption	531	571	533	541	547	551	554	557	559	561	562

Taking into account the assumptions regarding the development of the agricultural sector, the evolution of the energy demand in the period 2020÷2030 in the sector is determined for the two scenarios considered (**Table 32**).

Table 32. Evolution of energy demand in the period 2020÷2030 for NFR 1.4 ci, cii

Scenario	Energy demand	Years		
		Achieved	Forecasted	
		2020	2025	2030
WM	**Total in TJ, of which:**	**22234.0**	**23071.4**	**23532.0**
	Electricity	1934.0	2108.0	2229.0
	Heat	63.21	130.7	240.0
	Liquid fuel	2856.55	13.0	13.0
	Solid fuel	684.15	600.0	0
	Gaseous fuel	5066.8	5344.0	6550.0
	Biomass	415.97	210.0	0.
	Fuels for. cii	11213.32	14665.7	14500.0.
WAM	**Total in TJ, of which:**	**22234.0**	**23071.4**	**23532.0**
	Electricity	1934.0	3010.0	3475.0
	Heat	63.21	130.0	180.0
	Liquid fuel	2856.55	13.0	13.0
	Solid fuel	684.15	0	0
	Gaseous fuel	5066.8	5525.0	5650.0
	Biomass	415.97	0	0
	Fuels for. cii	11213.32	14393.4	14214.0

Forecasted emission factors

For the NFR 1.A.4 ci category (stationary combustion) the EMEP 2019 emission factors were used to develop the NOx, NMVOC, SO2, NH3, particulate matters (PM2.5) forecasts, and for the NFR 1.A.4 category (vehicles and machinery) the same emission values as those reported in the inventory in 2020 will be considered.

2.1.7 NFR 1.B Fugitive emissions from fuels

NFR 1.B.1 Fugitive emissions from solid fuels

Scenario with measures

Activity data

According to Romania's energy balance, electricity, thermal energy, liquid and gaseous fuels are needed for the extraction and handling of coal, crude oil and natural gas.

For the WM scenario, the forecast of the energy demand evolution for the period 2020÷2030 is presented in **Table 33**. This forecast was made by reducing the amount of fuels from 2020 at an annual rate of 10%.

Table 33. Evolution of energy demand in the period 2020÷2030

Energy demand, in TJ	2020	2025	2030
	Achieved	Forecasted	
Liquid fuels	871.998	541.45	336.19
Gaseous fuels	55.494	34.46	21.42
Solid fuels	0	0	0
Electricity	1379.678	856.67	531.92
Heat	101.993	63.32	39.31
TOTAL, in TJ	**2409.163**	**1495.90**	**928.84**

The fossil fuels in the table above are used in combustion processes.

Coal handling results in fugitive emissions of NMVOC and $PM_{2.5}$. In 2020, these emissions were about 3.56% of the total VOC emissions, respectively 0.09% of the total $PM_{2.5}$ emissions in Romania. Considering the difficulty of forecasting the sources of emissions as result of coal mining in the perspective of 2020÷2030, the forecast of these emissions was made by extrapolating the value from year 2020, for the scenario with measures, with the growth rates considered for solid fuel consumption related to the NFR category 1 A Energy.

Forecasted emission factors

For NFR category 1.B.1, historical emission factors are used for the development of forecasts of NMVOCs and particulate matters ($PM_{2.5}$).

Scenario with additional measures

In the WAM scenario, it is considered that the same amount of fuels is handled, with the same fuel consumption.

Forecasted emission factors

For NFR category 1.B.1, historical emission factors are used to develop forecasts of NMVOCs and particulate matters ($PM_{2.5}$).

NFR 1.B.2 Oil and natural gas

Scenario with measures

The systems related to the oil and natural gas sector consider the entire chain from the extraction of the resource (crude oil or natural gas) to the final consumer, including the transformation processes to meet consumer requirements.

Fugitive emissions of NOx, NMVOC, SOx, NH_3 and $PM_{2.5}$ result from these systems.

In 2020, the fugitive emissions of NOx, were 0.8862 kt, representing 0.5% of the total NOx emissions in Romania, the fugitive emissions of NMVOC were 8.0936 kt, representing 6.8% of total VOCNM emissions, SOx fugitive emissions were 0.9616 kt, representing 1.9% of total SOx emissions, and $PM_{2.5}$ fugitive emissions in 2020 were 0.9062 kt, representing 0.95% of total $PM_{2.5}$ emissions.

Considering the difficulty of forecasting the sources of emissions related to the oil and natural gas sector in the perspective of 2020-2030, the projections of these emissions were estimated by extrapolating the values from year 2020, with the rates considered for the consumption of liquid fuel and natural gas related to the NFR 1 category A Energy.

Forecasted emission factors

For the NFR 1.B.2 category, historical emission factors are used to develop NOx, NMVOC, SOx, NH_3 and particulate matter ($PM_{2.5}$) projections.

Scenario with additional measures

In the WAM scenario, it is considered that the same amounts of fuels are consumed for the exploitation, processing and transportation of oil and natural gas products.

Forecasted emission factors

For the NFR category 1.B.2, historical emission factors are used for the development of NOx, NMVOC, SOx, NH_3 and particulate matter ($PM_{2.5}$) projections.

2.2 NFR 2 Industrial Processes and Product Use

2.2.1 NFR 2.A Mineral Industry

The assumptions used for activity data forecast are the same in **WM** and **WaM** scenario.

NFR 2.A.1 Cement production

The activity data for *NFR 2.A.1 Cement production* is correlated with the evolution of GVA in the construction sector during 2023÷2030: the production is estimated to reach 7,677 kt clinker in 2025 and 7,989 kt clinker in 2030. Thus, for the year 2025 a production increase of +1.8% compared to 2020 and +4.1% in 2030 compared to 2025 were considered.

NFR 2.A.2 Lime production

Considering the internal market demand, the production is expected to reach 528 kt in 2025 and decrease to 500 kt in 2030. Thus, for the year 2025 it is considered a decrease in production by -24% compared to 2020 and by -5.3% in the year 2030 compared to the year 2025.

NFR 2.A.3 Glass production

Considering the internal market demand, the production is expected to increase to 410 kt in 2025 and to reach 426 kt in 2030. Thus, for the year 2025 a decrease in production by -3.2% compared to 2020 and an increase by +4.1% in 2030 compared to 2025 were considered.

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

Considering the internal market demand, the production is expected to reach 91,648 kt in 2025 and 94,618 kt in 2030. For the year 2025 a decrease in production by -8.4% compared to 2020 and an increase by +3.2% in 2030 compared to 2025 were considered.

NFR 2.A.5b Construction and demolition

Considering the internal market demand, the activity is expected to be 12,531,485 m^2 in 2025 and 14,051,977 m^2 in 2030. For this category, it was considered a 10.5% increase in production in 2025 compared to 2020 and a +12.1% increase in 2030 compared to 2025.

Emission factors

In the **WM scenario**, the emission factors for the category *NFR 2.A Mineral Industry* considered the implementation of IE Directive. The effect of implementation of IE Directive was estimated through gradual reduction of EFs (EMEP/EEA 2019) with the following percent:

- NFR 2.A.1 Cement production: 95% of historical EFs in 2025, respective 92.5% in 2030
- NFR 2.A.2 Lime production: 90% of historical EFs (2020) in 2025 and 2030
- NFR 2.A.3 Glass production: for PM2.5 - 95% in 2025, respective 94% in 2030 of the average EFs from the period 2018-2020; NH3 - 93% in 2025, respective 87% in 2030 of the historical EF (2020); NMVOC – constant value during the projection period
- NFR 2.A.5a Quarrying and mining of minerals other than coal: historical EFs (2020)
- NFR 2.A.5b Construction and demolition: 92,5% of historical EFs (2005).

In the **WAM scenario** for $PM_{2.5}$ in the categories 2.A.1 and 2.A.2 were used the EFs from Tier 2 methods which suppose that installations were equipped with filtration systems (considering that industrial units are complied with BAT requirements). The EFs considered have constant values over the projections period.

For all the other pollutants and categories, the EFs are equal with those used in WM scenario.

2.2.2 NFR 2.B Chemical Industry

Activity data

The assumptions used for activity data forecast are the same in **WM** and **WaM** scenario.

The considered activity data is correlated with the growth rates for the period 2023÷2030. Since the activity data for this category are confidential, only some information regarding their evolution compared to 2005 was presented:

- category 2.B.1 Ammonia production recorded large inter annual variations (- 59%, +47%) in the period 2018-2020. Compared to the value of 2005, the maximum value of production achieved during 2018-2020 represents 52%
- category 2.B.2 Nitric acid production recorded values between 47% and 67% of the 2005 production
- category 2.B.7 Caustic soda production recorded similar values in 2018 and 2019, but ceased in 2020
- category 2.B.10.a – the productions in this category evolved in different ways during the analyzed period. Thus, the production of chemical fertilizers recorded decreases (with percentages between - 81% in 2019 for the production of urea and - 63% in 2020 for the production of fertilizers), the production of polystyrene and polypropylene recorded increases of up to 52% (in 2019), and in some production activity has been stopped (eg production of ethylene, ethylene oxide, low density polyethylene production).

Emission factors

As the activity data for this category is confidential, the emission factors have not been presented in this report.

2.2.3 NFR 2.C Metal Industry

Activity data

The assumptions used to forecast the activity data are the same in **WM** and **WaM**.

Thus, for category *2.C.1 Iron and steel production*, it was considered that a production of 2,616 kt of steel will be reached in 2025 and 2,730 kt in 2030.

For the categories 2*.C.3. Aluminum production, 2.C.5. Lead production, 2.C.6. Zinc production* the production data are confidential and are not presented in this report.

For categories 2.C.2. and 2.C.7.a no emissions forecasts were made because the activity in these areas has ceased.

Emission factors

The emission factors used in the **WaM** scenario for category NFR 2.C are identical to those used in the **WM** scenario.

The emission factors for the category NFR 2.C Metal Industry were estimated through gradual reduction of EFs (EMEP/EEA 2019), as follows:

- For category 2.C.1 a reduction of the historical emission factors of 10% was considered for the emission factors for PM2.5 related to the agglomerate production activity. For the other activities in category 2.C.1, a 1% reduction in emission factors for PM2.5 was considered.

- For NMVOC emissions in category 2.C.1, a reduction of 10% for the year 2025, respectively 20% for the year 2030 was considered compared to the value of the historical emission factor.
- For category 2.C.3, the historical emission factors for all pollutants were considered for the entire projection period.
- Since for categories 2.C.5 and 2.C.6 the EMEP/EEA 2019 guidelines present values of emission factors based on recent technologies, no reduction of them was considered.

2.2.4 NFR 2.D Other Solvents and Product Use

Activity data

The activity data considered for emissions projection are the same in **WM** and **WaM** scenario.

The activity data considered in the **WM** scenario consider the evolution of the internal market and the growth rates for the period 2023÷2030 and are the same as those considered in the WM scenario of the National Projection of the GHG emissions. For category 2.D.3.a, the activity data are represented by the population.

Emission factors

The emission factors for NMVOC used for forecasting in the scenario **WM** for categories 2.D.3.a, 2.D.3.b, 2.D.3.c, and 2.D.3.g are equal to the historical value (represented by EMEP/EEA 2019 factors) and constant over the entire forecast period. The value of the emission factor for NMVOC (for the years 2025 and 2030) resulting from category 2.D.3.h represents 92% of the average value recorded in the last 2 years of the inventory. For category 2.D.3.i the value of the emission factor for NMVOC (for the years 2025 and 2030) represents 99% of the average value recorded in the last 2 years of the inventory.

Emission factors for PM2.5 were considered equal to historical factors (EMEP/EEA2019 factors).

For the WaM scenario, the emission factors are considered equal to those in the WM scenario, except for the emission factor for NMVOCs resulting from category 2.D.3.a. For this category, the value recommended by ESIG for Romania was used, namely 0.5 kg NMVOC/capita.

2.2.5 NFR 2. G Other product use

Activity data

In the WM scenario, the activity data considered in the projections are estimated based on the growth rates for the period 2023-2030.

In the WaM scenario, the activity data are the same as in the WM scenario.

Emission factors

The emission factors used in the WM scenario for the NFR 2.G category will be the EMEP EEA/2019 emission factors (which will also include the effects of technological improvements). The emission factors considered for emissions projection are the same in **WM** and **WaM** scenario

2.2.6 NFR 2. H – Other industrial processes

The activity data considered for emissions projection are the same in **WM** and **WaM** scenario.

The activity data considered in the WM scenario were estimated considering the growth rates for the period 2023÷2030 and the estimates provided by some economic operators. These are correlated with those considered in the WM scenario of the GHG national projection. The structure of activity data used in the projection is identical to that of 2020.

Emission factors

The emission factors considered for emissions projection are the same in **WM** and **WaM** scenario.

The emission factors used for the NFR 2.H category were the historical emission factors related to the year 2020.

2.3 NFR 3 Agriculture

2.3.1 NRF 3.B Manure management

Activity data

The forecasts for NFR 3.B Manure management considered the categories of animals (according with EMEP/EEA 2019), the manure management system used for each category of animals and the default emissions factors per each category and each manure management system (EMEP/EEA 2019).

For the estimation of category 3B emissions, several aspects was taken into account regarding the animal breeding system (industrial or domestic): the caloric level of the ration depending on the species, category and production value, days of life (the numbers must be corrected with the days-of-life factor for fattening categories), the waste management system (which in the traditional system is 100% solid), real forecasts regarding the dynamics of livestock in the target years (depending on market demand, energy consumption and technology growth), as well as the nitrogen cycle.

The evolution of the number of animals for the period 2025-2030, depending on the breeding system, is presented in following table.

Table no. 34. Livestock numbers in WM scenario (1000 head)

NFR	Category	2025	2030	2025		2030	
				Intensive system	Extensive system	Intensive system	Extensive system
3B1a	Dairy cattle	1150281	1166475	230056	920225	256625	909851
3B1b	Other cattle	778284	789241	311314	466970	355159	434083
3B2	Sheep	10449676	10785694	1567451	8882225	1617854	9167840
3B3	Fattening pigs	4427421	4625686	2213710	2213710	2312843	2312843
3B3	Sows	403305	421365	302479	100826	316024	105341
3B4d	Goats	1638447	2229051	163845	1474603	222905	2006146
3B4e	Horses	388198	369357	38820	349378	36936	332421
3B4a	Dairy buffaloes	13575	13766	1357	12217	1652	12114
3B4a	Other buffaloes	5912	5996	591	5321	719	5276
3B4gi	Laying hens	37410056	38578486	18705028	18705028	19289243	19289243
3B4ii	Broilers	35245855	36346690	15860635	19385220	17446411	18900279
3B4h	Rabbits	247744	241642				

The numbers of animals used in projection are the same in both scenarios.

Emission factor

The emission factors used to estimate emissions are default emission factors - EMEP/EEA 2019, which take into account the categories of animals and the related waste management system. The following manure management systems were used: cattle, sheep, goat and poultry manure - 100% solid storage; pigs' manure – 50% solid storage (extensive, traditional system) and 50% liquid storage (intensive, industrial system).

In developing the forecasts, in the scenario with measures, the following tools were used for NH_3:

- use of level 2 emission estimation, for all species and categories of animals using national data such as: specific weight, litter management system (according to climate type and size of farms), Nex; exception category "other animals = fur animals = rabbits", where method 1 was used, using the default emission factor with the value of 0.03 (table 3.2 EMEP/EEA 2019);
- for pigs, in the opinion of the expert, by applying BAT, a reduction of NH_3 emissions is estimated by 30% for 50% of the herd (pigs in the industrial system) in the year 2025 and by 30%, for 60% of the herd, in the year 2030 (only for fattening pigs and breeding sows in the industrial system); for animals in the household system, the emissions are those forecast for the year 2025, based only on the growth rates specified by the Animal Husbandry Policy Directorate (MADR);
- for birds, in the opinion of the expert, by applying BAT, a reduction of NH_3 emissions is estimated by 30% for 50% of the flock in 2025 (compared to 2020) and by 30% for 55% of the flock in 2030 (only for livestock in the industrial system), for animals in the household system, the emissions are those forecast for the year 2025, based only on the growth rates specified by the Animal Husbandry Policy Directorate (MADR);
- By implementing the Nitrates Directive and the Code of Good Agricultural Practices, for nitrogen oxides, due to the fact that farmers with large herds (operating in the industrial

sector) incorporate the litter as quickly as possible after spreading, plus spreading restrictions according to the climate zone, for all herds of animals raised in an industrial system, the reduction is estimated to be: 50% for dairy bulls and other bulls, pigs for fattening and sows, 10% for sheep, goats, horses, 45% for laying hens and broilers in 2025 (a total of 13.28% reduction in total emissions).

In 2030, the reduction in emissions is estimated to be: 25% for dairy cattle, 30% for other bulls, pigs for fattening, sows, laying hens and broilers (8.625% of total emissions).

- For NMVOC, through the implementation of the Nitrates Directive and the Code of Good Agricultural Practices, due to the obligation of farmers to incorporate the waste as soon as possible after spreading and the spreading restrictions according to the climatic zone, for all herds of animals raised in an industrial system and at which emissions were calculated using method 2, the reduction is estimated to be 10% in 2025 and 15% in 2030 (dairy and non-lactating cattle and poultry).
- For $PM_{2.5}$, the forecasted emissions for the target years will be the same in the scenario with measures.

The differences that appear in the estimation of emissions and forecasts, compared to RO-IIR 2019-2022, are due to the non-segregation of livestock by type of breeding system and the non-correction of the categories subjected to fattening with days of life or the period they spend in the shelter.

2.3.2 NFR 3.D Crop production and agricultural soils

Activity data

NFR 3.D.a.1 Inorganic fertilizers N (including urea)

The activity data come from the Romanian Ministry of Agriculture and Rural Development (MARD) through official way (address no. 4646/27-07-2022 to the Ministry of the Environment, Water and Forests - MEWF), refers to the quantities of inorganic fertilizers with nitrogen - N (including urea) for 2010-2021 period, the average of this interval and estimates for the years 2030 and 2050. For the reference year 2005, the source used in the previous reports was kept, namely the National Institute of Statistics (NIS). For the year 2025, the average of the 2010-2021 interval was used (**Table 35**), and for the year 2030, the MARD forecast was used.

Table 35. Activity data regarding the total amounts of inorganic fertilizers with nitrogen (N), including urea

Name/Year	2005	2018	2019	2020	2025	2030
	Realized				Forecasted	
The total amount of N fertilizers (tons a.s.*)	299195	468639	455964	468891	442960	570000
Media (kg N a.s./ha)	35.33	55.35	52.19	56.74	53.66	68.53

*) *a.s.: active substance Source MADR, 2022)*

- ***3.D.a.2.a Livestock manure applied to soils***

In order to calculate NH_3 and NO_2 emissions from manure and animal manure applied to agricultural soils, it was used the Tier 2 methods, which involves extracting their values from the Manure Management N Tool spreadsheet. The activity data that were used for this category are the same that were used to estimate the emissions for the NFR 3.B category.

- ***3.D.a.2.b Sewage sludge applied to soils***

According to the EMEP/EEA Guide 2019 (Tab. 3.1 and Appendices 1 and 2), NH_3 and NO_2 emissions produced by the application of sewage sludge on agricultural soil are related to the human population served by the sewage systems. Activity data (**Table 36**) for this category were obtained from the National Institute of Statistics, chapter "Sustainable Development - 2030 Goals" sub-chapter "Objective 6 - Clean water and sanitation" and covered the years 2018-2020. For the year 2005, the data used in IIR 2020 were used. For the year 2025, the average of the years 2018-2020 was used, and for the year 2030, the value related to the year 2025 was used, to which a 10% increase was added.

Table 36. Activity data regarding the population connected to sewage systems and treatment plants by residence

Name/Year	2005	2018	2019	2020	2025	2030
	Realized				Forecasted	
Population (number)	5738356	10293041	10514924	10794270	10534078.33	11587486.17

Source: INS, 06-04-2022

- ***3.D.a.3 Urine and dung deposited by grazing livestock***

For this category, emissions were calculated according to Tier 2 methods, together with emissions of ammonia and nitrogen oxides from category 3B – Manure Management. The expert recommends using the Manure Management N Tool spreadsheet, as it takes into account the nitrogen cycle and all the fractions (organic and inorganic) emanating from the different manure management systems, as well as the influence of the animal husbandry system (industrial or household).

- ***NFR 3.D.c Farm level agricultural operations including storage, handling and transport of agricultural products***

Particle emissions (***PM2.5*** from agricultural operations) as well as ***VOCNM*** emissions were estimated for this category. All activity data come from the Ministry of Agriculture and Rural Development (MARD) through official channels (address no. 4646/27-07-2022 to the Ministry of the Environment, Water and Forests - MEWF) and refer to the total cultivated area resulting from the aggregation of the areas detailed on crops for the years 2005, 2018-2020, 2025 and 2030 (**Table 37**). For the year 2025, the average of the years 2010-2021 was used, and for the year 2030, the value forecast by MARD was used.

Table 37. Total cultivated areas resulting from the aggregation of areas by crops

Name/Year	2005	2018	2019	2020	2025	2030
	Realized				Forecasted	
Aggregate surface (ha)	12368874	11701789	12043047	11517646	11756296	11565499

- ***NFR 3.D.e Cultivated crops***

The activity data, which comes from the Ministry of Agriculture and Rural Development (MARD), covers cultivated areas for the main species and includes the 2010-2021 interval, the average of this interval and estimates for the years 2030 and 2050 (**Table 38**). For the reference year 2005, the source used in the previous reports was kept, namely the National Institute of Statistics (NIS). For the year 2025, the average of the 2010-2021 interval was used, and for the year 2030, the MARD forecast was used.

Table 38. Activity data regarding crops cultivated areas

Crop/Year	2005	2018	2019	2020	2025	2030
	Achieved				Forecasted	
Rye (ha)	20653	10264	9355	11252	10760	13000
Wheat - total (ha)	2475974	2116158	2168370	2155254	2102998	2163999
Commun wheat (ha)	2472334	2110520	2162645	2150987	2097006	2200000
Durum wheat (ha)	3640	5634	5726	4267	5992	25000
Barley with 6 rows (ha)	221135	250797	285065	292079	269041	260000
Barley with 2 rows (ha)	263448	172703	163820	149903	192787	150000
Hops (ha)	280	255	252	246	228	250
Oat (ha)	214817	161484	161188	101340	162029	160000
Grain maize (ha)	2628471	2439842	2678504	2537104	2520187	2460000
Sorghum (ha)	1466	15929	15712	9591	14091	8000
Rice (ha)	3922	8251	7427	5996	9817	10000
Bean peas (ha)	22012	120247	104448	98104	60089	80000
Beans (ha)	21813	11391	11007	9041	11950	15000
Flax for fiber (ha)	185	85	0	34	28	500
Hemp for fiber (ha)	2147	1454	1433	1181	670	1500
Sunflower (ha)	970950	1006994	1282697	1142841	1044559	1100000
Rapeseed (ha)	87783	632679	352622	362865	411207	430000
Soybean (ha)	143085	169422	158149	168901	118336	150000
Flax for oil (ha)	80	2080	3081	1509	2146	2200
Sugar beet (ha)	25220	25723	22729	21320	24726	20000
Broom sorghum (ha)	4674	2978	2074	2216	2823	2300
Tobacco (ha)	3565	916	897	883	1001	1000

Crop/Year	2005	2018	2019	2020	2025	2030
		Achieved			Forecasted	
Medicinal and aromatic plants (ha)	4571	1781	1745	1759	5017	5000
Potatoes - total (ha)	284906	169304	170063	98498	181097	150000
Vegetable - total (ha)	266735	226328	227720	200501	235657	250000
Tomatoes (ha)	47133	40741	40845	34115	43262	45000
Eggplants (ha)	6881	9028	8985	8576	9234	9500
Dry onion (ha)	35658	30269	30346	29201	31098	31000
Garlic (ha)	12418	10195	10029	9539	10659	10000
White cabbage (ha)	54843	47330	47153	37626	46428	46000
Pepper (ha)	18978	17977	18677	17188	18746	19000
Edible roots (ha)	18056	15822	16137	15882	16774	17000
Green and yellow watermelons (ha)	37187	22088	22211	13816	24602	25000
Annual green fodder (ha)	233886	195854	204180	202341	201871	170000
Perennial fodder (ha)	586491	711396	696799	684516	672019	650000
Lucerne (ha)	310532	408678	412861	416676	378673	380000
Clover (ha)	91645	111735	109083	104583	113085	105000
Green fodder maize (ha)	23788	47576	50606	47029	47603	45000
Fodder roots (ha)	27101	10051	10641	10127	12923	7000
Strawberries (ha)	2773	3287	3312	3307	2783	2900
Flowers and ornamental plants (ha)	238	312	317	278	359	350
Fruit orchards (ha)	199968	137263	135102	135991	139698	145000
Arable land at rest (ha)	517432	218968	229034	219183	502237	200000

Source: Ministry of Agriculture and Rural Development,2022

Forecasted emission factors

To make the emission forecasts for the NFR 3.D categories, with the exception of categories 3.D.a.2.a and 3.D.a.3, the default emission factors from the EMEP/EEA Guide 2019 related to Tier 1 approach were generally used.

2.3.3 NFR 3F. Field burning of agriculture burning

A. The scenario with measures

Activity data

Within this category, the activity data for the reference year (2005) and for the historical years (2018, 2019 and 2020) from the source Report on the informative inventory of Romania, 2022 were used. To calculate the emission forecasts, the procedure was as follows:

- For the year 2025 it was forecasted a value representing 50% from value of 2020 year;

- For the year 2030 it was forecasted a value representing 50% from the value of 2025 year.

This was done taking into account the environmental protection and climate mitigation measures applied by MARD (Ministry of Agriculture and Rural Development) in collaboration with MEWF (Ministry of Environment, Water and Forests) and MIA (Ministry of Internal Affairs).

Table 39. Activity data regarding the amount of residual plant biomass (AR) burned in the field

Categories	2005	2018	2019	2020	2025	2030
	Realized				Forecasted	
Amount of wheat residue burned in the field (kg dry matter)	1646075	792024	908049	1522379	761189.5	380594.8
Amount of maize residue burned in the field (kg dry matter).	3916429	2046616	2513923	4002603	2001302	1000651
Amount of barley residue burned in the field (kg dry matter)	297378	146313	173520	274525	137262.5	68631.25
Amount of rye residue burned in the field (kg dry matter)	16899	4728	4822	9240	4620	2310
Amount of residues of other cereals burned in the field (kg dry matter)	2237	6995	6948	7456	3728	1864

Emission factors

The emission factors applied were default emission factors derived from research by Jenkins et al. (1992, 1996a and 1996b), along with NH_3 emission measurements reported by Lee and Atkins (1994).

2.4 NFR 5 Waste

2.4.1 NFR 5.A Biological treatment of waste - Solid waste disposal on land

A. Scenario with measures

The activity data considered in the elaboration of the emission forecasts, represented by the quantities of waste stored in household waste depots, were estimated based on the demographic evolution forecasted during the analyzed period, and, additionally, the need to comply with European and national legislation on waste storage was taken into account. The activity data considered for the development of emission forecasts took into account the national implementation of long-term investment plans and integrated waste management systems at the county level, which implies the reduction of landfill gases (in 2025 by 20% compared to 2020, and in 2030 by 25% compared to 2025).

The emission factors used in the development of the NMVOC forecasts, in the WM scenario, for the category NFR 5.A Biological treatment of waste - Storage of solid waste on land, are the historical emission factors related to year 2020.

B. Scenario with additional measures

In the **WAM scenario**, to reduce the amount of stored waste, the following were taken into account:

- increasing the degree of separate collection;
- development of new waste sorting stations;
- building a waste energy recovery facility;
- awareness and consultation of the population;
- analysis of the introduction of a pricing system based on the amount of waste produced or the volume of product on the principle of "pay as much as you throw away";
- operating the existing sorting stations and those under construction at optimal capacity;
- exploitation of the existing mechano-biological treatment stations and those under construction at optimal capacity.

Taking into account the additional measures to reduce the amounts of waste mentioned previously for this scenario, compared to the previous scenario, a greater share of landfill gas reduction was considered starting in 2025 of 25% compared to 2020, in 2030 a reduction by another 55% compared to the year 2025 due to the additional treatment facilities that would come into operation in the period 2022-2026.

2.4.2 NFR 5.B1 Biological treatment of waste – Composting

A. Scenario with measures

The **WM scenario** took into account the national implementation of long-term investment plans and integrated waste management systems at county level, which implies the exploitation of the entire composting capacity of 377,000 t/year starting from 2025, following that in 2030 the increase should be by another 26,800 t/year; after this year the amount composted will remain constant.

B. Scenario with additional measures

In the **WAM scenario**, the national implementation of long-term investment plans and integrated waste management systems at county level was taken into account, which implies the exploitation of the entire composting capacity of 377,000 t/year starting from 2020, following that in the years 2025, 2030 the increase should be by another 26,800 t/year.

2.4.3 NFR 5.B2 Biological treatment of waste – Anaerobic digestion at biogas facilities

A. Scenario with measures

For the **WM scenario**, it was considered that by 2025, anaerobic digestion facilities will be built with a total capacity of 200,000 t/year, and by 2030 another 612,000 t/year, which will remain constant at 812,000 t/year in the year 2030.

B. Scenario with additional measures

For the **WAM scenario**, it was considered that by 2020, anaerobic digestion facilities will be built with a total capacity of 200,000 t/year, and by 2025, another 712,000 t/year, which will remain constant at 912,000 t/year in the year 2030.

2.4.4 NFR 5.C Waste incineration

The data for the elaboration of the emission forecasts were correlated with the data from PNGD 2017, and the emissions were estimated for the analyzed period according to the following indicators:

- the forecasted demographic evolution in the analyzed period;
- the forecasted evolution of industrial production in the analyzed period;
- the forecasted evolution of the cultivated area and the measures to reduce burnt agricultural waste;
- construction period of the sludge incinerator.

The emission factors used are the historical emission factors related to the year 2020, by NFR subcategories.

- ***NFR 5.C.1.a Municipal waste incineration***

For the **WM scenario**, an incineration capacity of about 173,000 t/year starting from 2025 and about 250,000 t/year of residual waste coming from sorting stations or from mechano-biological treatment stations, having a high PCI, was considered, which will be treated in cement plants starting from 2021-2025.

For the **WAM scenario**, an incineration capacity of about 173,000 t/year starting from 2020 and about 300,000 t/year of residual waste coming from sorting stations or mechanical-biological treatment stations, having a high PCI, was considered , which will be treated in cement plants; from 2025 emissions are considered constant.

- ***NFR 5.C.1.b.i, 5.C.1.b.ii, 5.C.1.b.iv Industrial waste incineration, including hazardous waste and sewage sludge***

For the **WM scenario**, the increase in the amount of incinerated waste was considered due to the installation of an incinerator with a capacity of 63,000 t/year that will treat the sludge from the sewage treatment plants that serve the Municipality of Bucharest and 11 neighboring towns. The incinerator that will be built through the Large Infrastructure Operational Program (POIM) 2014-2020 is expected to be put into operation in 2024.

- ***NFR 5.C.1.iii Clinical waste incineration***

For the **WM scenario** and the **WAM scenario**, the quantities of medical waste incinerated are assumed to be constant from 2020 onwards.

- ***NFR 5.C.1.b.v Cremation***

For the **WM scenario** and the **WAM scenario**, the quantities treated in crematoria are assumed to be constant from 2020 onwards.

- ***NFR 5.C.2 Open burning of waste - Open burning of agricultural waste***

For the **WM scenario**, it was considered reducing the quantities of waste burned by 30% until 2025, with another 25% in the period 2025-2030, compared to the quantities in 2020.

For the **WAM scenario**, it is estimated that the application of additional measures will decrease the quantities of waste burned on a reduced scale by 40% until 2025 compared to 2020, and by another 25% in the period 2025-2030 compared to 2025.

2.4.5 NFR 5.D Wastewater handling

For the **WM scenario** and, respectively, the **WAM scenario**, the forecast evolution of NMVOC emissions was estimated by extrapolating the historical emissions recorded in 2020 with an average annual growth rate of 7.5% in the 2020-2025 interval and with a average annual rate of 1.14% in the interval 2025-2030 taking into account:

- the population decrease;
- the increase of the population connected to the sewage system with treatment;
- the construction of modern wastewater treatment plants and, respectively, the modernization of the existing ones.

For the **WM scenario** and, respectively, the **WAM scenario**, the evolution of NH_3 emissions for the period 2021-2030 was estimated by extrapolating the emissions related to year 2020, with an average annual rate of decrease of 2.65% in the period 2020-2025 and with an average annual rate of decrease of 5.6% in the period 2025-2030, taking into account the following:

- the population decrease;
- the increase of the population connected to the sewage system with treatment;
- the construction of modern wastewater treatment stations with nitrification and denitrification.

The projections for the **WM and WAM** scenario are presented in the Annex.

3. CONCLUSIONS

The national projection of the pollutants covered by the revised NEC Directive in **WM scenario** and **WAM scenario** are presented in table below.

Table no. 40. Results obtained in WM scenario and WaM scenario

Scenario	Pollutant	Emissions	Historical emissions, in kt				Projected emissions, in kt	
			2005	2018	2019	2020	2025	2030
WM	NOx	*Total*	330.651	221.764	217.127	204.400	196.775	202.283
		Total, without 3B and 3D	303.480	191.709	187.643	174.640	172.358	171.992
	COV_{nm}	*Total*	335.453	245.123	244.571	239.098	208.301	201.131
		Total, without 3B and 3D	259.419	188.242	186.789	182.407	168.332	161.667
	SO_2	*Total*	602.518	76.103	90.810	71.036	44.072	35.799
	NH_3	*Total*	194.556	161.356	159.663	157.116	97.004	104.222
	$PM_{2,5}$	*Total*	120.351	110.760	112.119	111.717	96.435	86.24
WAM	NOx	*Total*	330.651	221.764	217.127	204.400	146.869	148.441
		Total, without 3B and 3D	303.480	191.709	187.643	174.640	122.451	118.149
	COV_{nm}	*Total*	335.453	245.123	244.571	239.098	165.185	152.165
		Total, without 3B and 3D	259.419	188.242	186.789	182.407	125.215	112.702
	SO_2	*Total*	602.518	76.103	90.810	71.036	27.756	16.342
	NH_3	*Total*	194.556	161.356	159.663	157.116	94.075	100.506
	$PM_{2,5}$	*Total*	120.351	110.760	112.119	111.717	65.584	47.704

10 ADJUSTMENTS

No adjustments

I.I.R. REFERENCES

- EIONET CDR – CLRTAP Emission Inventories of ROMANIA
- EMEP/EEA 2019 Air Pollution Inventory Guidebook
- 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 calculations

Table 1. Tier 2 NH_3-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 2**	**125**	**60**	**1.9**
Nex (kg/yr)	83.038	61.448	Table 2	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 2. 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
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
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

Table 3. Amount of AR.feedstock (kg) material used in biogas units resulted from questionnaires

AR.feedstock Type/Year(kg)	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cattle slurry		1762.45	7184.94	15975.4	33612.04	39897.36	56623.08	61039.96	53407.55
Pig slurry				1950	9592.369	3376	642	672	1147
Solid cattle manure			1093	4616	17917	16129.2	18640.02	18767.18	20354.99
Solid pig manure					6658.84	3951.18	941	182	0
Poultry manure	9700	7430	1070	5690	4517	3524	3110	1390.5	1926

Table 4. 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

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.